TAB 1

LOWER WILLAMETTE GROUP

PORTLAND HARBOR RI/FS

PROGRAMMATIC WORK PLAN

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ADCP	Acoustic Doppler Current Profiler
AINW	Archeological Investigations Northwest
AOC	Administrative Order on Consent
ARAR	Applicable or Relevant and Appropriate Requirement
AWQC	Ambient Water Quality Criteria
BCF	bioconcentration factor
BEHP	bis(2-ethylhexyl)phthalate
bgs	below ground surface
BMP	best management practice
BSAF	biota sediment accumulation factor
BTEX	benzene, toluene, ethylbenzene, xylenes
CAD	confined aquatic disposal
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CGF	coarse-grained flood deposits and upper Troutdale Formation
COC	chemical of concern
COI	chemical of interest
COPC	chemical of potential concern
cfs	cubic feet per second
CRBG	Columbia River Basalt Group
CRD	Columbia River Datum
CSM	conceptual site model
CSO	combined sewer overflow
DDD	dichloro-diphenyl-dichloroethane
DDE	dichloro-diphenyl-dichloroethene
DDT	dichloro-diphenyl-trichloroethane
DEA	David Evans and Associates
DEQ	Oregon Department of Environmental Quality
DNAPL	dense non-aqueous phase liquid
DO	dissolved oxygen
DQO	data quality objective
ECSI	Oregon Environmental Cleanup Site Inventory
EPA	U.S. Environmental Protection Agency
ERA	ecological risk assessment
EROD	ethoxyresorufin O-deethylase
ESA	Endangered Species Act
FFA	fill, fine-grained facies of flood deposits, and Recent alluvium
FSP	field sampling plan
GLISP	Guild's Lake Industrial Sanctuary Plan
GPS	global positioning system
GRA	general response action
HHRA	human health risk assessment
HPAH	high molecular weight polycyclic aromatic hydrocarbon
HSP	health and safety plan

ISA	initial study area
K_d	soil/water partitioning coefficient
K_{oc}	organic carbon partitioning coefficient
K_{ow}	octanol-water partitioning coefficient
LASAR	laboratory analytical storage and retrieval
LCRMA	Lower Columbia River Management Area
LNAPL	light non-aqueous phase liquid
LOAEL	lowest observed adverse effect level
LOEC	lowest observed effect concentration
LPAH	low molecular weight polycyclic aromatic hydrocarbon
LWG	Lower Willamette Group
LWR	lower Willamette River
µg/kg	microgram per kilogram
µg/L	microgram per liter
m	meter
mg/kg	milligram per kilogram
mg/L	milligram per liter
mya	million years ago
MOA	memorandum of agreement
MOU	memorandum of understanding
MS	matrix spike
MSD	matrix spike duplicate
MSL	mean sea level
MTCA	Washington Model Toxics Control Act
NPL	National Priorities List
NAPL	non-aqueous phase liquid
NAVD	North American Vertical Datum
NGVD	National Geodetic Vertical Datum
NOAEL	no observed adverse effect level
NOEC	no observed effect concentration
NPDES	National Pollutant Discharge Elimination System
NRC	National Response Center
NRDA	National Resource Damage Assessment
OSU	Oregon State University
OSWER	Office of Solid Waste and Emergency Response
ODHS	Oregon Department of Human Services
PACG	preliminary analytical concentration goal
PAH	polycyclic aromatic hydrocarbon
PBT	persistent, bioaccumulative toxin
PCB	polychlorinated biphenyl
PCP	pentachlorophenol
ppm	part per million
PRD	Portland River Datum
PRE	preliminary risk evaluation
PRG	preliminary remediation goal

PRP	potentially responsible party
PSEP	Puget Sound Estuary Program
QA/QC	quality assurance/quality control
QAPP	quality assurance project plan
RA	remedial action
RAO	remedial action objective
RCRA	Resource Conservation & Recovery Act
RD	remedial design
RI/FS	remedial investigation/feasibility study
RM	river mile
ROC	receptor of concern
ROD	Record of Decision
RPD	redox potential discontinuity
SAP	sampling analysis plan
SEA	Striplin Environmental Associates
SMA	sediment management area
SOW	Statement of Work
SPI	sediment-profile imaging
SPMD	semipermeable membrane device
SRM	Sandy River Mudstone
STA®	Sediment Trend Analysis®
STORET	EPA's Data Storage and Retrieval System
SVOC	semi-volatile organic compound
TBC	to be considered
TBT	tributyltin
TCDD	2,3,7,8-tetrachlorodibenzo-*p*-dioxin
TCDF	2,3,7,8-tetrachlorodibenzofuran
TM	technical memorandum
TMDL	total maximum daily load
TOC	total organic carbon
TPH	total petroleum hydrocarbons
TRV	toxicity reference value
UCL	upper confidence limit
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey
VOC	volatile organic compound
WRDA	Water Resource Development Act

1.0 INTRODUCTION

This programmatic work plan describes the activities that will be undertaken by the Lower Willamette Group (LWG) as it develops and implements a remedial investigation and feasibility study (RI/FS) for the Portland Harbor Superfund Site (Site) in Portland, Oregon. The LWG is a group of Portland Harbor businesses and public agencies involved in the investigation and evaluation of ecological and human health risks at the Site. The Portland Harbor RI/FS Programmatic Work Plan (Work Plan) complies with the requirements of the Administrative Order on Consent (AOC) and Statement of Work (SOW) (EPA 2001a) between the LWG and the U.S. Environmental Protection Agency (EPA) for conducting the RI/FS.

As stated in the SOW, the purpose of the RI/FS is "to investigate the nature and extent of contamination for the in-water portion of the Site, to assess the potential risk to human health and the environment, to develop and evaluate potential remedial alternatives, and to recommend a preferred alternative" (EPA 2001a). A critical objective of the RI/FS will be to characterize the Site sufficiently to allow EPA to define site boundaries and select a remedy that is protective of the survival, growth, and reproduction of ecological receptors (e.g., benthic invertebrates, fish, shellfish, birds, and mammals, including those listed under the Endangered Species Act) and human receptors that may consume fish or shellfish or come in contact with sediments, surface water, or groundwater seeps from the Site.

The RI and FS will be conducted in an integrated fashion. Data needs for the RI and FS will be identified collectively, and results will be shared throughout the project such that the field investigation data, the outcome of the RI, and the associated risk assessments can support the development and evaluation of remedial alternatives. FS information that may affect the scope of the RI or risk assessments will also be incorporated into the RI approach. The RI/FS will initially focus on the stretch of the Willamette River from river mile (RM) 3.5 to RM 9.2 and adjacent areas logically associated with an evaluation of the in-water portion of this stretch of the river. This Work Plan refers to this initial study area as "the ISA." The ISA does not define the Superfund Site; the boundaries of the Site will be determined upon issuance of a Record of Decision (ROD).

The RI/FS will be conducted in a manner that is consistent with the Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (EPA 1988), EPA's Data Quality Objectives planning process (EPA 2000a), and other applicable guidance. This Work Plan describes the overall tasks to be conducted during the RI/FS, and provides the underlying rationale and objectives for each task, the data uses and analysis methods, and the principles that are being used to define the detailed sample collection and analysis efforts. Details of the sampling (e.g., locations, sampling methods) and the analytical methods are provided in the field sampling plans (FSPs) and the quality assurance project plans (QAPPs). Together, the FSP and QAPP comprise the sampling and analysis plan, which, in accordance with EPA guidance, are attachments to the overall Work Plan. EPA has approved the

Round 1 QAPP for use in the project. FSPs and the QAPP for the next round of sampling are being prepared and will be attached to this Work Plan. The overall organization of the RI/FS is described in Section 1.3. Details of the RI/FS program approach are summarized in Section 6, and the details of the RI/FS tasks are presented in Sections 7 and 8.

This Work Plan presents the RI/FS approach anticipated for the Site. Because additional data may be generated during the RI/FS that impacts the current understanding of the Site, the methods and assumptions presented in this Work Plan may be refined to incorporate new information. Changes to the RI/FS approach presented in this Work Plan will be discussed with EPA and its partners and submitted as interim deliverables or addenda prior to implementation. Similarly, it is anticipated that several technical memoranda will be prepared to provide detailed project approaches for various components of the RI, risk assessments, and FS. These memoranda will be submitted to EPA and its partners for review and approval, in accordance with the Work Plan schedule. Any EPA approved interim deliverable, addenda, or technical memorandum will be incorporated into this Work Plan and become a substantive part of this Work Plan under the AOC.

1.1 PORTLAND HARBOR OVERVIEW

Portland Harbor is located along an 11.6-mile dredged reach of the lower Willamette River (LWR) in Portland, Oregon (Figure 1-1 and Map 1-1) [1]. While the harbor area is heavily industrialized, it occurs within a region characterized by commercial, residential, recreational, and agricultural uses. Land use along the LWR in the harbor includes marine terminals, manufacturing, and other commercial operations as well as public facilities, parks, and open spaces. Map 1-2 illustrates land use zoning within the LWR, as well as waterfront land ownership.

Since the late 1800s, the Portland Harbor section of the LWR has been extensively modified to accommodate a vigorous shipping industry. Modifications include re-direction and channelization of the main river, draining seasonal and permanent wetlands in the lower floodplain, and relatively frequent dredging to maintain the navigation channel. Constructed structures, such as wharfs, piers, floating docks, and pilings, are especially common in the Portland Harbor where urbanization and industrialization are most prevalent. These structures are built largely to accommodate or support shipping traffic within the river and to stabilize the riverbanks for urban development. Riprap is the most common bank-stabilization measure. However, upland bulkheads and rubble piles are also used to stabilize the banks. Seawalls are used to control periodic flooding as most of the original wetlands

[1] In this Work Plan, the term "Portland Harbor" means the portion of the Willamette River containing the federal navigation channel, from RM 0 to RM 11.6. The terms "lower Willamette River" and "LWR" mean the portion of the Willamette River from Willamette Falls to its confluence with the Columbia River, or RM 0 to approximately RM 26.5.

bordering the Willamette in the Portland Harbor area have been filled. Constructed structures are clearly visible in the aerial photos provided in Maps 1-3a-n. Numerous municipal and private outfalls, including storm drains and combined sewer overflows, are located along both shores of the LWR in the metropolitan area.

A federal navigation channel, with an authorized depth of –40 feet, extends from the confluence of the LWR with the Columbia River to RM 11.6. Container and other commercial vessels regularly transit the river. Certain parts of the river require periodic maintenance dredging to keep the navigation channel at its authorized depth. In addition, the Port of Portland and other private entities periodically perform maintenance dredging to support access to dock and wharf facilities. Dredging activity has greatly altered the physical and ecological environment of the river in the harbor area.

While the ecological function of the LWR has been greatly modified by development, a number of species of invertebrates, fishes, birds, amphibians, and mammals, including some protected by the Endangered Species Act (ESA), use habitats that occur within and along the river. The river is also an important pathway for migration of anadromous fishes such as salmon and lamprey. Various recreational fisheries, including salmon, bass, sturgeon, crayfish, and others, use the LWR. A detailed description of ecological communities in the harbor is presented with the Ecological Risk Assessment Approach in Appendix B.

The long history of industrial and shipping activities in the Portland Harbor, as well as agricultural, industrial, and municipal activities upstream of the harbor, has contributed to chemical contamination of surface water and sediments in the LWR. Potential sources of chemical releases to the river are described in Section 3. As noted above, the primary purpose of this RI/FS is to characterize the effects of such chemicals on the environment in the LWR to the extent necessary to support risk management actions to protect human health and the environment.

1.2 NAVIGATIONAL CHANNEL AUTHORIZATION HISTORY

The LWR federal navigation project was first authorized in 1878 to deepen and maintain parts of the Columbia River and LWR with a 20-foot minimum depth. The channel for both rivers has been deepened at various intervals since that time. The navigation depth for both rivers was increased to 25 feet in 1899 and to 30 feet in 1912. Between 1930 and 1935, the navigation channel depth was again increased to 35 feet, and in 1962 the authorized depth was increased to 40 feet.

The current project authorization, as modified by Congress in 1962, encompasses 11.6 miles of the Willamette River below Portland and 103.5 miles of the Columbia River below Vancouver, Washington. Work on the authorized 40-foot-deep channel from Portland and Vancouver to the Pacific was completed in 1976. The Willamette

River channel, from the Broadway Bridge (RM 11.6) to the mouth (RM 0), varies in width from 600 to 1,900 feet.

1.3 SCOPE OF THE RI/FS

As stated in the SOW, the purpose of the RI/FS is "to investigate the nature and extent of contamination for the in-water portion of the Site, to assess the potential risk to human health and the environment, to develop and evaluate potential remedial alternatives, and to recommend a preferred alternative" (EPA 2001a). With respect to releases or threatened releases of any hazardous substances to the in-water portion of the Site, the RI/FS will specifically address the protection of human health, as well as survival, growth, and reproduction of the following ecological receptors:

- Benthic invertebrates
- Fish and shellfish
- Birds and mammals
- Species listed under the ESA.

In addition, the potential for risk to amphibians/reptiles will be evaluated.

Following completion of the RI/FS, EPA will prepare a ROD for the Site, which will define the site boundaries and potential cleanup areas and approaches. After the ROD is finalized, EPA will likely enter into a Consent Decree with one or more potentially responsible parties who will undertake remedial design (RD), remedial action (RA), and long-term monitoring of sediment management areas (SMAs) within the Site. Members of the LWG may or may not be signatories of the Consent Decree for the RD and RA.

The SOW identifies the ISA for the purpose of focusing sampling during implementation of the initial phase of the RI/FS. The ISA is defined as the lower Willamette River from RM 3.5 to 9.2, and adjacent areas logically associated with an evaluation of the in-water portion of this stretch of river (see Map 1-1). The actual boundaries of the Site will be determined through the RI/FS process and will be documented by EPA in one or more RODs when the final remedy is selected.

The SOW for the RI/FS (EPA 2001a) requires completion of a series of tasks:

Task 1 – Shared Server

Task 2 – Scoping

Task 3 – Community Relations

Task 4 – Dredging Coordination

Task 5 – Site Characterization

Task 6 – Treatability Studies

Task 7 – Development and Screening of Remedial Alternatives

Task 8 – Detailed Analysis of Remedial Alternatives.

This Work Plan completes the requirements of SOW Task 2 – Scoping, which is composed of the following subtasks:

Subtask 2a: Data Compilation/Site Background

Subtask 2b: Cultural Resources Analysis

Subtask 2c: Submission of Work Plans via the Stipulated Agreement

Subtask 2d: Data Review and RI Planning

- Preliminary Conceptual Site Model
- Preliminary Analytical Concentration Goals

Subtask 2e: Preliminary FS Planning Tasks

- Remedial Action Objectives Technical Memorandum
- Facility Siting Technical Memorandum
- Capping Material Evaluation

Subtask 2h: RI/FS Work Plan for the ISA.

The deliverables for subtasks 2a – 2e have been submitted under separate cover or are included in this Work Plan. The relationship of the RI to the remaining tasks is also summarized in Section 1.3.2. Subtask 2f (CERCLA/WRDA Integration and Coordination Plan) will be addressed outside the Work Plan process. The deliverable for subtask 2g (Early Actions Technical Memorandum) has been submitted to EPA as a part of earlier drafts of the Work Plan, and EPA has requested that it be removed from the Work Plan.

1.3.1 RI/FS Technical Approach

The RI/FS will be a multiyear program involving multiple rounds of data gathering and data evaluation as chemical distributions and the factors driving risks to ecological receptors and human health are identified. In concert with the RI field studies and data evaluations, data will be gathered to support the FS so that potential

remedial alternatives can begin to be considered and evaluated as the RI/FS process identifies and refines potential areas for cleanup.

Pursuant to the SOW requirements, the RI/FS technical approach is based on EPA guidance documents. Included in this guidance is the recent EPA memorandum, Principles for Managing Contaminated Sediment Risks at Hazardous Waste Sites [Office of Solid Waste and Emergency Response (OSWER) Directive 9285.6-08 (EPA 2002b)], which identifies 11 key concepts to be considered in the RI/FS process for the Site:

1. Control Sources Early.
2. Involve the Community Early and Often.
3. Coordinate with States, Local Governments, Tribes, and Natural Resource Trustees.
4. Develop and Refine a Conceptual Site Model that Considers Sediment Stability.
5. Use an Iterative Approach in a Risk-Based Framework.
6. Carefully Evaluate the Assumptions and Uncertainties Associated with Site Characterization Data and Site Models.
7. Select Site-specific, Project-specific, and Sediment-specific Risk Management Approaches that will Achieve Risk-based Goals.
8. Ensure that Sediment Cleanup Levels are Clearly Tied to Risk Management Goals.
9. Maximize the Effectiveness of Institutional Controls and Recognize their Limitations.
10. Design Remedies to Minimize Short-term Risks while Achieving Long-term Protection.
11. Monitor During and After Sediment Remediation to Assess and Document Remedy Effectiveness.

Consideration of this and other guidance documents, frequent communication with the agencies, and experience at other sites were utilized in designing this Work Plan. The resulting risk-based technical approach relies upon the initial use of existing data, the data quality objectives (DQO) process, iterative evaluation of data to guide subsequent activities, and identification of ongoing sources to focus the timely and efficient completion of the RI/FS. It is important to note that Oregon Department of Environmental Quality (DEQ) has the primary responsibility for identifying and directing control of upland sources to the Portland Harbor Superfund Site.

A flowchart depicting the generalized RI/FS process is shown in Figure 1-2. The technical approach is summarized in the following section and is described in detail in Section 6.

1.3.2 Overview of RI/FS Tasks

As shown in Figure 1-2, the RI/FS Work Plan builds upon information and evaluations developed as part of the Task 2 scoping effort, and lays out the "road map" for completion of the RI, baseline risk assessments, and FS. The steps in the RI/FS process shown in Figure 1-2 are coded with a number referenced in the following text (the text also provides the applicable SOW task/subtask number). Each step is discussed in detail in subsequent sections of the RI/FS Work Plan. These steps are briefly described below as an introduction to the overall process:

1. **Compilation and Evaluation of Historical Data (Box 1 in Figure 1-2, SOW Subtask 2a).** The RI/FS was initiated with an extensive compilation of existing information, which is summarized within this Work Plan (primarily Sections 2, 3, and 4) and associated appendices (particularly Appendices B, C, D, E, and F). Nearly 700 documents and data sets were obtained that address conditions in the LWR. This information was used to develop an initial understanding of the physical, chemical, and biological processes at the site and to assist in the development of the conceptual site model for the ISA (Section 5) and identification of data gaps (Section 7). At EPA's request, revisions to the preliminary conceptual site model presented in this Work Plan will be updated and resubmitted as a stand-alone report prior to development of the Round 2B sediment coring field sampling plan.

2. **Phase 1 Studies (Box 2, SOW Subtask 2c).** Recognizing that critical new site-specific physical and biological information was necessary to begin scoping the Work Plan, the LWG performed the following four pre-AOC "Phase 1" field studies approved by EPA in a stipulated agreement (EPA 2001b):

    - Juvenile salmonid residence time field study (Ellis Ecological Services 2002)
    - Multibeam acoustic bathymetry survey from RM 0 to Ross Island (DEA 2002a)
    - Integration of a sediment trend analysis and an evaluation of historical bathymetry (SEA 2002b)
    - Sediment-profile imaging field study (SEA 2002f).

Reports documenting the results of these pre-AOC "Phase 1" studies have been provided to EPA.

3. **RI Scoping Process (Box 3, SOW Subtask 2d and 2h).** During Work Plan development, the LWG and EPA undertook an extensive scoping process to allow a more focused approach to the RI/FS and associated risk assessments. In addition to developing and maintaining a high level of communication with the EPA Remedial Project Manager and staff, communication between the LWG, DEQ, Natural Resource Trustee agencies, and Tribes was a key element of the initial scoping. The LWG directed its consultant team to meet with EPA's technical support staff to identify issues that will need to be addressed in the RI and risk assessments and to discuss various approaches for addressing those issues.

   Historical data that were available to the LWG were compiled and reviewed for quality and utility in supporting the RI/FS and risk assessments. As part of the data review, DQOs for determining the usefulness of a given historical data set were developed and documented in a technical memorandum to EPA (SEA 2001b). Historical chemical data were compiled for use by all the parties in a relational database for easy retrieval, summarization, or transfer to geographic information systems and other software. Existing data are summarized in Section 4, and additional information is found in the Work Plan appendices described in more detail below.

   A preliminary conceptual site model (CSM) was developed based on the current understanding of the physical and biological characteristics of the ISA. Data gaps that need to be filled during the RI/FS also were identified, including data needed for developing and evaluating remedial alternatives. The preliminary conceptual site model is found in Section 5 of this Work Plan.

   A CSM will be developed that portrays the relationship among sources, chemicals, transport mechanisms (including sediment transport, surface runoff and groundwater discharges to the Site), receptors, and other parameters that are determined to be relevant.

   A CSM will be submitted in accordance with the approved schedule. The purpose of the CSM is to:

   1. Focus sampling.
   2. Gain a better understanding of potential contaminant loadings from upland sources (including direct discharge, overland transport, groundwater and bank erosion) and the relative importance of the various transport mechanisms in different river miles.

3. Identify where there may be continuing sources of contamination and pathways to the river (including persistent bioaccumulative toxins) based on historical site use information, site information and analytical data.
4. Identify historical sources of contamination and pathways to the river.
5. Identify overwater activities that may have released contamination to the Willamette River sediments.
6. Identify areas of the river where recontamination of sediments by upland and other sources is a risk.
7. Gain insight regarding upland source control strategies and help DEQ identify where additional work must be done by responsible parties and DEQ on upland sites.

Updated versions of the CSM will be submitted in the future as additional data are evaluated and the CSM is refined. Data needed to complete the RI/FS are identified in Sections 7 and 8.

Preliminary analytical concentration goals were developed from risk-based screening levels and method reporting limits, and were used to assist in the development of the Round 1 Quality Assurance Project Plan (SEA 2002e) that was approved by EPA (2002a). A technical memorandum providing this information was initially submitted to EPA on January 25, 2002 (SEA 2002c); the memorandum was revised based on EPA comments and resubmitted on April 1, 2002 (Windward et al. 2002).

The Work Plan and companion documents (SOW Subtask 2g) compile the results of the RI/FS scoping process. Field sampling plans (i.e., sampling and analysis plans referenced in Section 4.9.1 of the SOW), and site health and safety plans have been submitted under separate cover.

4. **FS Planning (Box 4, SOW Subtask 2e).** Prior to completion of this Work Plan, tasks to specifically assist in the planning of the FS were undertaken, including the development of preliminary remedial action objectives, methods for ensuring that capping material will meet remedial action objectives, and a process for siting a contaminated sediment disposal facility. These tasks are described in Appendix A.

5. **Early Action Evaluation (Box 5, SOW Subtask 2g).** A draft technical memorandum on Early Actions was submitted to EPA in two earlier drafts of this Work Plan. EPA has directed that this memorandum be removed from the Work Plan, and it is not discussed further in this document.

Implementation of any Early Actions will occur by separate agreement with EPA rather than as part of the AOC for the RI/FS.

6. **Remedial Investigation – Site Characterization (Box 6, SOW Task 5).** The RI will be implemented as an iterative process involving evaluation of risk, use of DQOs to identify data needs, field studies, and data evaluation. The steps taken to assess RI data needs are presented in Section 7. Results of this data evaluation process form the basis of the Round 2 field sampling plans, submitted under separate cover. Currently, four rounds of sampling (i.e., pre-AOC sampling/data and Rounds 1, 2, and 3), as described in Section 6, are anticipated, although the need for additional sampling rounds may be identified later. Consistent with EPA guidance, the goal of the RI is not to eliminate uncertainty, but to reduce it enough to allow sound risk management and remediation decisions.

   For each round of field sampling plans, the DQO process will be used to identify specific decisions and the quality and quantity of data needed to make the decisions. Field sampling plan addenda may also be prepared that describe data collection needed to address the data needs during the same field season. Resulting data will then be analyzed to determine if risk is sufficiently well understood to allow decisions regarding risk management and remedial actions.

7. **Baseline Risk Assessments (Box 7, SOW Task 5).** Draft baseline human health and ecological risk assessments will be prepared following the Round 3 data collection effort. The baseline risk assessments will be based on pre-AOC, Round 1, Round 2, Round 3, and historic Category 1 data, as well as other data agreed to by EPA and the LWG. Following Round 1, an ecological preliminary risk evaluation report will be prepared to help frame data gaps and information needs to complete the baseline ecological risk assessment. The approaches to the ecological and human health risk assessments based on the anticipated RI/FS process are summarized in Section 7 and provided in detail in Appendices B and C, respectively. If needed, modifications to the risk assessment methodologies and procedures presented in this Work Plan will be discussed with EPA and its partners and submitted as technical memoranda.

8. **Feasibility Study (Box 8, SOW Tasks 6, 7, and 8).** The FS will be conducted from the beginning of the overall RI/FS process, as much of the data collected throughout the process (e.g., subsurface coring samples, water samples, sediment physical characteristics, and bathymetry) will be of significant value to the FS. In addition, some preliminary documents have been generated that are primarily concerned with FS-related tasks, including:

- Preliminary Remedial Action Objectives Technical Memorandum
- Disposal Facility Siting Evaluation Technical Memorandum
- Capping Material Evaluation Technical Memorandum
- Natural Attenuation Data Gaps Technical Memorandum.

These memos are provided in the detailed FS approach contained in Appendix A of this Work Plan. The last bullet, Natural Attenuation Data Gaps Technical Memorandum, identifies information needs for evaluating natural attenuation. This issue is addressed several times throughout this document because the Work Plan provides the basis for determining data needs and approaches to collecting those data.

Based on the methods described in the above memos and the requirements of the SOW, the following FS tasks will be conducted during the course of the RI:

- Facility siting evaluation
- Natural attenuation sampling and modeling (in several steps)
- Treatability study literature survey and needs determination
- Refinement of areas and volumes of sediment requiring remediation.

Development of this information in concert with the RI will allow the FS to proceed without delay once the RI and risk assessments have been completed. As the RI is proceeding, the volume and extent of sediments that appear to require remediation will be defined for the FS. As more definitive information is generated by the risk process, these sediment volumes and extents can be further refined and the process of developing remedial areas (i.e., SMAs) and developing remediation alternatives can begin. The development of the remediation alternatives will mark the formal beginning of the FS process and will likely start as the RI and baseline risk assessments are being completed. Areas of localized risk and site-wide risk will be considered in the FS.

There will continue to be considerable interaction between the risk assessors and the FS team during the determination of SMAs and during the evaluation of potential remedial alternatives as the risk team evaluates the risk reductions associated with the various remedial alternatives. Once a set of potential remedial alternatives has been developed for each SMA, the FS will follow CERCLA guidance and evaluate the set of remedial alternatives against the nine CERCLA evaluation criteria. These criteria are summarized in Section 8 and detailed in Appendix A.

1.3.3 RI/FS Data Generation and Reporting

Major components of the RI/FS process will include identifying data needs, developing work plans and possible related addenda to fill data gaps, and generating and evaluating the resulting data. Currently, it is anticipated that these steps will be repeated four times (including the pre-AOC studies conducted in 2001) before the RI and FS are completed. Additional focused data gathering in support of remedial design and remedial action may occur after the ROD. The RI process is both iterative and sequential. Validated results with corresponding sampling location information from previous rounds of investigation will be documented and provided in accordance with the approved project schedule to EPA for review to guide in scoping subsequent rounds of the investigation. The Round 1 data, collected in 2002 and described in greater detail below, will be evaluated in a Round 1 site characterization summary report and an ecological preliminary risk evaluation report (described below), both of which will be submitted within 120 days after the Round 1 data collection and analysis effort is completed. It is anticipated that several Round 2 FSPs will be developed to address the various investigation tasks defined for Round 2 (Section 7).

Validated analytical data will be provided to EPA within 90 days of each sampling activity (e.g., Round 2 surface sediment sampling, Round 2A sediment coring, Round 2B sediment coring, sediment beach sampling, surface water sampling, groundwater pathways sampling, Round 3 sampling and any other sampling activity). As specified in the AOC, and upon request, analytical data will be made available to EPA within 60 days of each sampling activity. Field sampling reports will be prepared and submitted to EPA within 60 days of completing of each sampling activity. The field sampling reports will summarize field sampling activities, including sampling locations (maps), requested sample analyses, sample collection methods, and any deviations from the FSP. Sample analysis results will be reported in tabular format in site characterization reports within 120 days of completing sampling and analysis for each sampling activity. Data will be provided in electronic format showing location medium and results. Data will be provided in sufficient detail for EPA and its partners to begin preliminary analysis.

Round 2 data evaluation results will be presented in the comprehensive site characterization summary and data gaps analysis report (together with pre-AOC and Round 1 data), which is planned for submittal 120 days after the Round 2 data collection and analysis effort is completed. The ecological and human heath baseline risk assessment reports will be submitted concurrently with the RI report, which will be prepared after all sampling and analysis rounds for the project are completed.

The EPA (2000a) DQO process was applied to the existing data (see Section 7). Results of this data evaluation process form the basis of the field sampling plans, submitted under separate cover. A similar data evaluation and DQO process will occur following the evaluation of data generated during Rounds 1 and 2. The DQOs will be updated and focused following the various Round 2 investigation efforts to

incorporate new data. Prior to future sampling events, work plan addenda will be prepared, in which the DQO process will be revisited and the new data needs identified. Field sampling plans will be prepared to address the new sampling needs.

Round 1 sampling was conducted in the summer and fall of 2002, prior to the approval of the Work Plan. Sampling in 2002 was conducted in accordance with the Round 1A and Round 1 field sampling plans (SEA et al. 2002b,c). Round 1A sampling (described in the Round 1A FSP) included:

1. Collection of fish and shellfish tissue for chemical analysis
2. Evaluation of epibenthic colonization using multiplates
3. Reconnaissance survey of plants and amphibians
4. Reconnaissance survey of adult lamprey
5. Measurement of riverbank erosion and accretion using sediment stakes
6. Multibeam bathymetry – low water.

The subset of Round 1 sample collection tasks (described in the Round 1 FSP) that were approved by EPA in September 2002 included:

1. Beach sediment chemistry
2. Reconnaissance-level benthic infauna community analysis
3. Collocated sediment chemistry at sculpin, crayfish and benthic infauna stations.

In September 2002, the LWG also undertook a reconnaissance survey of juvenile lamprey and benthic infauna for potential tissue analysis. Because these were the only data collection efforts in 2002, the combined efforts are referred to simply as "Round 1" sampling in the remainder of this document.

Results of each of these sampling tasks will be submitted to EPA either as stand-alone data reports or as part of the Round 1 Site Characterization Summary Report. A list of all RI/FS project reports and deliverables provided to EPA through September 2003 is presented in Table 1-1.

Round 2 will focus on determining the distribution of chemicals in sediments in the ISA. Also, water quality data will be collected to evaluate potential effects of sources on the river system and to support the risk assessments. These data will be used, along with Round 1 and historic Category 1 results, to identify areas with elevated concentrations of chemicals in the sediments and the water column, and tissue residue levels, so that risk estimates can be made to identify the receptors and pathways that appear to be driving risks at the Site. The derivation of the Round 2 sampling

program, and the associated data uses, are described in detail in Section 7 of this Work Plan.

Round 3 work will be conducted to refine sediment management areas (including principal threats areas, if necessary), gather data for the evaluation of FS alternatives, and fill in risk assessment or RI data gaps, as necessary.

1.4 CULTURAL RESOURCES

The LWG has initiated planning activities for an evaluation of cultural resources and cultural uses using a typical approach provided for under Section 106 of the National Historic Preservation Act (16 USC Section 470). The LWG will coordinate cultural resource work with appropriate tribes to ensure a full and comprehensive cultural resource analysis is done when characterizing Site use. The cultural resource analysis will be initiated in 2004 following receipt of a memorandum from EPA that defines the scope of work and will be considered in future work.

1.5 COMMUNITY RELATIONS

As described in the SOW (Section 5, Task 3), the development and implementation of the plan are the responsibility of EPA.

1.6 WORK PLAN ORGANIZATION

This Work Plan, consisting of 11 sections and seven associated appendices, contains information for the overall implementation of the RI/FS. As approved by EPA in a letter dated April 10, 2002, background information on the Site is provided within the Work Plan and associated appendices instead of in a separate historical data compilation report. Consequently, the body of the Work Plan contains considerable detail on Site background information. Several appendices are also significant documents that include additional data summary information, as well as the ecological risk assessment (ERA) approach, the human health risk assessment (HHRA) approach, and the FS approach. A preliminary CSM is presented in Section 5. Revisions to the CSM will be submitted prior to the development of the Round 2B sediment coring FSP. The Round 1 QAPP (SEA 2002e) for the Site has already been submitted to, and approved by, EPA. A Round 2 QAPP will be prepared, and approved by EPA, before Round 2 sampling activities are conducted. The Health and Safety Plan (SEA 2002d) has also been provided to EPA. Field sampling plans will contain the rationale for sampling, as well as the sampling station locations, numbers of samples, and analytes. They will also contain sampling and analysis methods. The remaining sections of this Work Plan include the following information:

Section 2: Physical Setting. This section discusses the physical attributes of the study area, including hydrogeology, hydrology, bathymetry, and physical characteristics of sediments, sediment transport, and dredging.

Section 3: Chemical Sources. This section describes different types of chemical sources that may affect the ISA, and chemical transport.

Section 4: Summary of Previous Investigations. This section contains an overview of previous sediment, water quality, ecological, and cultural and human use studies. The data quality review process that was applied to the existing chemical and biological data is also discussed in this section. Additional information on ecological receptors is provided in Appendix B (Ecological Risk Assessment Approach).

Section 5: Preliminary Conceptual Site Model. This section presents the physical, ecological, and human health conceptual site models.

Section 6: Overview of Portland Harbor Site RI/FS Process. This section contains the road map for the project, including sections on remedial action objectives, sampling rounds, ecological and human health risk assessment, reporting, feasibility study, and the Record of Decision.

Section 7: Site Characterization Approach. This section contains the DQOs developed for each significant work element, a description of the data needed for those work elements, a description of the RI and risk assessment task work elements, and information on how those data will be used in the RI/FS.

Section 8: Feasibility Study Approach. This section contains the DQOs developed for each significant FS work element, a description of the data needed for those work elements, a description of the FS task work elements, and information on how those data will be used in the FS.

Section 9: Project Management Plan. This section reviews information on how the project will be managed, including roles and responsibilities, contact information, communications, schedules, and cost control.

Section 10: References. This section contains references for the documents cited in the Work Plan.

Section 11: Glossary of Terms. This section contains definitions of terms used in the Work Plan.

As noted above, the following appendices to this Work Plan are, in themselves, significant documents:

Appendix A: Feasibility Study Work Plan. This appendix contains the approach for conducting the FS, as well as the four FS-related technical memoranda required by the AOC. This approach is summarized in Section 8 of this Work Plan.

Appendix B: Ecological Risk Assessment Approach. The ecological risk assessment approach is discussed in detail in Appendix B. A brief overview of the ERA approach is provided in Section 7.3 of this Work Plan.

Appendix C: Human Health Risk Assessment Approach. Similar to Appendix B, Appendix C contains the detailed human health risk assessment approach. A brief overview of the approach is also provided in Section 7.4.

Appendix D: Changes in Sediment Volume. Appendix D contains a series of graphs, organized by river mile, that show net change in sediment volume in Portland Harbor since 1990. These graphs were developed by comparing sequential bathymetric surveys performed in the federal navigation channel by the U.S. Army Corps of Engineers (Corps), Portland District. A description of the process used to generate the graphs is included.

Appendix E: Chemical Sources and Spill Records. This appendix contains information on chemical sources and Oregon Department of Environmental Quality (DEQ) spill records.

Appendix F: Data Sources and QA/QC Reviews. The sources of information compiled to develop the Work Plan are provided in Appendix F. For ease of use, Appendix F is organized by subject. Assessments of data quality assurance/quality control (QA/QC) are also provided for sediment chemistry, water chemistry, tissue chemistry, bioassays, and benthic infauna surveys.

Appendix G: Data Management Plan. This final appendix contains the project Data Management Plan.

2.0 PHYSICAL SETTING

This section describes the physical setting of the Portland Harbor Site, including an understanding of the hydrogeology in the vicinity of the ISA, as well as river hydrology, bathymetry, physical sediment characteristics, fate and transport processes, and dredging history. Each of these factors must be considered in the development of the conceptual site model, future sampling events, and the design of remedial alternatives. This discussion focuses primarily on the physical setting in the ISA and immediately adjacent areas of the Portland Harbor. However, LWR and Willamette basin physical features are also described generally as warranted based on their potential influence on the Site. A corresponding presentation of the ecological setting of the ISA is provided as part of Appendix B (Ecological Risk Assessment Approach).

The Willamette River drains the Willamette basin from the Cascade Range to the Coast Range. The river basin has a drainage area of 11,500 square miles and is bordered by foothills and mountains of the Cascade and Coast ranges up to 10,000 feet high to the south, east, and west (Trimble 1963). The main channel of the Willamette forms in the southern portion of the valley near Eugene, at the convergence of the Middle and Coast forks. It flows through the broad and fertile Willamette Valley region and at Oregon City flows over the Willamette Falls and passes through Portland before joining the Columbia River.

The Willamette flows predominantly from the south to the north and has a total channel length of about 309 miles. It is the 10th largest river in the contiguous United States in terms of volume and the 13th largest in terms of discharge. The portion of the river from the Willamette Falls to the Columbia is considered the lower Willamette River (Map 1-1).

Water velocity in the Willamette is variable, but is generally higher in the upstream reaches of the river. Major tributaries draining the Coast Range and flowing east into the main channel of the Willamette include the Mary's, Luckiamute, Yamhill, and Tualatin rivers. The McKenzie, Calapooia, Santiam, Mollala, and Clackamas rivers flow westward from the Cascades into the Willamette. The Pudding River flows south to north and intersects the Mollala before flowing into the Willamette south of Portland.

The upstream reaches of the Willamette constitute a meandering and, in some cases, braided river channel. Upstream flooding is largely controlled by 13 major tributary reservoirs (Uhrich and Wentz 1999). In the LWR, especially near and around Portland, the channel banks have been stabilized, and the channel itself has been deepened to an authorized depth of –40 feet. These measures have created a stable channel in the LWR. The federally maintained navigation channel defines Portland Harbor and extends upstream from the Columbia River to RM 11.6 (Broadway Bridge) (Map 1-1). From 1973 through 2000, annual mean flow in the Willamette

River flow averaged approximately 33,800 cubic feet per second (cfs) at the Morrison Bridge in Portland.[2]

2.1 HYDROGEOLOGY

The generalized hydrogeology of the ISA is presented in this section. This information represents the current understanding of the general hydrogeologic setting of the ISA. Additional information will be developed during the RI/FS to further the understanding of the hydrogeology of the ISA. The detailed hydrogeology of the upland areas on both sides of the river varies by location. This generalized discussion is intended to describe the important basic hydrogeologic units and their properties and groundwater flow within the ISA and does not completely represent any one particular location. An upland groundwater data review that summarizes information from a review of hydrogeologic and groundwater quality data from upland sites in the vicinity of the ISA has been completed by the LWG. Results of groundwater reviews will be provided in Conceptual Site Model updates.

2.1.1 Geologic Setting

The ISA is located along the southwestern edge of a large geologic structure known as the Portland Basin. The Portland Basin is a bowl-like structure bounded by folded and faulted uplands. These northwest-trending structural zones are interpreted as dextral wrench faults that delineate the Portland, pull-apart basin (Beeson et al. 1985; Yelen and Patton 1991).

The basin has been filled with up to 1,400 feet of alluvial and glacio-fluvial flood deposits between the middle Miocene [approximately 12 million years ago (mya)] and the present. These sediments overlie older (Eocene and Miocene) rocks including the Columbia River Basalt Group (CRBG), Waverly Heights basalt, and older marine sediments. The older rocks are exposed where uplifting has occurred on the margins of the basin, including adjacent to the ISA.

Because the ISA is located at the edge of the basin, both the older rocks and overlying sediments are present near the surface and play a significant role in defining interactions between groundwater and the river. The geologic units found in the area of the ISA are illustrated in Figure 2-1 and briefly described below from youngest to oldest (Beeson et al. 1991; Swanson et al. 1993):

- **Recent Fill.** Fill blankets much of the lowland area next to the river and is predominantly dredged river sediment, including fine sand and silty sand. Hydraulic dredge fill was used to fill portions of the flood plain, such as Doane Lake, Guilds Lake, Kittridge Lake and Mocks Bottom, and a number of sloughs and low-lying

[2] Data obtained from the U.S. Geological Survey Water Resources web site (http://waterdata.usgs.gov/or/nwis/sw).

areas. The fill also was used to connect Swan Island to the east shore of the Willamette River and to elevate or extend the bank along significant lengths of both sides of the riverfront by filling behind silt and clay artificial and natural flood levee dike structures. Rocks, gravel, sand, and silt also were used to fill low-lying upland and bank areas. The thickness of this unit ranges from 0 to 20 or more feet. The permeability of this unit, where composed of clean dredge fill sand, is higher than the natural fine-grained alluvium. The presence of silt fill or a silty matrix in the sand fill generally reduces the permeability of the unit significantly.

- **Fine-grained Pleistocene Flood Deposits and Recent Alluvium (Undifferentiated).** This unit includes fine-grained facies of the Pleistocene Flood Deposits, as well as recent alluvium deposited by the present Willamette River. This unit generally consists of silt, clay, silty sand, and fine to medium sand that borders and underlies the present floodplain of the river (Beeson et al. 1991). The lower portions of this unit and where it forms the large bluffs bordering the east side of the river likely consist of the fine-grained facies of the flood deposits; whereas the upper portions near the river are likely more recent alluvium. The upper fine-grained portion of the unit has likely been reworked and deposited by the present Willamette River. The sands of this unit may be indistinguishable from overlying dredge fill in some places (Landau Associates 2002). The thickness of this unit ranges from 20 to over 100 feet. The permeability of the clay, silt, and silty sand of this unit is generally relatively low, whereas the portions of the unit consisting of clean sands may have a relatively higher permeability. This unit forms part of the Unconsolidated Sedimentary Aquifer regional hydrostratigraphic unit proposed by Swanson et al. (1993).
- **Coarse-grained Pleistocene Flood Deposits (Gravels).** This unit includes fluvial deposits from the Pleistocene Missoula floods. The deposits fill deep channels that were incised into the Troutdale Formation and CRBG during the floods. The unit consists of uncemented sand, gravel, and cobbles with boulders in places. This unit is generally between 10 and 200 feet thick in the vicinity of the ISA and underlies fine-grained flood deposits and recent alluvium under much of the ISA. The Willamette River subsequently incised the flood deposits in places. The rise in sea levels from the end of the Pleistocene to the present created aggradational conditions that resulted in the filling of the incised channel by finer-grained flood and recent alluvial facies to form the current floodplain channel of the river. .

- **Upper Troutdale Formation.** The upper Troutdale Formation in the vicinity of the LWR includes cemented and uncemented alluvial sand, gravel, and cobbles deposited by the ancestral Willamette and Columbia rivers. The Troutdale Formation comprises the Troutdale Gravel Aquifer hydrostratigraphic unit. This unit is present in some places on the west side of the ISA to thicknesses of 100 feet, and is present along the entire length of the east side of the ISA at thicknesses of up to 200 feet (Swanson et al. 1993).
- **Lower Troutdale Formation/Sandy River Mudstone.** The Sandy River Mudstone (SRM) is a fine-grained equivalent (over-bank facies) of the lower Troutdale Formation (channel facies) that overlies the CRBG in the center of the basin and at the margins of the basin away from the axis of the Columbia River. The SRM is present in places under the LWR (Swanson et al. 1993) and borders the Portland Hills, but is not considered a significant hydrogeologic unit within the ISA. The SRM consists mostly of silt and clay with lenses of sand and gravel. The SRM tends toward fine-grained (low permeability) textures at the basin margins (Swanson et al. 1993).
- **Columbia River Basalt Group.** The CRBG consists of a thick sequence of Miocene basalt flows dating from between 17 mya and 6 mya, but the CRBG flows that underlie much of the Portland Basin entered the area between 16.5 mya and 12 mya. Basalt flows of the CRBG were folded and faulted during the uplift of the Tualatin Mountains, concurrent with eruption and emplacement of younger flows present in the Portland Basin (Beeson et al. 1991). The CRBG is present at the surface or at relatively shallow depths along the west side of the ISA and may be in direct contact with the river in places. The top of the unit drops off below ground surface (bgs) over a relatively short distance and is 400 or more feet bgs on the east side of the ISA. The thickness of the CRBG in the vicinity of the ISA is estimated to be approximately 600 feet (Beeson et al. 1991).

2.1.2 Hydrogeologic Units

The geologic units described above can be grouped into ISA-wide hydrogeologic units on the basis of having generally similar hydrogeologic characteristics. Important hydrogeologic characteristics include the position of the groundwater surface relative to each hydrogeologic unit, the physical relationship between each hydrogeologic unit and the river, and physical characteristics of each hydrogeologic unit, such as permeability, heterogeneity, and anisotropy.

These hydrogeological units are described from uppermost to lowermost in the following sections:

Fill, Fine-grained Facies of Flood Deposits, and Recent Alluvium (FFA). The FFA unit is composed of the fill, and the combined fine-grained facies of the Pleistocene flood deposits and Recent alluvium geologic units described by Beeson et al. (1991), and in Section 2.1.1. This unit encompasses a broad range of soil textures and hydraulic characteristics that blankets much of the lowland area next to the river and comprises much of the material abutting the river. The unit consists of the fine sand and silty sand dredge fill overlying recent and Pleistocene silt and clay overbank sediments, which are interbedded with lenses and layers of fine to coarse sand. As discussed in Section 2.1.1, the dredge fill was placed behind low-permeability, artificial and natural flood levee dike structures in some locations. The overall thickness of this unit ranges up to 150 feet; the thickness of the unit more typically ranges between 30 and 100 feet.

The FFA hydrogeologic unit is the primary unit of importance in defining the interactions between upland groundwater and the river because of the following characteristics of the unit:

- The unit forms most of the river channel within the ISA as well as the surrounding upland areas, and therefore controls groundwater interactions with the river.
- Most groundwater chemical plumes present in the upland areas occur within strata of this unit.

The distribution of textures and thus groundwater flow properties of the unit vary both vertically and horizontally by location along the ISA. Silt, clay and silty sand are present adjacent to the river at a majority of locations where the unit is observed near low river stage levels. Boring logs at sites north of RM 4 on the east side of the river indicate that a greater portion of the unit north of RM 4 and at depths below low river stage levels consists of sand layers. Comparison of hydraulic conductivity values for different textures within the FFA unit listed below illustrates the importance of the channel sand lenses and layers in focusing groundwater fluxes to the river at any particular location where present within this unit:

- Silt/clay: 0.005 to 2 feet per day
- Silty Sand: 0.1 to 2 feet per day
- Sand: 0.5 to 30 feet per day.

Typical measured hydraulic conductivities in the silt/clay facies of the FFA indicate that groundwater fluxes from these sediments within the ISA are generally low. Observations of seeps present in silt/clay during the seep reconnaissance survey (GSI 2003b) are consistent with this conclusion. Conversely, groundwater fluxes from the

uplands to the river within the FFA are expected to be greater in those areas where more permeable sand zones are present.

Coarse-grained Flood Deposits and Upper Troutdale Formation (CGF). The CGF unit combines the unconsolidated coarse-facies flood deposits, including sands, gravels and cobbles, with the underlying uncemented and cemented gravels and cobbles of the upper Troutdale Formation. The flood gravels comprising the upper portion of this unit typically occupy scour channel surfaces on older units (e.g., the CRBG). Fill, silt, clay, and sand of the flood deposits and alluvium mostly blanket the CGF, except in places on the highland bluffs on the east side of the river where the unit may be exposed.

The CGF unit is adjacent to and underlies much of the ISA to thicknesses exceeding 200 feet. The overall thickness of the unit is more typically in the range of 100 feet. However, the unit is missing in places, including on the west side of the river towards the south end of the ISA and directly under the river at RM 7. The top of the CGF unit is present at elevations of 0 feet to over -100 feet mean sea level (MSL). The unit is present at relatively shallow depths adjacent to the west side of the river in the vicinity of the Doane Lake area, and may be in contact with river sediments (Figure 2-1). The hydraulic conductivity of this unit measured in the vicinity of the Doane Lake area ranges from 3 feet per day to greater than 40 feet per day (AMEC 2001).

This unit may act as a preferential groundwater flow pathway for groundwater flow to deeper units and for deeper groundwater flow to the river where the unit is present adjacent to the river. Higher fluxes to the river within the CGF unit may increase downward gradients and thus groundwater and contaminant plume movement in the FFA unit. The effect of the CGF unit on groundwater flow in the FFA is a factor in the selection of characterization methods. Locations where the CGF unit may exert a stronger influence on deeper groundwater flow to the river and thus vertical gradients in the FFA include the Doane Lake area, the southern edge of the ISA, and on the east side of the river in the vicinity of the International Terminal.

Lower Troutdale Formation/Sandy River Mudstone. This hydrogeologic unit is present in some places under the west side of the ISA and is present under the entire length of the east side of the ISA. The unit is predominantly silt and clay where explored in the vicinity of the ISA, and thus the permeability of the unit is low. Where present, the unit overlies the CRBG below depths of –100 to –150 feet MSL, and tends to pinch out on the west side and towards the southern end of the ISA where the CRBG is present at shallower depths. The unit typically is separated from the river by at least 100 to 200 feet of alluvium and the upper Troutdale Formation. Based on the hydrogeologic characteristics of this unit and the depth relative to the river, it is not considered to contribute significantly to surface water/groundwater interactions within the ISA.

Columbia River Basalt Group. The CRBG consists of a concordant sequence of basalt lava flows. Groundwater flow in the CRBG is focused along the higher

permeability interflow zones and in some areas of fracture-enhanced permeability (e.g., faults). Hydraulic conductivities measured in individual basalt interflow zones in the vicinity of the ISA range from 1.5 to 10.9 feet per day (AMEC 2001). Hydraulic conductivities measured in CRBG basalt flow interiors at Hanford, Washington, range from 1×10^{-4} to 1×10^{-7} feet per day (Strait and Mercer 1986), illustrating that the basalt interflow zones (flow top and bottom collectively) are the primary groundwater flow pathways in the CRBG.

The CRBG is present at relatively shallow depths along portions of the west side of the ISA and may be in direct contact with the river in places. The top of the unit is irregular on the west side of the ISA with channels from scouring by flood events and the ancestral Willamette River. The top of the unit on the west side of the ISA is between elevation 0 MSL and – 50 feet MSL north of RM 9, except for an ancestral channel in the vicinity of Doane Lake. The top of the CRBG slopes down to an elevation of –250 feet MSL or more across the river on the east side of the ISA (Figure 2-1). The relief of the unit across the ISA appears to be due to structural downwarping towards the center of the basin, and may be accentuated by normal faulting postulated along both sides of the ISA (Beeson et al. 1991; Beeson 2003). The overall significance of the CRBG with regard to groundwater/surface water interactions within the ISA is not known; however, the CRBG is considered for to be most relevant to groundwater interactions with the river on the west side of the river downstream of about RM 9 because of its proximity to the river.

2.1.3 Groundwater Flow

Up to three general groundwater flow systems of interest are recognized along the ISA: a shallow (shallow FFA), an intermediate (deep FFA), and a deep (CGF and CRBG) system. A deeper, regional flow system also is present, which includes the CRBG where it is deep below the river (on the east side of the river) and lower Troutdale Formation/SRM. This deeper, regional flow system is not considered to be important in understanding the critical interactions directly between upland groundwater and the river that are relevant to this RI/FS.

At a local level, these divisions between flow systems are likely indistinct in places along the ISA. Many investigations have focused on the FFA and, in places, the CRBG, and have identified further flow system refinements or divisions based on the local hydrogeology. However, the general flow systems described above appear to apply for the majority of the ISA and provide a basis for evaluating variations from the general model.

The Willamette River is the focus of discharge for the three flow systems of interest to the RI/FS, including where the CRBG is present near the surface on the west side of the river. The shallow flow system is the primary focus of most upland groundwater investigations, and will be the focus of this RI/FS because most of the upland groundwater affected by contaminants of interest is present within this system,

and this system discharges to the shallow and nearshore areas where exposure to human and ecological receptors is most likely. The potential for impact to the deeper system is relatively low, except where there may be a large source of dense non-aqueous phase liquid (DNAPL) that has the potential to migrate to the FFA and/or upper portion of the basalt. Impact to sediments from the shallow and intermediate flow systems will be the focus of the Work Plan effort (described in Section 7), except at locations where the CGF and CRBG appear to be impacted by chemical constituents and are connected to the river.

Shallow Flow System

A shallow, unconfined, groundwater flow system along the margins of the ISA consists mostly of fill and alluvial silt and clay deposits and some medium to coarse-grained channel sand of the shallow FFA that blankets the lowlands next to the river (Figure 2-1). At many locations, the shallow flow system is hosted within the lower portion of fine dredge fill sand and underlying silty sand and silt. The shallow system is recharged by direct precipitation and infiltration, infiltration from the hills on the west side of the ISA, and exchange with several surface water bodies along the ISA (e.g., Doane Lake). Groundwater in this system is unconfined. Groundwater level data in the upland areas indicate that there is a downward gradient toward deeper units from the shallow system. Groundwater levels and fluxes in the shallow system are affected by seasonal river stage changes, as well as by diurnal tidal influences, with decreasing degree of influence with increasing distance from the river and shallower groundwater depths. Groundwater gradients within the shallow system are generally steep immediately adjacent to the river and flatten out away from the riverbank. The shallow flow system discharges to the river as surface seeps and subsurface discharge in near-shore areas.

The permeability of the FFA materials is variable within the shallow flow system, but generally is relatively low. Thus, fluxes to the river from shallow flow system are low. The presence of low-permeability features, such as silt and clay dikes constructed to retain hydraulically emplaced dredge fill, cutoff walls and retaining walls, may act to impede groundwater flow in the shallow system, resulting in higher groundwater levels and steep shallow groundwater gradients near the shore. Because of the generally low permeability of the shallow FFA sediments and the presence of these low-permeability features, preferential pathways (human-made and natural) influence the discharge of groundwater to the river.

Light non-aqueous phase liquid (LNAPL) spills are present only within the shallow flow system. Dissolved chemicals associated with upland releases are present in the shallow flow system. Dissolved plumes may be affected by vertical hydraulic gradients, which may cause vertical migration of the dissolved constituents. The shallow system also appears to influence the effect of DNAPL releases by retaining a portion of the released volume through spreading and retention in or along less permeable sediments. These stratigraphic controls can limit the depth of downward migration of DNAPL.

Intermediate Flow System

The intermediate flow system occurs within thicker sequences of the fine-grained alluvial sediments of the FFA. Groundwater in the intermediate system discharges to the Willamette River below the river surface to deeper portions of the river, with discharge focused at the locations where more permeable strata (typically sand) may intersect the river. Horizontal hydraulic gradients within the intermediate flow system tend to be flatter near the river than the shallow system, and thus high river stages and tidal changes may exert a greater influence on fluxes from the intermediate system to the river by further flattening or perhaps reversing the gradient locally.

The intermediate flow system is particularly relevant for groundwater transport of chemicals to the river where DNAPL is present or where chemical densities, preferential pathways, or downward gradients could potentially allow dissolved chemical constituents to penetrate into the deeper units. The intermediate flow system is the most likely mechanism that would allow for groundwater discharge into the sediments present in the deeper portions of the Willamette River. However, most groundwater chemical plumes identified in the upland areas of the ISA do not occur within the intermediate flow system.

Deep Flow System

The deep flow system occurs within the CGF and basalt interflow zones of the CRBG where the CRBG is present near the surface on the west side of the river. Groundwater in the deep system discharges to the Willamette River only in deeper portions of the river, with discharges focused at the locations where the gravels and/or basalt interflow zones are near or intersect the river sediments (Figure 2-1).

The CRBG ceases to play a role in this flow system on the east side of the river. The flow system becomes strongly affected by the Columbia River on the east side of the ISA with increasing distance from the Willamette River. The CGF is generally highly transmissive; however, gradients may be relatively low. Seasonal gradient reversals are known to occur during periods of high river stages. Where near the river, the connection and thus response to river stage changes is expected to be great.

The deep flow system is not anticipated to play a significant role in groundwater contaminant transport from the upland areas to the river within the ISA because the majority of contaminants in groundwater are not present within this system.

2.1.4 Processes Governing Discharge of Groundwater to the ISA

Generally, groundwater flow adjacent to the ISA is toward the river. In the absence of preferential pathways, groundwater flow to the sediments and river will be diffuse along the length of the interface of each flow system with the river. However, permeability contrasts of several orders of magnitude can be expected in the FFA where alluvial processes create lenses and channels of sand within or surrounding finer-grained materials. The result of these permeability contrasts is that groundwater

discharge will tend to be heavily influenced by the location and geometry of higher permeability layers (e.g., sands) in relation to the river.

Discharge from the shallow water-table groundwater system will tend to be focused at or below the river/shore interface. Low river stages expose zones of focused discharge as seeps along the bank where the shallow groundwater surface intersects the ground surface. Preferential pathways, including coarse backfill (e.g., around utilities), historic stream channels, or sand/gravel layers focus groundwater flow, particularly where they occur in predominantly fine-grained sediment sequences in the shallow groundwater system. The majority of discharge to the river generally occurs where these preferential pathways intersect the riverbank. Full gradient reversals between the river and the shallow groundwater system are rare and likely localized near the bank because of the relatively high groundwater levels within the shallow groundwater system in the upland areas and resultant steep hydraulic gradients along the riverbank. However, very high river stages tend to reduce and may, in some areas, even temporarily reverse the shallow groundwater gradient locally. The groundwater flow regimes of all of the flow systems show seasonal patterns related to seasonal river stage and precipitation variations.

The gradient and resultant flux from these systems fluctuate with seasonal river stage changes, with temporary flow reversals occurring during seasonal high river stage events. Diurnal stage changes also result in temporary gradient and thus flow changes, particularly where the degree of connection between the river and adjacent aquifer is greater. Discharge of these deeper groundwater flow systems through the river sediments to surface water is controlled by (1) the permeability contrast between the sediments and underlying aquifer, and (2) the difference between the hydraulic head in groundwater at the aquifer/sediment interface and the river stage, which determines hydraulic gradient.

2.1.5 Groundwater/Surface Water Transition Zone

The groundwater/surface water transition zone (Transition Zone) is the interval where both groundwater and surface water comprise some percentage of the water occupying pore space in the sediments. The physical and biochemical properties of water within the Transition Zone reflect the effects of mixing between groundwater and surface water that occurs within the sediments. The Transition Zone is significant to the RI/FS because it is the location where important chemical and biological transformation processes occur that affect the properties of chemicals that may be present in groundwater, and it encompasses the sediment bioactive zone where benthic infaunal ecological receptors reside.

The zone of mixing between groundwater and surface water that defines the size of the Transition Zone exhibits temporal and spatial variability due to changes in gradients between the surface water and groundwater. The depth and degree of mixing is anticipated to be relatively small in shallow river sediments that are in

contact with the shallow groundwater flow system. In these areas, relatively high groundwater hydraulic heads within the shallow groundwater flow system adjacent to the river dominate the river stage fluctuations. High river stages will change the relative hydraulic gradient and thus reduce the discharge rate from the shallow groundwater flow system through the sediments, but will not likely result in a significant overall increase in the depth of mixing of surface water with groundwater. Groundwater is expected to comprise a greater percentage of the water in the shallower water bioactive zone than deeper water locations where the deeper flow systems discharge to the river.

2.2 HYDROLOGY

River stage and currents in the LWR and Portland Harbor are influenced by hydrologic conditions in both the Willamette and Columbia rivers, and are further affected by the operations of federal and non-federal dams along these two rivers. River stage refers to the height of the river measured relative to a specific elevation or "datum." A variety of vertical datums are used in the Portland Harbor region, and these are discussed below. Definitions of regional datums and other hydrologic terms are also included in the Glossary of Terms (Section 11).

2.2.1 Regional Datums

Current or historical bathymetric and topographic data may be referenced to a variety of vertical datums in Portland Harbor. The bathymetric data collected as a part of this RI/FS are presented relative to the **North American Vertical Datum of 1988 (NAVD88)**. This vertical datum is the national standard geodetic reference for heights and was selected for this project because it is a level datum and is easy to use with global positioning systems (GPS). NAVD88 is a fixed datum derived from local mean sea level observations at Father Point/Rimouski, Quebec, Canada. NAVD88 replaced NGVD29/47 as the national standard geodetic reference for heights.

The **National Geodetic Vertical Datum of 1929 through the Pacific Northwest Supplemental Adjustment of 1947 (NGVD29/47)** is a fixed datum adopted and adjusted in 1947 as a national standard geodetic reference for heights prior to June 24, 1993 and is now considered superseded by NAVD88. NGVD29 is sometimes referred to as Sea Level Datum of 1929 or as MSL on some early issues of U.S.Geological Survey topographic quads. NGVD 29 was originally derived from observations at 26 long-term tide stations in the U.S. and Canada. Data referencing MSL as the vertical datum in the Portland Harbor is technically on NGVD29/47.

The **Columbia River Datum (CRD)** is used as the chart datum for the lower Willamette River. CRD is a reference plane established by the Corps in 1912 by observing low water elevations at various points along the Columbia and Willamette

rivers (USACE 1966). Consequently, the CRD is not a fixed/level datum but slopes upward as one moves upstream. The CRD is used upstream of RM 24 on the Columbia to the Bonneville Dam and on the Willamette River to Willamette Falls. Mariners can obtain the depth on a chart and apply tide or river-level gauge readings, relative to CRD to compute actual water depth at the time of sailing. Low water values are used for navigation charting to provide conservative depth values in the event accurate tide data are not available to the mariner.

These three datums, NAVD88, NGVD29/47, and CRD, are the major ones used on maps and charts of Portland Harbor. The relationships or conversion factors between them are shown in Table 2-1 for the LWR to about RM 16 (Ross Island). This conversion table is also included on all LWG project bathymetry maps. In the lower Willamette, elevations reported relative to the CRD are approximately 5 feet less than NAVD88 elevations (e.g., the –15 foot NAVD88 contour on LWG bathymetry maps equates to a –20 foot CRD elevation).

Water level (river stage) data measured by the Morrison Bridge gauge (RM 12.8) are recorded as the **Portland River Datum (PRD)** and are 1.55 feet above NGVD29/47 (USACE 1991). The CRD is 1.85 feet above NGVD29/47 at the Morrison Bridge. On December 27, 2001, David Evans and Associates, Inc. (DEA) confirmed the relationship between this gauge and the CRD by running a differential leveling circuit from a nearby control monument used in the control network for the Willamette multibeam surveys. This survey confirmed that the Morrison Street staff gauge reports water levels 0.30 foot above CRD, as defined by the Corps (1991).

The river stages discussed below in Section 2.2.2 are the directly measured Morrison Bridge gauge levels and are therefore reported as PRD elevations in feet. To convert from PRD to CRD, subtract 0.3 foot from the reported river level.

2.2.2 Willamette River Stages

The Columbia River drains a large segment of the northwestern United States and parts of western Canada. The basin is so large that isolated events such as rainstorms may have little or no effect on river flow. In its natural state, high flows on the Columbia River are most influenced by snow melt, which takes place in the basin during the spring months. This results in high water typically occurring in late May or early June followed by receding water levels until the rains begin in late fall.

Lowest water on the Columbia River typically occurs in the months of October or early November, reflecting a lack of precipitation and snowmelt in the basin during the summer months. With the onset of winter rains and snow, runoff will vary during the winter months until the snowmelt takes place in the spring leading to the high water period described above.

The Willamette River is a major tributary of the Columbia River and flows into the river at Columbia River mile 103. Lowest water in the Willamette, as in the Columbia, typically occurs between September and early November prior to the initiation of the winter rains. With the onset of the rains, flows in the Willamette will generally increase, sometimes in rapid (several days) response to regional storms. The record winter floods (e.g., 1964 and 1996) occurred when a period of heavy snowfall at lower elevations was followed by a period of warming and heavy rains. The combination of the snowmelt and rain leads to exceptionally high runoff that occurs rapidly due to the small size of the basin as compared, for example, with the Columbia River basin.

Figure 2-2 shows plots of the mean daily river stage data (reported in feet, PRD) measured by the U.S. Geological Survey (USGS) gauge (#14211720) on the Morrison Bridge in Portland near RM 12.8, from 1973 through mid-August 2003[3]. The seasonal water level trends described above are evident in these plots. Low water typically occurs during the regional dry season from August to November. Winter (November to March) river stage is relatively high but variable due to short-term changes in precipitation levels in the Willamette basin. Finally, a distinct and persistent period of relative high water occurs from late May through June when Willamette River flow into the Columbia is slowed during the spring freshet by high-water stage in the Columbia River.

The effect of the multipurpose dams on the Columbia River and its tributaries has been to generally reduce the spring high water flows through ponding of the excess water to the extent permitted by the capacity of the reservoirs at each of the dams. Starting in late summer, this stored water is released, which increases flows above the low flows that would otherwise occur. By winter, these reservoirs have been drawn down and the reservoir capacity is used to take the peak off of winter flows and to optimize the generation of electricity.

There are 13 federal reservoirs on the Willamette River and its tributaries, having a combined storage capacity of over 1.6 million acre-feet. These reservoirs reduce the river flow during the winter snow and rain events by storing water (Table 2-2). With each major storm, water is stored and then released at the end of the storm to smooth out the flow of the river. During persistent rainy periods and/or during exceptionally large precipitation events, the storage capacity may be exceeded, and additional flow entering the system leads to flooding as occurred in 1964 and 1996. During these flood events, water flow in the river can be up to 50 times greater than the flow during low-water periods. Late in the winter, after the probability of a major flooding event has passed, the reservoirs are filled to capacity. These reservoirs are used for

[3] Data obtained from the U.S. Army Corps of Engineers (Portland District) Reservoir Regulation and Water Quality Section web site (http://www.nwd-wc.usace.army.mil/cgi-bin/DataQuery). This site notes that these "data have not been verified and may contain bad and/or missing data and are only provisional and subject to revision and significant change." The data are used here only to illustrate long-term relative trends in the Willamette River stage at Portland. No data were available for 1991 and 1992.

recreation during the summer and are drawn down in the fall to supplement natural low flows and to provide storage capacity in preparation for the flood season.

Water levels and currents in the LWR can be influenced by the Columbia River in several ways. The most apparent influence occurs during spring when high flows from the Columbia River increase the hydraulic head at the confluence of the two rivers and causes the Willamette River flow to be detained (Figure 2-2). When this occurs, currents in the Willamette are much reduced due to the elevated river stage in the Columbia River. As the Columbia River drops, the Willamette water level will also drop and flows will increase to more typical conditions.

A less obvious influence can occur in the winter when the Willamette River is in flood. The flows on the Columbia River can be held back by its dam system, which has the effect of lowering the backwater effect of the Columbia and thus dropping the levels in Portland Harbor below their typical condition. This mechanism was used in the 1996 flood to reduce the flood levels of the Willamette in Portland Harbor.

Compounding the complexity of the influence of two separate river systems and drainage basins, the Portland Harbor reach is also affected by tidal action. The tidal range at the Pacific Ocean is approximately 8 feet and there are two high tides and two low tides daily. The tidal "wave" comes up the river and when the Willamette River is at a low stage, the tidal action can influence river levels by up to 3 feet in Portland Harbor. These tidal fluctuations can result in upstream flows in the Portland Harbor during times of extreme low discharge combined with a large variation in tide levels, which can occur in late summer to early fall**.** As river stage rises, the tidal effect is gradually dampened and disappears at river levels around 10 feet CRD.

2.2.3 Willamette River Flows

Velocity data for the LWR consist mainly of data collected over the years by the USGS. The USGS report, Water Discharge Determinations for the Tidal Reach of the Willamette River from Ross Island Bridge to Mile 10.3, Portland, Oregon, (Dempster and Lutz 1968), mentions a total of 127 discharge measurements that were conducted during the period from July 1962 to January 1965. The USGS measured velocities using a Price current meter suspended from the Broadway Bridge near RM 11.7 and the Ross Island Bridge near RM 14 (see Map 1-1). Stream flow conditions varied from low tidal-affected flows to the near maximum flood of record during December 1964. Measured cross-sectional mean velocities ranged from a maximum of 8 feet/second downstream during the December 1964 flood to a low upstream velocity of nearly 1 foot/second during a tidal cycle on October 15-16, 1963 (Demptser and Lutz 1968).

From October 1972 to September 1994, the USGS maintained an acoustic velocity meter with water stage and velocity index recorder at the Morrison Bridge gauge near RM 12.8. During that time period, rating curves were periodically updated with

velocity measurements at the gauge location over a range of flow conditions. Since October 1994, the gauge has been jointly operated with the Corps and measures unverified stage only (Lee 2002).

On January 14, 2000, the USGS collected isolated transects of velocity data using a vessel-mounted Acoustic Doppler Current Profiler (ADCP). Transects were collected upstream of the ISA in a relatively narrow stretch of the river at RM 12.8 (just downstream of the Morrison Bridge; see Map 1-1), and in a broader stretch of the river in the ISA near RM 4.1 (Barrett 2002; Wood 2002). According to the upstream Morrison Bridge gauge, the estimated discharge for January 14, 2000 was 99,000 cfs.

Additional ADCP data were collected by DEA for the LWG during a high water event on April 19, 2002 (DEA 2002b). The ADCP was mounted on a 30-foot survey vessel, and transects were taken at RMs 1, 2, 2.5, 3.1 (Multnomah Channel), 4, 4.6 (into T-4 Slip 3), 5.8 (St. John's Bridge), 6.3 (off Gasco), 6.8 (into Willamette Cove), 7.8 (off Willbridge Terminal), 8 (from Coast Guard Station, across shipyard to west bank), Swan Island Lagoon (2 short transects - one across mouth, one at upper end), 9.6, 10, and 11 (see Map 1-1). The river stage at the time of the data collection was approximately 11.6 feet CRD at the Morrison Street Bridge (DEA 2002b).

Water velocities obtained from the ADCP survey ranged from an upstream velocity of nearly 1 feet/second (upstream flow in back eddy) to a downstream velocity of 2 feet/second. Flows across the transects were computed at approximately 70,000 cfs above Multnomah Channel and approximately 35,000 cfs below Multnomah Channel. The Willamette flow on April 19, 2002 was roughly double the average Willamette discharge rate of about 32,000 cfs. Table 2-3 summarizes ADCP transect time, location, and approximate total flow.

Figure 2-3 presents historical daily mean flows from USGS gauge #14211720 located at the Morrison Street Bridge on the Willamette River in Portland. Data from October 1972 to September 1994 were computed using velocity measurements from an acoustic velocity meter. Data after September 1994 are based on estimated flows by the USGS. No estimates were located after 2001. The USGS plans to install an acoustic velocity meter on the Morrison Street Bridge during the 2003 water year, which should be operational by summer 2003 (Kittelson 2003).

Figure 2-3 references the 70,000-cfs flow under which the 2002 ADCP survey was conducted. Average flow ranges from 58,000 cfs in winter (December through March) to 9,000 cfs in late summer (July and August). Peak events can trigger flows in excess of 150,000 cfs, with maximum flows over 400,000 cfs (1996 winter flood).

Figure 2-4 is a vector plot of the water-column-averaged velocity, magnitude, and direction at transect 4 at RM 3.1, located at the entrance to the Multnomah Channel. Figure 2-5a illustrates a color plot of the velocity magnitude, and Figure 2-5b presents the projected velocity perpendicular to the transect. These data indicate that close to

one-half of the total flow (35,000 cfs) was being diverted down Multnomah Channel during the ADCP measurement period.

Parameters that would affect total flows and the amount of flow diverted down Multnomah Channel include relative stage of the tides in St. Helens and Portland, flow in the Columbia River, and Willamette River flow into the Portland Harbor. The velocity depicted in Figure 2-5b is the result of only using the velocity component perpendicular to the transect. This is further illustrated by the vector plot in Figure 2-4, which depicts the diversion of flow into Multnomah Channel. Flow into the Multnomah is likely greatest when low river stages at St. Helens and the Columbia correspond with high stages in the Willamette; this was the situation during the ADCP survey on April 19, 2002. It is unclear how often this occurs, but the inter actions of these factors over time will be evaluated as part of the hydrodynamic modeling of the system. Figure 2-5b also reveals some variation in velocity with depth in the shallow water entrance to Multnomah Channel on the west side of the river and a back eddy effect on the east bank.

Figure 2-6a presents ADCP data at transect 11 at RM 8, just downstream of Swan Island and the Portland Shipyard. Both the vector plot (Figure 2-6a) and velocity profile (Figure 2-6b) reveal a sharp drop in velocity behind Swan Island and a small back eddy into Swan Island Lagoon. The velocity profile in Figure 2-6b also illustrates some vertical structure with increased flows in the upper water column in mid-channel.

Figure 2-7a presents the measured ADCP data at transect 14 at RM 9.6 across the deep dredged hole off of Swan Island. An increase in the water column average velocities can be seen in Figure 2-7b. A back eddy can be observed in both the vector plot and the velocity profile. The velocity profile also shows strong near-bottom velocities in the hole with increased velocity toward the water surface.

2.3 BATHYMETRY

As part of the pre-AOC RI/FS studies, a multibeam bathymetric survey was conducted of the LWR from the confluence with the Columbia River to RM 15.6 (upstream end of Ross Island; see Map 1-1). The primary goal of the survey was to develop an accurate, baseline, riverbed elevation database for this portion of the LWR. This precise bank-to-bank bathymetric survey was conducted by DEA between December 13, 2001 and January 14, 2002, during the winter period of relatively high water. The vertical accuracy of the water depth measurements was specified at less than or equal to 0.5 foot (NAVD88), and the horizontal accuracy was set at less than or equal to 1 meter. The data were processed using a 1-meter grid size to generate a digital terrain model, and the survey results were plotted in both hillshade and contour formats. A bathymetry report detailing the methods used and the survey results has been provided to EPA under separate cover (DEA 2002a).

Map 2-2 provides a summary of the baseline bathymetric survey results and shows LWR bed elevations as of January 2002. [Higher resolution maps are provided in DEA (2002a).] From RM 0 to 11.6 (Portland Harbor), elevations in the federal navigation channel are generally 40 to 50 feet in depth. Several deep holes, particularly off Terminal 4 and Swan Island, reach 70+ feet in depth; these are borrow areas dredged in the past to provide fill to create the adjacent uplands. Most of the ISA is characterized by relatively steep slopes from the riverbank to the authorized channel depth (- 40 feet). The broadest gradually sloping areas that extend from 0- to about 30-foot depth occur off Sauvie Island from RM 0 to the Multnomah Channel, at the head of Swan Island Lagoon, and along the west side of the river between Willbridge Terminals and Terminal 2. Upstream of the federal channel, river bed elevations are more variable and generally follow the river bed morphology, with the deeper areas (40+ feet) occurring on the outside of the river bends and scour features evident downstream of the downtown Portland bridge footings. The side channel east of Ross Island Lagoon is a relatively shallow area (< 20 feet), while the main channel west of Ross Island extends to 60-foot depth in places.

A second bathymetry survey was conducted in the summer of 2002 (DEA 2003). Comparison of the time-series bathymetry survey results allows areas of riverbed that shoaled or scoured between December 2001 and September 2002 to be identified. These results are presented and discussed in Section 2.6.

2.4 PHYSICAL CHARACTERISTICS OF SEDIMENTS

The physical properties of sediments yield significant information regarding the physical dynamics of the river system. Coarse-grained sediments are generally found in erosional areas where water currents remove fine particles from the sediment, while fine-grained sediments typically occur in depositional areas where water velocities are low enough to enable the settling of fine-grained particles.

Grain-size distribution of sediments throughout the LWR was measured in September 2000 during a Sediment Trend Analysis (STA®) survey (Map 2-3) (GeoSea Consulting 2001). Surface sediment sampling was attempted at 935 locations from the Willamette Falls at RM 26.5 downstream and into the Columbia River. Of the 935 sampling stations, 99 were classified as "hard ground," meaning sediments could not be collected after three casts of the grab sampler. As noted by the authors, the actual ground may not have been hard (i.e., bedrock), but rocks and other debris may have prevented the grab sampler from closing.

The distribution of sediment grain sizes in the LWR from this survey shows a predominance of "hard ground" in the upstream reaches of the river south of Ross Island. This pattern may be due to outcroppings of Columbia River basalts in the riverbed in that region (GeoSea Consulting 2001), as well as increased flow velocities due to a smaller cross-sectional area of the river as compared with the ISA. Natural

sediment composition in the LWR is variable. Sand and gravel particles are predominantly quartz, feldspar, or lithic fragments. Lithic fragments are typically basalt.

The grain-size distribution of sediments in the LWR becomes finer downstream, especially where the river widens and/or where water has an opportunity to pool. In general, sandy sediments dominate the riverbed upstream of RM 11, while surface sediments below RM 10 are predominantly silt (Map 2-3). Surface sediment texture between RM 10 and 11 is transitional between the upstream sandy and downstream silty areas. In general, silts dominate surface sediments in Portland Harbor, with localized areas of sandier material occurring at narrower portions of the river, such as in the navigation channel between RM 5 and 7, and at the mouth of the Willamette River where Columbia River sands may be moving into the LWR. Sheltered areas throughout the LWR, such as the Ross Island and Swan Island lagoons, are generally characterized by finer-grained sediments than the adjacent main channel. Some coarser sediments are found near bridge supports in some nearshore or berthing areas; these are likely the result of vessel propeller wash (prop wash). As part of the LWG's pre-AOC studies for this RI/FS, a December 2001 sediment-profile imaging survey of the Willamette River from Ross Island to the Columbia River documented similar grain-size distribution patterns in this stretch of the river (SEA 2002f; see Section 2.5).

2.5 SEDIMENT TRANSPORT AND TRANSPORT REGIMES

River currents, vessel movements, wave activity, and the supply of sediment affect sediment transport in the LWR. Finer-grained sediments (silts and clays) have lower settling velocities and thus tend to remain suspended in the water column longer than coarser-grained materials (ASCE 1975). The quantity of suspended sediment load varies seasonally, with higher quantities delivered by storm or high flow events. USGS measures suspended sediment concentrations at the Morrison Bridge (RM 12.6) gauge approximately once a month, in addition to a few surveys have been conducted at various locations in the Portland Harbor during specific high flow events (Lee 2002).

Figure 2-8 is a composite of long-term suspended sediment data collected at the Morrison Bridge and some short-term, high-flow, suspended sediments measurements upstream of the St. Johns Bridge, which depicts the tendency for increased sediment concentrations in the water column during high flow events. In general, however, the Willamette has relatively low suspended loading during most flow conditions. Furthermore, most of the suspended sediments coming into the Portland Harbor are relatively fine-grained. Some percentage of the sediments remains in suspension and passes through the Portland Harbor, while the remainder tends to settle in depositional areas. Subsequent redistribution of sediments may occur more through bedload transport than by erosion, resuspension, transport, and deposition.

Depending upon the hydraulic conditions during high water events, sediments can be deposited, transported through, or scoured in the lower harbor. For example, with a high Willamette River discharge and a low Columbia River stage, velocities through the Portland Harbor will be high, and critical transport velocities of fine-grained sediments will be exceeded, thus transporting material downstream either as bedload or as resuspended sediments in the water column. Conversely, if the high discharge event on the Willamette River is coincident with a high stage on the Columbia, the velocities in the Portland Harbor will be lower, and suspended or bedload sediments entering the harbor are likely deposited there. Localized and sporadic anthropogenic disturbance or riverbed sediments (e.g., dredging, prop wash) provide an additional mechanism of reintroducing sediments into the water column. Their transport fate would be a function of LWR flows at the time of their disturbance.

A review of a series of historic bathymetric survey overlays of the navigation channel (RM 0 to 11.6), conducted two to three times annually from August 1990 to May 2001 by the Corps, Portland District, indicates that, as expected, channel riverbed elevations are variable in places (Map 2-4). The locations of federal and private dredging areas are also shown on this map, and significant deposition within these deeper areas is evident over time (e.g., near RM 11, between RM 9 and 10, near RM 5, and between RM 2 and 3). The historic bathymetric data evaluation also estimated change in sediment volume by river mile from survey to survey. These results are graphed and presented for all river miles in Appendix D. Figure 2-9 shows the volume changes over time for two segments, RM 4 to 5 and RM 7 to 8. These approximations suggest that a significant volume of sediments is deposited and subsequently transported from different portions of the navigation channel over time.

Although a few models have been developed to analyze water levels, velocities, and water quality in the LWR, no numerical models have been developed for Portland Harbor to specifically examine sediment transport.[4] The September 2000 STA® (GeoSea Consulting 2001), however, provides a broad-scale picture of sediment movement from the Willamette Falls downstream to the river's convergence with the Columbia. The STA® methodology statistically examines the relative changes in grain-size distributions that occur along transport paths. Maps are produced that indicate the patterns of sediment transport and areas of erosion, equilibrium, and accretion (Map 2-5).

The STA® analysis concluded that sediments in transport or those discharged from outfalls into the system from Willamette Falls downstream to about the Fremont Bridge (RM 11) are essentially in dynamic equilibrium or "conveyor-belt" movement downstream (Map 2-5). Below the Fremont Bridge, sediments are finer and the transport environment becomes depositional. The analysis concluded that the main stem of the river between RMs 7 to 10 is a depositional sink for sediments.

[4] The LWG is planning to develop a hydrodynamic and sediment transport model of the LWR as part of this RI/FS (see Section 2.6.2).

Downstream of this reach from about RMs 7 to 3.5, another conveyor-belt sediment transport regime is present. From RMs 3.5 to 1, the transport environment is classified as a mixed case (i.e., there are alternating periods of deposition and erosion). Finally, where the Willamette enters the Columbia River system at RMs 0 to 1, the STA® analysis suggests that dynamic equilibrium and/or erosion dominate this portion of the river.

The STA® analysis infers sediment transport dynamics from surface sediment grain-size distributions for the time frame represented by the surface grab samples, which is unknown and likely varies spatially throughout the system. The effects of infrequent, large-scale events, such as 10+ year floods, on sediment movement within and out of the LWR have not been described, although the historical data shown in Figure 2-9 and Appendix D suggest that the February 1996 flood event resulted in significant deposition of sediments in many portions of the navigation channel.

The results of STA® survey and the historic bathymetric data evaluations were compared in SEA (2002b). This comparison was limited to the navigation channel within the ISA and reached the following conclusions:

- The channel in the ISA from approximately RM 9 to approximately RM 7 is a net depositional area, while the rest of the ISA channel area (from RMs 7 to 3.5) is predominantly a system that is in dynamic equilibrium, with localized areas of deposition and erosion.
- Deposition rates in depressions and in the depositional area from RMs 7 to 9 consistently fall between the range of 0.5 to 1 foot /year; most of this deposition occurs in bathymetric lows (commonly associated with dredging or borrow areas) and along the inside bends of the river.
- Erosion is most consistent outside of the ISA, but occurs within the ISA in localized areas such as along the outside bends of the river. Episodic erosion occurs based on short-term hydrologic events; however, periodic dredging can obscure actual events of erosion in the bathymetric depth difference analysis.

Two other pre-AOC efforts, the December 2001 multibeam bathymetric survey and sediment-profile image (SPI) surveys (DEA 2002a; SEA 2002f) from Ross Island to the Columbia River, provide results that are consistent with the broad sediment movement patterns described by the STA®/bathymetry data comparison. In addition, these results provide information on surface sediment dynamics in areas beyond the ISA and in particular, in shallow, nearshore areas outside of the navigation channel. Based on the mapped SPI/bathymetry results, eight major benthic condition zones were defined in the Willamette from Ross Island downstream (Map 2-6).

Seven of these zones occur upstream to downstream in the main stem or channel of the river (deeper than –20 feet CRD), where the sediment transport regime appears primarily controlled by physical factors, specifically river shape, width, and flow. These factors appear to govern the types of sediments seen within the main channel, substrate stability and heterogeneity, and possibly the soft-bottom benthic community structure. The eighth zone, which occurs in nearshore areas (all areas shallower than –20-foot-depth CRD along both margins of the river), represents areas in which the conditions observed at any particular location vary as a function of small-scale variations in river morphology/dynamics, bank treatments, and river use. The general characteristics of each benthic zone delimited in Map 2-6 are shown in Table 2-4.

Overall, the evaluation of historic bathymetry data and the results of the STA® and SPI surveys produce a consistent picture of sediment transport regimes in Portland Harbor. These data and the direct measurements of elevation changes discussed below form the basis of portions of the physical CSM detailed in Section 5, and provide an important foundation for scoping key elements of the RI such as the distribution of chemicals in sediments.

2.6 RIVERBED ELEVATION CHANGES (2001-2002)

The second bathymetric survey conducted by DEA in the summer of 2002 was to directly measure seasonal changes in riverbed elevations that had occurred since the previous winter (DEA 2003). The survey was conducted in two phases: RMs 2 to 11 were surveyed between July 3 and 18, 2002, and RMs 0 to 2 and RMs 11 to 15.6 were surveyed between September 16 and 20, 2002. The summer 2002 data were processed in the same manner as the winter 2001/2002 data (Section 2.3) and updated contour and hillshade maps were generated. In addition, a set of elevation difference maps that show the riverbed elevation changes that occurred over the 9-month period from December 2001 to September 2002 were generated (Map 2-7a-k).

As shown in Map 2-7, the elevation change maps were created by overlaying the 1-meter cells from each survey and subtracting the winter 2001/2002 data from the summer 2002 data to generate a direction and magnitude of change for each cell. The vertical resolution of the multibeam survey overlay was +/– 0.25 foot, so cell comparisons that show positive or negative change less than or equal to 0.25 foot represent no discernable change in riverbed elevation.[5] Because the winter 2001/2002 data were subtracted from the summer 2002 data, negative elevation changes (shallower in summer compared to the previous winter) indicate shoaling and positive elevation changes (deeper in summer compared to the previous winter) indicate deepening. In Map 2-7, the no-change areas are shaded gray, while shoaling

[5] The survey vertical accuracy specification of ≤ 0.5 foot was exceeded for both individual surveys. An analysis of bathymetric change data indicated that the vertical resolution of the survey overlay was ± 0.25 foot for approximately 80% of the data (DEA 2003). Therefore, this interval was used as the no-change category.

areas (negative change) are shown in yellow to orange shades, and areas that deepened (positive change) are shown in blue shades.

As shown in Maps 2-7a-k, sediment accretion and erosion occurred in various parts of the LWR between December 2001 and September 2002. Some general sediment movement patterns include:

- Areas of shoaling and deepening occur more frequently in off-channel, shallow nearshore areas than in the main navigation channel.
- River zones that were inferred to be higher energy zones based on the STA® and SPI summarized above (e.g., above RM 12 and between RMs 5-7) show numerous small-scale changes from bank-to-bank.
- Zones that were inferred to be lower energy (e.g., RMs 3-5, 7-9) show fewer small-scale changes in the channel.
- In some places, bedforms (e.g., at RM 5-6 and RM 11-12) can be seen propagating downstream (alternating high and low spots).
- Deposition or in-filling of some former in-channel dredged or borrow areas (e.g., at RMs 2, 5.2, and 9-10) is evident.
- The most extensive stretch of nearshore deepening extends along the west side of the river from RMs 0 to 3; this appears to be a natural sediment erosion pattern.
- The most extensive stretch of nearshore shoaling extends along the west side of the river from RM 4 to 5; this appears to be a natural sediment shoaling area.
- Bridge footings create localized areas of deep scour and accretion (e.g., the Railroad Bridge at RM 7).
- Many areas of deepening appear to be closely associated with pier structures, berthing areas, and slips (e.g., Terminal 4, Portland Shipyard, Willbridge Terminals); it is likely that much of this sediment movement is the result of anthropogenic factors (e.g., prop wash).
- Some recently dredged areas (e.g., at RM 10 off Terminal 2) are evident.

2.6.1 Patterns in the Distribution of Shoaling and Deepening Areas in 2002

The bathymetry change data shown in Map 2-7 are tabulated by river mile in Table 2-5a for shallow nearshore areas and in Table 2-5b for the deeper main channel areas. The definition of the nearshore and channel areas is based on the results of the

December 2001 SPI survey (SEA 2002f). As indicated in Section 2.5, the sediment transport regimes inferred from the SPI results in the deeper portions of Portland Harbor (navigation channel and lower channel slopes) differed notably from those inferred for the nearshore areas (upper channel slopes, off-channel benches and beaches). The division between these "channel" and "nearshore" areas was delineated by the –15-foot NAVD88 contour that equates approximately to the –20-foot CRD contour in the survey area. The nearshore area defined by the NAVD88 15-foot contour is shown in Map 2-8.

Table 2-5 lists the numbers of square meters in each river mile that show no change, shoaling, and deepening across the full range of vertical change intervals observed. The no-change category is defined as +/– 0.25 foot based solely on the vertical resolution of the overlain bathymetry measurements. The percentage of the area within each river mile that fits into each of these three categories is shown at the bottom of Tables 2-5a and 2-5b, and cumulative shoaling and deepening percentages by change interval are tabulated on the right. The percentage of the area within each river mile showing no change, shoaling, and deepening is graphed on Figure 2-10. Several general trends are evident:

- First, consistent with the patterns on the bathymetry change maps, the proportion of each river mile that shows no change (gray bars) is substantially greater in the channel areas (Figure 2-10b) than nearshore areas (Figure 2-10a).
- Second, in nearshore areas (Figure 2-10a), the percentage of the river exhibiting shoaling (green bars) peaks between RMs 4-5 and 10-11; these are reaches identified as "depositional zones" based on the SPI survey data (SEA 2002f). Channel shoaling peaks are less distinct than the nearshore peaks, but also occur in the "depositional zones" at RMs 1-2, 4-5, and 9-10, as well as in an upstream area around Ross Island (RM 14-15.7).
- Finally, in the nearshore areas, the percentage of the area that deepened (red bars) peaks at RMs 0-3 and 11-13. In channel areas, the peaks in deepening occur at RMs 2-3, 5-6, 11-13 and 14-15.7. The upstream (RMs 11-13) and mid-reach (RMs 5-6) areas were identified as "transport zones" based on the STA® (GeoSea Consulting 2001) and SEA (2002b) results. The peak in deepening in the nearshore downstream areas (RMs 1-3) appears to reflect the large, contiguous zone of erosion that is evident along the west side of the river from RMs 0 to 3 (Map 2-7a and 2-7b).

The data compiled in Tables 2-5a and 2-5b allow the total percentage channel and nearshore areas that either deepened or shoaled to be quantified.

Channel Areas. Across all channel areas combined, approximately 65.9% of the riverbed shows no change in elevation between the two surveys, while 22.5% of the area deepened measurably and 11.6% shoaled. The cumulative percent of the channel area that is shoaling and deepening by vertical change interval is also provided in Table 2-5b. For both shoaling and deepening, over 90% of the cells that exhibit vertical change show change that is less than or equal to 1 foot in magnitude, and over 98% of the cells show vertical change that is less than or equal to 2 feet. When the no-change cells are included in the calculation (i.e., the sum of the no-change cells and the shoaling/deepening cells ≤ 1 foot over the total cell count), only 2.8% of the total area of the channel shows vertical change (either shoaling or deepening) greater than 1 foot. This represents a total channel area of about 260,000 m^2.

Nearshore Areas. Across all nearshore areas combined, approximately 43.3% of the riverbed shows no change in elevation between the two surveys, while 40.3% of the area deepened measurably and 16.4% shoaled. The cumulative percent of the nearshore area shoaling and deepening by vertical change interval is shown in Table 2-5a. The magnitude and the extent of vertical change are greater in nearshore areas than offshore. Still, over 75% of the cells that exhibit vertical change show change that is less than or equal to 1 foot, and over 93% of the cells that show vertical change show change that is less than or equal to 2 feet. When the no-change cells are included in the calculation, the percentage of the total area of the nearshore riverbed that shows vertical change (either shoaling or deepening) greater than 1 foot is approximately 13.4%. This represents a total nearshore area of about 215,000 m^2.

2.6.2 Temporal Considerations

The vertical changes in riverbed elevations that were measured by the LWG cover an 8 to 9-month period from January to September, 2002. Because changes in riverbed elevations are assumed to be directly influenced by river flow, an analysis of river stage height data was also conducted. The 2002 river stage height year is included on each water year plotted in Figure 2-2 for comparison purposes. Visual examination of Figure 2-2 indicates that the January to September period in 2002 was relatively typical in terms of river stage heights compared with the same period in other years since 1973 for which there are relatively complete river stage data. The January to September 2002 river stage pattern was similar in magnitude to that observed in 1978-80, 1985, 1987, 1989, 1990, 1993, 1995, 2000, and 2003, notably less than the January to September river stages observed in 1974-76, 1981-84, 1986, 1996, and 1997-1999, and notably greater in magnitude than the river stages measured in 1973, 1977, 1988, 1994, and 2001. For the 30-year period from 2003 to 1973 only 28 year-to-year comparisons could be made because there are no data for 1991 and 1992. Based on those data, the 2002 river stages were either greater than or similar to the river stages observed in other years 57% of the time (16 years), and were less than the river stages observed in other years 43% of the time (12 years).

In reviewing the river stage data in Figure 2-2, note that LWR flood stage is +18 feet CRD (18.3 feet PRD), and the ordinary highwater mark in the LWR is approximately +15 feet CRD (15.3 feet PRD).

The patterns of sediment movement measured over the 8-9 month period in 2002 are consistent with the understanding of sediment transport regimes in the system based on the work conducted during the planning phases of the RI/FS (GeoSea Consulting 2001; SEA 2002b,f). In addition, the scale of the observed elevation changes is consistent with the annual depositional rates of 0.5 to 1 foot/year estimated by comparing historical dredge records from the navigation channel for the 10-year period 1990-1999 (SEA 2002b). Additional activities currently undertaken or planned by the LWG to verify and expand this understanding of the Portland Harbor physical system are listed below and discussed further in Section 7.1:

1. A third multibeam survey of the Portland Harbor was conducted in May 2003 to provide a third data set in the bathymetry time series. The riverbed elevation changes from winter 2001 and summer 2002 were compared with the spring 2003 data (SEA and DEA 2003). The spatial patterns and magnitude of bathymetric changes seen between May 2003 and the summer of 2002 were comparable to those described above for the period from the winter 2001 to the summer 2002.
2. A fourth multibeam bathymetric survey, including ADCP flow measurements was initiated in February 2004 following a relatively high flow (~ 140,000 cfs) event on the LWR. The riverbed elevations observed immediately following this event will be compared to previous survey data as a direct measure of riverbed elevation changes following a high energy event.
3. A hydrodynamic and sediment transport model of the LWR will be developed in 2004 pending approval of the proposed modeling approach described the modeling technical memorandum submitted to EPA in Febraury 2004 (West Consultants 2004). This model will be developed, calibrated, and validated using the physical data (e.g., time-series bathymetry, flow measurements, sediment characteristics) available prior to the Round 2 data collection efforts. The model will be refined based on additional physical data (e.g., sediment surface and core data) collected in Round 2. The model is designed to allow long-term predictions of sediment movement during hydrological events (i.e., floods) that will not likely be experienced during the RI/FS. Additional details on how the model results will be used in the RI/FS are provided in Sections 6 and 7 of this work plan.

2.7 DREDGING

Dredging records for the Portland Harbor were requested from the Corps, the Port of Portland, and private entities. Data for dredging projects from 1980 through 2001 were obtained from the Corps, Portland District, and from the Port of Portland and are compiled in Table 2-6. For federal and Port dredging projects, Table 2-6 lists the year dredging occurred, the dredging location, the purpose of the dredging, and the quantity of dredged sediment. Map 2-2 identifies the approximate dredging location for most events. For the purposes of presentation, dredging area boundaries have been grouped into two intervals (1980-1991 and 1992-present), in order of occurrence. However, the areas identified as private dredging on the figure are approximations of dredge borrow site locations. The dredge borrow sites were identified by comparing pre- and post-dredge hydrographic surveys of the sites. Some recently dredged areas are also evident on the bathymetric survey difference maps presented in Map 2-7a to k (e.g., the Port of Portland's Terminal 2 dredging prism just upstream and downstream of RM 10; Map 2-7g and 2-7h). A compilation of available dredging permits issued by the Corps, pending permit applications, or permits to be issued by the Corps during the implementation of the RI/FS will be included in the RI. This information will also include third-party permits.

Review of the data in Table 2-6 indicates that from 1980 to 2001 about 95% of the maintenance dredging (on a cubic-yard basis) had occurred between RMs 8 and 10, the main Portland Harbor depositional zone. The next largest percentages, approximately 2% and 1%, occurred in the downstream depositional zones at RMs 4 and 2, respectively. The remaining 2% of the maintenance dredging has been spread throughout the other portions of the Portland Harbor. This historical pattern in federal and Port dredging needs further supports the sediment transport regimes described previously.

3.0 CHEMICAL SOURCES

This section discusses potential current and historic sources of chemicals released to sediments in the ISA. It is intended to be a summary of currently recognized potential sources, not a definitive discussion of all possible sources of chemicals to the ISA. Ongoing sources to the ISA are likely a combination of the different types of sources discussed in this section. The magnitude of ongoing sources may vary spatially and temporally.

As required by the SOW, the LWG "will identify source areas that are contributing to contamination to the in-water portion of the Site. Although DEQ is primarily responsible for the control of upland contaminant sources to the Site, as part of the RI/FS, Respondents [the LWG] shall evaluate the distributions of sediment contaminants and, if appropriate (e.g., if the sediment data suggests the presence of an ongoing source), make recommendations to EPA and DEQ if the need for further investigation or control of sources is identified." Information provided in this section will be augmented by background source information to be provided in the updated CSM report.

3.1 CURRENT AND HISTORICAL INDUSTRIAL ACTIVITIES

Current or historical industrial activities and processes that may lead or may have led to either point or nonpoint releases to the ISA include petroleum storage and distribution; chemical (e.g., pesticide, herbicide, asphalt, paint, resins, acetylene) manufacturing and formulation; other manufacturing (e.g., laminated wood products, windows, refractory brick, silicon chips); oil gasification; pole treating; metals salvage and recycling (e.g., metals, batteries, oils, solvents, and automobiles); metals forging, fabrication and plating; storage and warehousing of various goods; marine fueling, construction and repair; electrical power generation; electrical substation operation and maintenance; railroad switching, fueling and maintenance; and shipping. In addition, Portland Harbor was the site of extensive shipbuilding and repair throughout World War II. Shipbuilding facilities were constructed beginning in 1941 (Osborn 1945).

Types of chemicals that may have been (or are being) released from facilities within the ISA include petroleum products, polycyclic aromatic hydrocarbons (PAHs), other semivolatile organic compounds such as phthalates and pentachlorophenol (PCP), polychlorinated biphenyls (PCBs), organic solvents, perchlorate, pesticides, herbicides, dioxins/furans and metals. Antifouling agents such as butyltins have also been released to the river in areas of commercial vessel traffic.

Table 3-1 includes a list of potential chemical sources within the ISA. The types of industries associated with specific chemical uses or chemical types are summarized in Table 3-2.

Facility-specific information on operations and potential chemical use or release is contained in Appendix E. The DEQ Environmental Cleanup Site Inventory (ECSI) database and nearly 40 Strategy Recommendations prepared by DEQ were reviewed to generate information on facility operations, possible chemicals of concern associated with the processes that would be anticipated, and pathways to the ISA. Results of this review for the facilities that received EPA General Notice Letters are provided in Appendix E, Table E-1. The information in Table E-1 is considered preliminary, and site-specific data may be available that more specifically addresses upland sources. Facility locations are shown on Map 1-2a-g

3.2 DISCHARGE OUTFALLS

Locations of outfalls compiled by the City of Portland Bureau of Environmental Services (1998) are shown in Map 3-1. General information on the types of dischargers to the LWR is summarized below. Drainage basins for City storm drains and combined sewer overflow (CSO) locations are also shown in Map 3-1. More detailed descriptions and evaluations of the city's outfalls, drainage basins, and facilities discharging to these outfalls are contained in a report compiled by CH2M Hill (2000b,c).

There are approximately 94 National Pollutant Discharge Elimination System (NPDES)-permitted discharges to the ISA[6]. Many of these permitted facilities discharge to the City's stormwater system. NPDES permits issued to facilities in the ISA are listed in Table 3-3; NPDES permits in the LWR outside of the ISA are listed in Table 3-4.

The types of permitted discharges in the ISA include industrial process wastewater, contact and non-contact cooling waters, treated water from cleanup projects, and stormwater from municipal sources, construction sites, and industrial facilities. Nearly all the ISA permittees are industrial dischargers classified as minor. There are no municipal sewage treatment plant discharges in the ISA.

Stormwater throughout the ISA drainage is collected and routed through stormwater collection systems and discharged at outfalls. There are approximately 234 non-City stormwater outfalls within the ISA (see Appendix E, Table E-2). There are about 13 City stormwater outfalls and four CSOs, with a high level of separation, within the ISA (Map 3-1). The City stormwater outfalls and CSOs generally drain large areas with multiple facilities within each drainage basin. CSOs only discharge sewage to the river during storm events when runoff combined with sewage flows exceeds the capacity of the wastewater collection and treatment system. The four combined basins in the ISA have been separated to prevent CSO discharges into the river except for storms exceeding a 3-year summer storm.

[6] 85 general and 9 individual NPDES permits

DEQ issues and enforces NPDES permits in Oregon. The permits set discharge limits or guidelines and specify the frequency and type of monitoring data that must be collected. Monitoring requirements are based on the size and type of facility and typically include basic parameters such as flow and pH. They may also include chemicals of concern at a given facility or bioassays. Chemical monitoring requirements for individual NPDES permittees in the ISA are summarized in Table 3-5. Examples of NPDES general monitoring requirements are listed in Table 3-6, although these requirements may be modified to address specific facility concerns. Individual permit limits may be based on either effluent concentrations or total loadings and may incorporate factors such as mixing zones or available technologies. Industrial stormwater discharges with general permits do not have flow or chemical limits. Instead, benchmark concentrations are established to assist permittees in evaluating the effectiveness of their stormwater management practices (Table 3-7).

Facilities are required to submit discharge monitoring data to DEQ. Currently, DEQ does not have an electronic database for discharge monitoring reports, although some facilities have begun submitting discharge monitoring reports electronically. In general, little or no quality assurance information is provided with the data submitted on the discharge monitoring report. Repeated violations of reporting requirements or exceedances of discharge limits may result in an enforcement action. Information on NPDES-related enforcement actions for permitted industrial and municipal dischargers in the ISA was compiled from 1995-2000 annual reports of the DEQ Office of Compliance and Enforcement (DEQ 2000a), and is summarized in Table 3-8.

The City entered into a memorandum of agreement (MOA) with DEQ for administration of NPDES General Permits 1200-Z, 1300-J, 1200-COLS, and future General Permits for Industrial Stormwater for those facilities located within the City of Portland that discharge to receiving waters and to the municipal stormwater system. As part of the MOA, the City reviews the facilities' stormwater pollution control plans, conducts independent stormwater sampling, and conducts inspections to ensure compliance with the plan and permit conditions.

3.2.1 Stormwater Runoff

Stormwater runoff to the ISA is discharged almost entirely via stormwater outfalls. However, there is some overland flow of water from properties immediately adjacent to the river. The volume of overland flow is small relative to the amount of stormwater discharged via outfalls.

Stormwater runoff can transport contaminated soils, wastes, or spills from areas throughout the drainage basin. Some potential sources of chemicals in runoff from the urban residential and commercial areas are pesticide and weed control products, leaking transformers, hydraulic and lubricating fluids, petroleum products, erosion,

street dust, and deicing salts. Heavy metals, PAHs, and pesticides are some of the priority pollutant constituents found in urban runoff (Tetra Tech 1992; EPA 1983). For example, among the chemicals exceeding water quality criteria in stormwater runoff samples collected in Portland (at I-84 and at Harbor Way) in 1994 were cadmium, chromium, copper, lead, zinc, benzene, heptachlor, dieldrin, malathion, PCBs, and total dichloro-diphenyl-trichloroethane (DDT) (Anderson et al. 1996).

Numerous stormwater controls throughout the drainage basin were instituted over the last decade. The City of Portland and many facilities are now required to have NPDES permits for stormwater discharges, as well as stormwater management plans that incorporate best management practices (BMPs) to reduce the amount of pollutants in stormwater runoff. Monitoring is required, and although NPDES general stormwater permits do not generally set discharge limits, there are guidelines or benchmarks that are used to evaluate the effectiveness of stormwater controls. Common BMPs include removing industrial activities from exposure to rainfall and stormwater runoff, catch basin cleaning, street sweeping, and stormwater treatment (e.g., oil/water separators and other technologies).

NPDES stormwater monitoring data are submitted to DEQ. As with all NPDES monitoring data, information is compiled in individual facility files. The City of Portland Bureau of Environmental Services also maintains an electronic database of stormwater monitoring data for NPDES permits that it administers. Stormwater data for facilities within the City's outfall basins have been compiled for each City outfall (CH2M Hill 2000b,c).

3.2.2 Combined Sewer Overflows

The volume of CSO discharged from Portland's combined sewer system has been reduced as a result of stormwater controls and improvements to the combined and stormwater collection system (CH2M Hill et al. 1994). CSO overflows typically consist of 80% stormwater but also contain untreated sewage. Prior to 1994, the CSO system discharged an average of 4.8 billion gallons of untreated CSO (stormwater and sewage) to the Willamette River between RM 4 and 17 (CH2M Hill et al. 1994). The Cornerstone and Willamette CSO control projects helped Portland to achieve a 42% annual average CSO reduction in the Willamette system as of December 2001. By December 2011, the City's CSO program will achieve a 95% annual average reduction in the LWR.

Within the ISA, the CSOs experienced an average of 50 overflow events (up to a total of 112 days) per year in the early 1990s before the Cornerstone and Willamette CSO control projects in the ISA were implemented (City of Portland Bureau of Environmental Services 1998). Since 1997, CSO discharges in the ISA have been reduced to an average of three events per year, discharging about 1 million gallons annually. This represents an approximate 97% reduction of annual average CSO events within the ISA.

3.3 GROUNDWATER DISCHARGE

Extensive groundwater data have been collected from upland facilities throughout the ISA through site investigations conducted under Voluntary Cleanup Program agreements and consent or unilateral orders with DEQ. Approximately 83 sites have been identified on the DEQ ECSI database between RM 2 and 11. Of these sites, approximately 67 are known to have some groundwater quality data (Map 3-2).

There are abundant data from explorations at many sites that document groundwater conditions adjacent to the river, including hydrostratigraphy, groundwater gradients, and groundwater quality. The LWG is currently completing a review of available groundwater data to assess the locations and types of chemicals of interest (COIs) in groundwater adjacent to the ISA and to identify data gaps. For the purposes of this study, COIs are chemicals that have been detected in upland groundwater and have not been screened relative to potential impacts to the ISA using risk-based criteria. The existing data indicate that shallow and intermediate system groundwater under sites within the ISA generally discharges to the river. Direct evidence of discharge of groundwater containing COIs to the river is available at some sites along the ISA. Other sites have been identified as potential sources of COIs to the river via groundwater discharge; however, data are not available to verify whether or not contaminated groundwater is discharging at these locations.

Information on the groundwater physical system and existing groundwater quality data has been compiled from DEQ files and published literature, and will be submitted as part of the updated CSM report. The original documents obtained from DEQ on which the conclusions in this report were based will be provided to EPA for purposes of verifying the conclusions.

3.4 SPILLS

Spills are inadvertent, intermittent releases that occur directly to the waterway or adjacent upland areas. Spill records for the LWR were obtained from DEQ for the period 1995 to 2002 and are contained in Appendix E, Table E-3. Additional records of spills from the 1940s to present were requested from the U.S. Coast Guard and the National Response Center's (NRC) centralized federal database of oil and chemical spills. Detailed reports of spills from 1990 to present were provided, and summary information for spills from 1982 to 1989 was obtained from the NRC online database. These records are also contained in Appendix E.

Information on spill locations, particularly in the earliest reports, is often very general (e.g., RM). Spills reported in the LWR ranged from dropped bottles or sheens from unknown sources to fuel spills of over 500 gallons from vessels. Four of 20 spills reported to the U.S. Coast Guard between 1990 and 2003 involved volumes greater than 5 gallons. Of these four spills, one was greater than 1,000 gallons and was due to operator error while transferring fuel oil from a barge.

Additional historic spill information from transfer and handling practices or overwater activities is sometimes available in site-specific upland site assessments or remedial investigations. Spill information from these documents, when available, will be summarized in an updated CSM report.

Some of the types of activities commonly associated with spills are briefly described below:

- **Product Transfer and Handling.** The types of facilities on the LWR and products or chemicals associated with these industries are listed in Appendix E. Many facilities are now required to have spill prevention plans and have instituted practices to reduce spills.
- **Overwater Activities.** Overwater activities, including ship repair or vessel refueling, are potential sources of chemicals to sediments. Regulations and BMPs have reduced contributions from these activities in recent years. Currently, DEQ spill reports indicate that fuel spills during refueling are the most common type of spill from overwater activities, but small spills during transfer of other materials (e.g., paint) have also been reported.
- **Utility Crossings.** Pipelines carrying petroleum products have the potential to leak or break. There is one petroleum pipeline crossing the Willamette River within the ISA. It is located between the Willbridge bulk fuel terminal and south end of Triangle Park (approximately RM 7.7) (Maps 4-3b to 4-38b).
- **Vessels.** An average of 20 spills from vessels directly to the LWR are reported to the U.S. Coast Guard each year (NRC 2002). Nearly all involve diesel fuel, gasoline, hydraulic or lubricating oil, or waste oil. Vessels may also release bilge or ballast water to the river.

DEQ has developed spill rules that identify the emergency response actions, reporting requirements, and follow-up actions required in response to a spill of oil or hazardous materials. DEQ has also included spill records in its evaluation of potential contaminant sources to the LWR.

3.5 BANK EROSION

The majority of the ISA is industrialized with modified shoreline and nearshore areas. Wharves and piers extend into the channel, and bulkheads and riprap revetments armor much of the riverbank. The Portland Bureau of Planning mapped the banks of the Willamette River from the mouth to Ross Island (RM 15). They calculated that

50% of the banks were riprap, sea walls, other bank stabilization coverage, or structures. Remaining areas consisted of natural material (rock outcrops or native earth material with varying living or dead vegetation), river beach, or unclassified fill. Areas of unprotected shoreline where soils or fill containing chemicals may erode and be washed into deeper areas of the waterway are potential sources of chemicals to sediments. Some shoreline areas with known or suspected contaminated bank soils are located adjacent to ATOFINA, Crawford Street, GASCO, Linnton Plywood/Columbia River Sand and Gravel, and McCormick and Baxter facilities.

3.6 CHEMICAL LEACHING FROM COATED SURFACES

In-water structures, such as docks, pilings, dolphins and bulkheads, may be constructed of wood treated with creosote, chromated copper arsenate, or copper zinc arsenate. These preservatives are sources of PAHs, copper, chromium, arsenic, and zinc to sediments either through direct contact or via the water column. Sites with treated wood structures may have nearshore sediments potentially affected by chemical leaching; however, impacts are generally limited to the immediate area. For example, the spatial impact of creosote-treated wood, based on increases in sediment PAH, was less than 33 feet for small structures (i.e., less than 50 pilings); the spatial impact of leached metals to sediment was limited to within 10 feet (Poston 2001).

Leaching from vessel hull paints is a potential source of trace chemicals to sediments in areas with vessel activity (e.g., marinas, boatyards, shipyards) (Young et al. 1979; Crecilius et al. 1989). Antifouling pigments make up from 2% to 60% of the volume of a gallon of commercial marine paint (Burch 1987). Fouling marine organisms are killed as these pigments gradually leach out into the water. Antifouling paint and bottom primer components include cadmium, chromium, copper, lead, and zinc (Michelsen et al. 1996; Young et al. 1979). Historically, the most common antifoulants were organotins including tributyltin (TBT) and various mercury compounds. Use of mercury and TBT in antifouling paints has been restricted in the United States since 1972 and 1988, respectively, but ongoing sources include shipping traffic from countries without regulations and domestic vessels that are still allowed to use TBT paints.

3.7 ATMOSPHERIC DEPOSITION

Atmospheric deposition occurs both on the land and water surfaces in the ISA. Airborne chemicals deposited on land may be transported to the river in surface water runoff and therefore are associated with storm drain and stormwater runoff.

3.8 UPSTREAM SOURCES

Potential sources that may affect sediment quality in the ISA include all point and nonpoint discharges within the Willamette River basin. Chemicals in discharges and runoff from many diverse land uses in the basin are eventually deposited and mixed in the river by the time the river reaches the ISA.

3.8.1 Non-ISA Sources in the Lower Willamette River

Sources in the LWR, both downstream and upstream of the ISA, may contribute to chemical deposition in the ISA. Industrial and commercial facilities below RM 3.5 include petroleum storage and distribution, steel manufacturing, cement manufacturing, wood products storage and distribution, and marinas. The tidal influence of the Columbia River estuary causes seasonal flow reversals in the Willamette River near its mouth and within Multnomah Channel under certain river stage, river flow, and tidal conditions. These flow reversals could serve to transport sediment-bound chemicals from the downstream reach of the river into the ISA. Industrial and commercial activities immediately upstream from the ISA include aluminum storage, rail yard maintenance and operation, cement manufacturing, and marinas. Shoreline facilities upstream of the ISA that are listed in DEQ's ESCI database are listed in Appendix E, Table E-5, and locations are shown in Figure E-1). Permitted discharges are listed in Table 3-4. The City of Portland manages 34 CSOs upstream of the ISA. There are also numerous private and municipal outfalls upstream of the ISA.

3.8.2 Sources Above Willamette Falls (Upper Willamette River)

There are over 800 permitted discharges to the Willamette River upstream of Willamette Falls. The 28 major point source dischargers to the upper Willamette include over a dozen municipal sewage treatment plants and several pulp, paper, lumber, and fiberboard manufacturers. Hundreds of facilities also have general permits for discharge of non-contact cooling water and filter backwash, gravel mining activities, and tank cleaning. Over 300 permits for industrial stormwater discharge are held by a wide variety of facilities handling products such as paint, steel, metal plating, semiconductors, adhesives or food products, as well as landfills and transportation companies.

Nonpoint sources upstream of Willamette Falls include most of the agricultural and forested land in the Willamette River basin. Forested areas in the Willamette basin are located primarily in the mountains that border the western and eastern sides of the basin. The primary nonpoint source problem associated with forestry is accelerated sediment transport. Forestry practices also contribute runoff containing nutrients, fertilizers, and herbicides. Agricultural land in the Willamette basin is located predominantly in the Willamette Valley, and erosion from agricultural lands is the most commonly cited nonpoint source pollutant in the upper reaches of the

Willamette River basin (Tetra Tech and E&S 1993). Fertilizers, pesticides, and herbicides are agricultural chemical sources of nonpoint source pollution. USGS studies of pesticides in the Willamette basin reported the highest concentrations of organochlorine pesticides and PCBs at three, mostly agricultural, sites (Wentz et al. 1998). Urban areas in the Willamette basin, while a relatively small component of land use in the river above Portland (e.g., Eugene, Salem), may be sources of nonpoint pollutants associated with urban stormwater runoff (e.g., pesticides, PAHs, metals). The upstream reaches of the Willamette River basin also receive runoff from natural volcanic sources and past mining activities, which have resulted in a fish advisory for mercury throughout the entire main stem of the Willamette River.

DEQ's (1998) 303(d) list of impaired waters in Oregon includes the main stem and tributaries of the Willamette River above Willamette Falls. Most of the 303(d) listings for impaired water quality above Willamette Falls are for temperature and bacteria; other listings relate to nutrients, dissolved oxygen, and pH. There are some listings for toxic chemicals. Mercury, PCBs, aldrin, dieldrin, and DDT are listed for RMs 24.8 to 54.8. There are also smaller creeks in the middle and upper Willamette basins that are listed for arsenic, copper, lead, mercury, or zinc.

Based on the 303(d) list, DEQ is currently developing total maximum daily loads (TMDLs) for the 12 Willamette River subbasins (Table 3-9). Nine of these plans are due to be completed by 2003, and allocations have not yet been developed. Mercury is being addressed for the entire basin, and a dioxin TMDL was developed by EPA in 1991 for the Willamette and Columbia rivers.

4.0 SUMMARY OF PREVIOUS INVESTIGATIONS

As mentioned in Section 1, nearly 700 documents and data sets relating to the LWR from the confluence with the Columbia River (RM 0) to Willamette Falls (RM 26.5) were compiled during the preparation of this Work Plan. This section presents a brief summary of the environmental and human uses data. Additional ecological data are summarized in the Ecological Risk Assessment Approach (Appendix B).

The compilation of existing data relied on recent documents and data obtained from many sources, including LWG members, EPA, DEQ, Oregon Department of Fish and Wildlife, USGS, Corps, Oregon Natural Heritage Program, and county and university libraries. An extensive annotated list of data sources, along with data QA/QC information, is provided in Appendix F.

4.1 HISTORICAL DATA QUALITY REVIEW

Data quality reviews were performed for compiled historical sediment chemistry, water chemistry, tissue chemistry, bioassay, and macroinvertebrate data. The reviews were performed prior to entering the historical data into the project database. The purpose of this review was to fully evaluate each data set and categorize the quality of the data in the database, ensuring that these data were appropriate for use in the RI/FS. The two categories of data are as follows:

Category 1. Category 1 data are of known quality and are considered to be acceptable for use in decision making for the Site. There is sufficient information on these data sets to confidently verify that the data, along with associated data qualifiers, accurately represent chemical concentrations present at the time of sampling.

Category 2. Category 2 data are of generally unknown or suspect quality. The QA/QC information shows that data quality is poor or suspect, or essential QA/QC data (e.g., surrogate recoveries, matrix spike/matrix spike duplicates) are either incomplete or lacking.

The evaluation of data quality was conducted at the finest level of detail available for each data set. In many cases, complete QA/QC information was available and individual sample delivery groups could be evaluated. For other data sets, this level of detail was not possible because less backup information was available. The Category 1 and Category 2 designations are made at the finest level possible, which may result in some data from a given study being classified as Category 1 while other data are classified as Category 2. For example, metals data from a survey may be Category 1 while some of the pesticides data are Category 2. In many cases, data from one survey will contain both Category 1 and 2 data. Category 1 and 2 designations were entered into the project database for each sample and analyte.

Analyses upon which project decisions will be based will utilize Category 1 data. As examples, the ecological and human health risk assessments will use select Category 1 data in the risk calculations, and the definition of sediment management areas will rely on Category 1 sediment data. Only Category 1 data that have had an EPA-approved level of data validation, comparable to Washington State Department of Ecology's "QA2" evaluation, will be used for human health or ecological risk assessments. Usability of historical data is discussed in Section 4.6. Category 2 data will be used during project scoping. For example, Category 2 tissue data were used to help identify chemicals of interest, and Category 2 sediment data were used in the initial assessment of trends in chemical concentrations, which was useful for defining the site characterization sampling program.

4.1.1 Chemical Data Quality Reevaluation

During the review of the 2002 Round 1 Work Plan, the agencies emphasized the need to identify as many suitable chemical data points as possible for various components of the RI. In response, the LWG reevaluated historical Category 2 chemical data, and some data were reclassified as Category 1. The results of the reevaluation are presented in a technical memorandum entitled, Historical Chemistry Data Category Reclassification (SEA 2003). This section briefly describes the reevaluation process and its outcome.

The reevaluation focused on three distinct questions with regard to initial classification of the data:

1. Was all information necessary to assess data quality available initially?
2. Were chemical data quality criteria too restrictive?
3. Were criteria applied to data consistently?

The first step in the reevaluation process was to assess the outcome of the initial data quality review provided in Appendix F of the Round 1 Work Plan. It was noted that many surveys with Category 2 classification were lacking appropriate quality assurance/quality control (QA/QC) documentation necessary for data validation. It was also noted that in some cases the lack of chain-of-custody forms was responsible for Category 2 classification of otherwise high quality data. The second step in the process was to obtain source documents for all Category 2 data for the project library. Authors of those studies were contacted (whenever possible) and asked to obtain and transmit the necessary backup information. In the final step, the LWG performed the following tasks:

- Evaluate the adequacy of the chemical quality criteria
- Ensure that data quality criteria were consistently applied to all data, including those classified as Category 1

- Identify any QA/QC information that was either not initially available or that may have been originally overlooked
- Classify data based on newly acquired back-up documentation.

One of the original criteria for evaluation of data quality was revised. A data set was not rejected as Category 1 data based solely on the absence of chain-of-custody documentation as it was during the initial data quality evaluation. The revised process used to assess "traceability" is described in the next section. Additional QA/QC information was obtained for several studies, and chemical review criteria were consistently applied to all QA/QC results, both newly acquired and existing.

For tissue data, one study was upgraded to Category 1 for all chemical groups, and one study became a mixture of Category 1 and Category 2 data. Results of the reevaluation effort and reasons for Category 2 designation are provided in Table 4-1 and Appendix F.

4.1.2 Chemical Data Review Criteria

The chemical data review was conducted by analyte group (i.e., metals, semivolatile organic compounds, etc.) for each matrix type. As a result, a data set may contain all Category 1 data, all Category 2 data, or both categories 1 and 2 data. Data quality was assessed by evaluating the following four factors:

- **Traceability.** Based on the reevaluation of the chemical data, chain-of-custody is preferably documented and complete, and attached to the report or supporting documentation package. However, a data set is not rejected as Category 1 data based solely on the absence of chain-of-custody documentation. If a high-quality data set satisfies all criteria except chain-of-custody documentation, there may either be references to chain-of-custody forms in the text of a report or appendix or there may be other documentation consistent with state or federal guidelines that demonstrate investigators are typically compliant with industry standard field collection and documentation requirements and imply chain-of-custody forms were used. In that instance, an assumption is made that the investigator and contracted laboratories used appropriate sample tracking methods, and the data set is assessed as Category 1.
- **Comparability.** Analytical procedures or methods are identified and are accepted in the industry as "standard" or "universal."
- **Sample Integrity.** Sample holding times and conditions between collection and analysis meet established criteria,

which are generally identified by the EPA Puget Sound Estuary Program (PSEP 1986, 1997a,b,c) or other pertinent and published guidance.

- **Potential Measurement Bias.** Procedural and/or analytical method blanks are available to evaluate potential for introduction of positive bias in reported results, and bias is within acceptable limits. Lower reporting or quantitation levels may be limited by the presence of background or laboratory contamination. Potential measurement bias includes an evaluation of both accuracy and precision:

    - **Accuracy.** Matrix spikes (MS), laboratory control samples, (which may be spiked blanks or other pertinent reference materials), and/or organic surrogate compounds are available for review, and accuracy falls within an acceptable range. Recoveries fall within ranges typically established by major national monitoring programs, regional guidance, or other accepted "standards." Acceptable analyte recoveries tend to be in the range of 50% to 150%. Recoveries measured outside specified acceptance ranges generally result in the qualification of associated analytical results as estimates or unusable/rejected.

    - **Precision.** Replicate samples are generally available to evaluate analytical variability, and variability falls with an acceptable range. However, the lack of replicate data does not preclude Category 1 status as long as other laboratory quality control data to evaluate bias (e.g., blanks and accuracy quality control samples) are available for review to bolster the evaluation. When available, duplicate or triplicate analyses are normally performed at frequencies of 5% or once for every 20 samples analyzed (of the same matrix). Measurement of analytical variability for organic compounds is performed by analyses of MS and matrix spike duplicate (MSD) samples. (Occasionally, MS/MSD analyses are unable to provide desired measurements due to spike levels that were significantly less than native concentrations. This occurs mostly for highly contaminated solids where *in-situ* levels can be extreme compared to spiking levels.) Acceptable replicate analyses in most monitoring programs are less than or equal to 25% to 50% relative standard deviation or relative percent difference. Variability outside acceptance ranges results in the qualification of associated results as estimates.

Data sets that met the criteria above were assigned Category 1.

Sediment

Since March 2003, sediment chemistry results for four studies were added to the LWG's existing chemistry database:

- Lab Data for Phase 1 Data Evaluation and Phase 2 Work Planning for City of Portland Outfall 18 and Lab Data for City of Portland Outfall M-1 (City of Portland 2002)
- Environmental Site Assessment of GATX Terminals Corporation (KHM Environmental Management 1999)
- Forensic Geochemical Assessment of Nearshore Sediments, Remedial Investigation Work Plan, Atlantic Richfield/BP Terminal 22T (SECOR 2002)
- Revised 60-Inch Storm Sewer Interim Remedial Actions, Tosco Willbridge Terminal (KHM Environmental Management 2001).

Data quality reviews were performed for the four newly obtained studies plus 72 existing sediment studies, for a total of 76 sediment studies. Results of the evaluation are provided in Appendix F, Attachment F1, and are summarized in Table 4-1. Of the 76 data sets that were reviewed by analytical group, 36 were classified as Category 1 and 15 were classified as Category 2. Twenty-five surveys contained a mixture of Category 1 and Category 2 data.

Water

The water chemistry data from studies listed in Table 4-1 were evaluated for data quality. Results of the evaluation are provided in Appendix F, Attachment F2 and are summarized in Table 4-1. Data from STORET and LASAR were classified as Category 2. The remaining data sets were classified as Category 1. The lower rating for the monitoring data was primarily due to the lack of QA/QC documentation.

Data collected by DEQ monitoring programs are reviewed for quality assurance, and data in DEQ's laboratory analytical storage and retrieval (LASAR) database are provided with a quality ranking. All data from the LASAR database had been classified by DEQ as Level "A " or better, indicating that there is a Round 1 QAPP approved by DEQ, QA criteria are met, and that the data are suitable for evaluating compliance with water quality standards. The quality of data included in the EPA Data Storage and Retrieval System (STORET) database cannot be easily determined. However, data collected by USGS generally undergo QA/QC review. Data quality reviews of some of the USGS data compiled in this report are reported by Fuhrer et al. (1996) and Anderson et al. (1996). In general, these reports determined that data quality is adequate for use, with the following exceptions:

- Some USGS metals data collected prior to 1992 may be biased high due to contamination of the samples by the field sampling apparatus (Tetra Tech et al. 1993). Therefore, metals data

collected prior to this date were not included in this compilation.

- Caution must also be used in comparing metals results as several different analytical methods were used. Therefore, in this plan the applicable method has been noted wherever appropriate.

Tissue

Data quality reviews were completed for eight surveys, and results are provided in Appendix F, Attachment F3, and are summarized in Table 4-1. All but two surveys were assigned to Category 2. The remaining two data sets were classified as Category 1 and a mixture of Category 1 and 2. In general, insufficient QA/QC documentation was available for the tissue chemistry data sets.

4.1.3 Biological Data Review Criteria

Bioassay and benthic community data quality were evaluated based on validation guidelines and performance criteria from the Puget Sound Estuary Program (PTI 1989).

Bioassay validation guidelines include checks of completeness, holding conditions, standard reporting methods, and QA/QC results for negative control, reference sediment, positive control (reference toxicant), and measured water quality parameters according to standard testing methods. Reference and control performance requirements were as follows:

- **Amphipod**. Control absolute mortality does not exceed 20%; reference absolute mortality does not exceed 30%.
- **Midge**. Control absolute mortality does not exceed 30%; reference absolute mortality does not exceed 35%.
- ***Daphnia sp.*** Control absolute mortality does not exceed 10%.
- ***Lumbriculus***. On Day 4, numbers of organisms should not be significantly reduced in test relative to control sediment. Organisms should burrow into sediment.

Reference sediment must have similar grain size as test stations.

For benthic community data sets, each study was reviewed for collection, laboratory, and sorting QA/QC methods. Data comparability among benthic data sets was also evaluated by comparing sampling methodology and sampler size, sample processing, and measured endpoints.

Bioassays

Data quality reviews were completed on seven types of bioassays (amphipod survival, midge survival and growth, oligochaete 28-day bioaccumulation (*Lumbriculus*), Microtox bacterial luminescence, *Daphnia* 48-hr and 96-hr mortality, and rainbow trout mortality for surface, subsurface, and sediment porewater spread over 18 surveys (Table 4-9 and Appendix F, Table 5). Four surveys assigned to Category 2, three surveys were assigned a mixture of Category 1 and Category 2 data, and the remaining bioassay data sets were assigned to Category 1.

Benthic Invertebrates

A literature search for information documenting the condition of the benthic invertebrate communities in the LWR found very little peer-reviewed data. Since 1993, only three studies, both inside and outside of the ISA, have focused on both the shallow and deep-water benthic communities in the Willamette River:

- Willamette River Basin Water Quality Study (Tetra Tech 1993, 1995; Tetra Tech and Taxon Aquatic Monitoring Co. 1994)
- Portland Shipyard Benthic Community Study (Dames & Moore 1998)
- Ecological Survey: Fall & Spring 2000 Ross Island Sand & Gravel Co. (Landau Associates 2000b).

A review of the methods used to obtain, process, and analyze the samples found that, with minor variations, internal QA/QC procedures (i.e., sample collection and processing; species sorting, identification, and enumeration; verification) were followed and that the data were suitable for the objectives of each study. Data from all three surveys (the only benthic data available in the LWR) were assigned Category 1 (see Appendix F, Table 6). However, a comparison of major benthic ecological indices among the three surveys is not possible because of differences in sampling gear, surface areas sampled, splitting methods, and sieve sizes.

4.2 CHEMICAL DISTRIBUTIONS IN SEDIMENT

The purpose of this section is to summarize sediment chemical concentrations in the LWR. Data presented here have been used in the Work Plan to assess data gaps. Depending on sediment stability, these concentrations may or may not be representative of current conditions or representative of sources that originated in the ISA. Historic data will be evaluated based on a weight-of-evidence approach as part of a data suitability analysis following the completion of Round 2 sampling. In this section, data from early investigations performed by the USGS and the Corps are summarized first (Section 4.2.1). Section 4.2.2 contains a discussion of the majority of compiled sediment chemical data from facility investigations that began after 1990.

4.2.1 Early Willamette River Sediment Quality Studies

This section summarizes sediment chemistry data collected prior to 1990. Some of the earliest publications with sediment chemistry data were USGS and Corps reports, primarily associated with dredged material characterizations. These early data sets were designated Category 2 primarily due to the lack of QA/QC documentation. Pre-1990 data are not mapped due to their age but are narratively described here.

Rickert et al. (1977) indicated that the sediment data collected prior to their study, which was performed in 1973, were "sparse" and that he and his colleagues were unable to assess the overall quality of sediment in the Willamette River given the lack of analytical data. Consequently, the purpose of their 1973 study was to provide baseline sediment metal concentrations for future comparisons.

Sediment was collected from 31 locations in the Willamette main stem, with 19 of the 31 samples collected from the LWR. The study limited the chemical analysis of sediments to trace metals, citing the lack of toxic organics listed in industrial discharge permits at the time. Aliquots of the sediment samples were separated to obtain fractions of fine silt and clay [i.e., <20 micrometers (µm)] that would be representative of local soils and worldwide averages of claystones and shales. In the LWR, arsenic ranged in concentration from 10 to 20 mg/kg (mean = 13); cadmium ranged from 0.5 to 2.5 mg/kg (mean = 1.2); chromium ranged from 50 to 80 mg/kg (mean = 57); copper ranged from 35 to 70 mg/kg (mean = 45); lead ranged from 25 to 90 mg/kg (mean = 43); mercury ranged from 0.03 to 0.34 mg/kg (mean = 0.14); silver ranged from 0.5 to 1.0 mg/kg (mean = 0.6); and zinc ranged from 260 to 1,295 mg/kg (mean = 419). All measurements were reported in dry weight.

In February 1977, the USGS and the Corps, Portland District, collected two surface sediment samples (top 8 inches) from a nearshore area slated for dredging at RM 9.2 (western shore) (McKenzie 1977). Samples were analyzed for grain size, conventional parameters (i.e., ammonia, total organic carbon, phosphorus, etc.), trace metals, phenol, PCBs, and several pesticides, including DDT and its breakdown products. Both samples were sandy silts with a mean value of 59% fines (silt plus clay). Trace metal concentrations were detected below the mean metal concentrations reported by Rickert et al. (1977). Among organics, PCBs, dichloro-diphenyl-dichloroethane (DDD), dichloro-diphenyl-dichloroethene (DDE), DDT, aldrin, dieldrin, chlordane, diazinon, lindane, and methoxychlor were detected. Total DDTs ranged in concentration from 11 to 15.6 µg/kg, dry weight (mean = 13.3), and PCBs ranged in concentration from 51 to 57 µg/kg, dry weight (mean = 54). The remaining detected pesticides and herbicides were detected at concentrations ranging from 1.0 to 10 µg/kg, dry weight.

As a follow-on to the February 1977 work, the USGS conducted an elutriate study on sediment samples collected from the same approximate location at RM 9.2 (Rinella and McKenzie 1977). Characterized sediments were slated for dredging. Two composite surface sediment samples were collected in May 1977 and prepared for

both bulk sediment chemical analysis and elutriate-test filtrate testing. The elutriates were prepared by mixing dredged sediments collected from RM 9.2 with Willamette River and Columbia River water samples. The mixture was allowed to settle, and the supernatant was then decanted, centrifuged, and filtered. Both the bulk sediment samples and filtrates were tested for ammonia, trace metals, aldrin, chlordane, DDD, DDE, DDT, and dieldrin. The sediment sample contained approximately 60% silt and 12% clay. Arsenic, chromium, copper, lead, and zinc were detected at low levels in both samples. No sediment metal concentrations were detected above the average metal concentrations reported by Rickert et al. (1977). No pesticides or PCBs were detected in the elutriate test samples; however, PCBs, chlordane, DDD, DDE, DDT, and dieldrin were detected in the bulk sediment sample. Chlordane was detected at 15 µg/kg, total DDTs were detected at 26 µg/kg, dieldrin was detected at 0.5 µg/kg, and total PCBs were detected at 130 µg/kg.

In 1987, the Corps tabulated sediment chemical data from four surveys performed in the early 1980s by the Port of Portland, the Corps, EPA, and CH2M Hill (USACE 1987). These data were also summarized in Fuhrer (1989). Samples were collected from RMs 1 to 11.3, mostly from nearshore stations including slips and berths. Data for total organic carbon (TOC), grain-size distribution, several pesticides, and total PCBs were reported in the Corps' 1987 report. Concentrations of dieldrin, endosulfan, endrin, heptachlor, lindane, methoxychlor, perthane, and toxaphene were either not detected or detected at low levels (0.1–5 µg/kg; maximum at RM 9.2). Detected concentrations of some or all of these chemicals were measured in samples collected from RMs 4.3, 4.5, 8.7, 9.2, 9.8, 10.1, 10.7, and 11.2. Detected concentrations of chlordane ranged from 2 to 7 µg/kg (maximum at RM 10.7) and were found at RMs 4.3, 4.5, 8.7, 9.2, 9.8, 10.1, 10.7, and 11.2. Concentrations of aldrin ranged from 2 to 7 µg/kg and were measured in sediments from RM 9.2. Total DDTs ranged in concentration from 1.6 to 3,413 µg/kg (maximum at RM 7.1) and were measured in sediments from RMs 1.2, 4.3, 4.5, 6.8, 7.1, 8.7, 9.2, 9.8, 10.1, 10.7, and 11.2. Total PCBs were detected in all samples but two and ranged in concentration from 14 to 550 µg/kg (maximum at RM 9.7, Berth 201).

In 1983, the USGS and Corps collected sediment and water samples from 10 locations in the navigation channel to determine concentrations of trace metals and organic compounds in elutriate-test filtrate and bulk sediment (Fuhrer et al. 1989). Samples were collected using both a ponar surface grab (top 10 cm) and a gravity core sampler (up to 1 meter), depending on the sample location. Samples were collected at RMs 4.3 and 4.5, mid-channel near Swan Island (RMs 8.3, 8.7, 9.2, 9.6), at RM 9.8, mid-channel at RM 10.1, and at RMs 10.7 and 11.3. Bulk metals concentrations were detected below mean metal concentrations reported by Rickert et al. (1977). Among organics, chlordane, DDD, and total PCBs were detected in all samples. Other organics, such as DDE, DDT, dieldrin, heptachlor, bis(2-ethylhexyl)phthalate (BEHP), and PAHs, were detected in specific samples. Total DDTs ranged in concentration from 1.6 to 19.2 µg/kg (maximum at RM 4.3), and total PCBs ranged in concentration from 14 to 170 µg/kg (maximum at RM 10.1).

Chlordane ranged in concentration from 1 to 10 µg/kg (maximum at RM 10.1). Bis(2-ethylhexyl)phthalate was detected in seven of 10 samples, ranging from 40 to 120 µg/kg (maximum at RM 9.8). The maximum total PAH concentration (3,190 µg/kg) was measured in sediment from RM 11.3.

In 1989, Fuhrer (1989) compiled and evaluated sediment chemical data collected between 1977 and 1983 in Portland Harbor, including the data reported above. Fuhrer (1989) concluded that the navigation channel sediments appeared to have lower chemical concentrations than sediments located in nearshore areas. That trend is supported by the data compiled for this Work Plan as well (see next section).

4.2.2 Sediment Chemistry Data Compiled by LWG

Available Category 1 and 2 historical sediment chemical data collected from 1990 to the present are summarized and mapped in this section. Category 1 and 2 designations by data set are presented in Table 4-1 and Appendix F, Attachment F1. As noted in Appendix F, sample density is the highest at facilities undergoing remedial investigations and dredged material characterizations. Maps 4-1 and 4-2 indicate the years samples were collected for surface and subsurface sediments, respectively. The majority of samples were collected either by EPA in 1997 during its Site Inspection (Weston 1998) or since 1990 by facility operators located between RM 4 and RM 9. In sediment investigations since 1990, chemical concentrations are most commonly reported for bulk sediment (i.e., the concentration in a sample of sediment). For some analytes, sediment porewater (i.e., water centrifuged from a sediment sample) is the preferred media. Data evaluations presented in this section are based on the data available. It's important to note that a consistent suite of chemical constituents was not measured at each historical sediment sampling location.

Table 4-2 summarizes the sediment investigations performed in the LWR since 1990. Data from these investigations are currently available in the LWG's database. Detailed descriptions of these historical sediment investigations are provided in Appendix F. This section provides a general description of sediment chemical concentrations measured in LWR sediments and porewater.

Chemical results for sediments that have subsequently been dredged are included in the LWG's existing chemistry database and flagged as such. While dredged material sediment chemistry results do not provide an assessment of current conditions, the data provide information about potential historical sources and temporal changes. Dredged sediments received both Category 1 and 2 designations based solely on the assessment of laboratory QA/QC results as applied to all the data sets in the database. In this section, statistical summaries of the sediment chemistry exclude dredged sediment results to represent recent conditions. However, in maps the samples that have been dredged are marked and results are shown. In both the tables and maps, only data from 1990 to the present are summarized or mapped. Summary statistics

for surface sediment samples collected in the LWR are presented in Table 4-3 (historical Category 1 and Category 2 data from 1990 to present, excluding dredged sediments). Summary statistics for all subsurface sediment samples in the LWR are presented in Table 4-4 (historical Category 1 and Category 2 data from 1990 to present, excluding dredged sediments). Surface samples are those that were exposed to the overlying water column to a maximum depth of 30 cm at the time of collection. Chemicals are sorted in order of descending detection frequency in the tables to identify which chemicals may have a relatively broad distribution in Portland Harbor.

With few exceptions, the same chemicals were detected at a frequency of 10% or greater in both surface and subsurface sediments, including metals, PAHs, diesel fuel, phthalates, total DDTs, total PCBs, butyltins, dioxins and furans, 4-methylphenol, dibenzofuran, xylenes, and acetone. Some noteworthy exceptions include the following. In the compiled surface sediment data, 2,4-D, 2,4-DB, chlorobenzene, di-n-octyl phthalate, heavy oil, and lube oil were detected in more than 10% of historical surface sediments (due to higher concentrations), but not in more than 10% of the historical subsurface samples. In subsurface samples, ethylbenzene, m,p-xylene, o-xylene, methylene chloride, methylethyl ketone, benzoic acid, 3- and 4-methylphenol (coelution), and alpha- and gamma-hexachlorocyclohexane were detected in more than 10% of the subsurface sediments, but not in more than 10% of the surface sediment samples. Tetrabutyltin and butyltin (as ion) were also detected in more than 10% of the subsurface porewater samples, but not in more than 10% of the surface porewater samples. It's important to note that the number of samples used to calculate frequency for each analyte group varies from 1 to 656 (surface) and from 1 to 390 (subsurface).

Detected concentrations of arsenic, cadmium, copper, lead, mercury, zinc, TBT (bulk measurements and in porewater), bis(2-ethylhexyl)phthalate, total high molecular weight PAH (HPAH), total low molecular weight PAH (LPAH), total PCBs, 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD), total DDTs, dibenzofuran, 4-methylphenol, and xylene are mapped in Maps 4-3 through 4-38 to show the distributions of these frequently detected chemicals in the LWR. These chemicals were selected because they were detected in greater than 10% of the surface and subsurface samples in more than 10 analyzed samples, and they best represented major chemical groups (i.e., metals, pesticides/PCBs, SVOCs/PAHs, VOCs, butyltins, dioxins/furans).

Chemical distribution maps show data compiled to RM 16 because few data exist beyond this point. The chemical concentration ranges plotted on the maps vary between chemicals, and were determined by plotting frequency distribution curves (Category 1 and 2 detected concentrations) and selecting up to seven intervals that would represent the greatest number of samples for each chemical. Therefore, the maps summarize the relative concentration gradients for each target analyte for all existing surface and subsurface sediment data (detected values only). Sample locations of non-detected chemical concentrations are also shown. The same chemicals are mapped for subsurface sediment using the same concentration interval

as those used for surface sediments. The maximum concentration measured in subsurface samples from each core location is shown. The distributions of metals (including organotins) and organic chemicals are discussed separately below. The discussion of chemistry data below is restricted to the location of *maximum* concentrations (i.e., red-colored symbols). A comprehensive discussion of chemical distributions in sediment within the LWR will be provided in the updated CSM. The selected chemical distribution maps presented in Maps 4-3 to 4-38 indicate that the highest detected chemical concentrations across a range of metals and organic compounds are not widespread in the LWR and are generally restricted to specific off-channel areas.

Metals and Tributyltin

The bulk sediment distributions of arsenic, cadmium, copper, lead, mercury, zinc, and TBT (bulk and in porewater) are plotted in Maps 4-3 through 4-20 (surface) and Maps 4-21 through 4-38 (subsurface). Overall, high metal and TBT concentrations are not widespread in the ISA and generally appear to be associated with specific facilities and operations occurring in physically sheltered areas off the main river channel. Relative to other concentrations detected in the ISA, maximum concentrations of arsenic were measured off MarCom (surface), U.S. Moorings (surface), Triangle Park (subsurface), Portland Shipyard (surface and subsurface), and in Swan Island Lagoon (surface). Maximum cadmium concentrations were measured in Terminal 4 (Slips 1 and 3, surface and subsurface), Willbridge Bulk Fuel Terminal (surface), Swan Island Lagoon (surface), and on the riverside of the Equilon dock. Maximum copper concentrations were measured in surface Marcom sediments, the Portland Shipyard (surface and subsurface), and in Swan Island Lagoon surface sediments. Maximum lead concentrations were measured off several facilities, including Oregon Steel Mills (surface), Terminal 4 Slip 1 (surface) and Slip 3 (surface and subsurface), MarCom (surface and subsurface), Hendron Tow Boat (surface), U.S. Moorings (subsurface), ATOFINA (surface), Portland Shipyard (surface and subsurface), Swan Island Lagoon (surface), between the City of Portland Outfall 18 and the inside of the Equilon dock, and the riverside of the Equilon dock. Maximum mercury concentrations were measured in surface and subsurface Portland Shipyard sediments. Maximum zinc concentrations occur in Terminal 4, Slip 3 surface and subsurface sediments, MarCom (surface), U.S. Moorings (surface), Portland Shipyard (surface and subsurface), Swan Island Lagoon (surface), and in the vicinity of Terminal 1 and Outfall 16 (surface and subsurface). The Portland Shipyard and the mouth of the adjoining Swan Island Lagoon have the highest porewater TBT levels in surface sediments. In addition to those facilities with porewater TBT, facilities with the highest bulk TBT in sediments included Schnitzer Steel's International Slip (surface) and Triangle Park (subsurface).

In general, sediments in the main river channel do not show maximum metals concentrations relative to nearshore areas. Exceptions include navigation channel sediments at RM 7.7 (surface copper, subsurface bulk TBT) and RM 6.5 (surface TBT porewater).

Organic Compounds

The distributions of bis(2-ethylhexyl)phthalate, total HPAH, total LPAH, total PCBs, 2,3,7,8-TCDD, total DDTs, dibenzofuran, 4-methylphenol, diesel fuels, and xylene in sediments (detected concentrations only) are plotted in Maps 4-3 through 4-20 (surface) and Maps 4-21 through 4-38 (subsurface). As with the metals, relatively high levels of organic chemicals are generally restricted to nearshore facilities in the ISA. For example, the highest concentrations of total HPAH and/or LPAH have been measured in the vicinity of bulk fuel facilities (ARCO – surface and subsurface, Mobil Oil - surface, Kinder-Morgan Liquid Terminal – subsurface), PGE Harborton (subsurface), Linnton Plywood Association (subsurface), Transloader (subsurface), Hendron Tow Boat/Marine Finance (surface and subsurface), U.S. Moorings (surface and subsurface), Gasco facility (surface and subsurface extending into the channel), Wacker Siltronics (surface and subsurface), the McCormick & Baxter site (surface and subsurface) and Willamette Cove (surface and subsurface), the dock at ATOFINA (surface and subsurface),Goldendale Alumina (surface), offshore at UPRR, and at the Port of Portland's Terminal 4 (surface and subsurface). Similarly, the highest concentrations of total DDTs have been measured just offshore of the ATOFINA Chemicals facility.

Maximum PCBs concentrations have been observed in the vicinity of Oregon Steel Mills (surface), Wacker Siltronics (surface), around the Portland Shipyard and in Swan Island Lagoon (surface and subsurface), between the City's Outfall 18 and inside the Equilon dock, (surface), in the vicinity of Terminal 1 and the City's Outfall 16 (surface and subsurface), off Goldendale and UPRR (surface), and Glacier Northwest (subsurface). Maximum concentrations of dioxins and furans were detected off McCormick & Baxter (surface). Maximum concentrations of bis(2-ethylhexyl)phthalate have been measured in Swan Island Lagoon(surface); at the adjacent Portland Shipyard (surface); at the Equilon facility (riverside - subsurface); at ATOFINA (subsurface); at Terminal 4, Slip 1 (surface); at the McCormick & Baxter site (surface); and in the vicinity of Terminal 1, both offshore and near the City's Outfall 16 (surface).. Maximum dibenzofuran concentrations have been measured in sediments adjacent to the McCormick & Baxter site (surface),Willamette Cove (subsurface), Oregon Steel Mills (surface), Terminal 4 Slip 3 (surface), Mobil Oil (subsurface), Transloader (subsurface), Hendron Tow Boat (subsurface), Gasco (surface), Wacker Siltronics (surface and subsurface), U.S. Moorings (subsurface), and offshore of UPRR (surface). Maximum concentrations of 4-methylphenol were measured in sediments at Willbridge Fuel Terminals (surface), in Swan Island Lagoon (surface), and off the Gunderson facility (surface). Maximum concentrations of xylene have been detected at the Portland Shipyard (surface) and at Gasco (surface and subsurface). Maximum concentrations of diesel fuels occurred at Terminal 4 Slip 3. Like the metals, some organics are present in channel sediments, including dibenzofuran and PAHs at RM 6.3.

Trends in Chemical Concentrations by River Mile

Summary statistics for surface sediments and subsurface sediments, organized by river mile, are shown in Tables 4-5 and 4-6, respectively (historical Category 1 and Category 2 data since 1990, dredged sediment concentrations removed). Among analyte groups in the historical surface and subsurface data, PAHs were detected most frequently and were detected in greater than 10% of the samples collected in the LWR. Between RM 2 and RM 11, metals, PAHs, phthalates, total DDTs, total PCBs, dibenzofuran, 4-methyphenol, diesel fuels, and butyltins were detected in greater than 10% of the samples. However, some chemicals were unique to particular river mile segments in part because of the sample locations where these chemicals were analyzed. These chemicals are shown by river mile in Figure 4-1.

Average chemical concentrations for arsenic, cadmium, copper, lead, mercury, zinc, TBT (bulk measurements), bis(2-ethylhexyl)phthalate, total HPAH, total LPAH, total PCBs, total DDTs, 4-methylphenol, dibenzofuran, diesel fuel, xylenes, 2,3,7,8-TCDD, total organic carbon and percent fines (clay+silt) are shown graphically by river mile in Figure 4-2. Both surface and subsurface average sediment chemical concentrations are compared on each graph. It should be noted that the patterns that emerge from this display may result from the fact that there are more surface than subsurface samples. Some general observations are presented here for purposes of preliminary screening. Average subsurface chemical concentrations of mercury, bulk TBT, total DDTs, and diesel fuel are generally higher than corresponding average surface concentrations. This pattern is also true for total PCBs between RM 4 and RM 9. In contrast, average surface concentrations of bis(2-ethylhexyl)phthalate and 4-methylphenol are generally higher than corresponding average subsurface concentrations. The same is true for total HPAHs between RM 6 and RM 11; copper between RM 1 and RM 3, RM 4 and RM 7, and RM 8 and RM 11; and arsenic between RM 2 and RM 4, RM 5 and RM 7, and RM 8 and RM 11. For the few historical xylene and 2,3,7,8-TCDD measurements, average surface concentrations were greater than corresponding subsurface measurements. In addition, average surface and subsurface concentrations of TBT, total DDTs, total PCBs, total HPAHs, total LPAHs, and copper do not greatly differ from one another.

Patterns also emerge relative to river miles. In general, average surface chemical concentrations were generally higher than corresponding average subsurface concentrations between RM 2 and RM 3 and between RM 9 and RM 10. The opposite (greater subsurface than surface average concentrations) was true between RM 0 and RM 1 and between RM 3 and RM 4. Peaks in average concentrations also occur at certain river miles. Average surface concentrations of dibenzofuran (RM 7 to 8), zinc (RM 9 to 10), cadmium and lead (RM 2 to 3), and arsenic (RM 2 to 4, RM 5 to 6 peak well above corresponding average subsurface concentrations. For mercury, average subsurface concentrations peak well above average surface concentrations between RM 3 and RM 4. Peaks in metal concentrations generally occur between RM 2 and RM 6 and between RM 8 and 9. Peaks in DDT, 2,3,7,8-TCDD, and diesel fuel concentrations occur between RM 7 and RM 8. Xylene

concentrations peak between RM 6 and RM 7. Total PCBs concentrations peak between RM 2 and RM 3 and again between RM 9 and RM 10. With the exception of bis(2-ethylhexyl)phthalate and 4-methylphenol, maximum chemical concentrations generally occur between RM 2 and RM 9, bracketing Portland's industrial area. The broad, bell-shaped curves of average total HPAH and total LPAH concentrations between RM 2 and RM 9 support this observation.

4.3 WATER QUALITY STUDIES

Water quality in the LWR reflects the diverse land uses and large size of the watershed. Chemicals in discharges and runoff from the variety of agricultural, urban, and forested land uses in the Willamette River basin are combined in the river by the time it reaches Portland. Water quality in the ISA may be additionally affected by point source discharges, surface water runoff, contaminated groundwater, and other sources discharging directly to this reach of the river (see Section 3).

The objective of this section is to review the water quality data most relevant to sediments and aquatic life in the ISA. For purposes of this Work Plan, data collected prior to 1990 are considered historic; data collected since 1990 represent current water quality conditions. For both recent and historic data, conventional parameters, including temperature, pH, dissolved oxygen, and nutrients, have the largest number of measurements. These parameters are the least costly to measure, provide a preliminary indication of water quality conditions, and use analytical methods that have been available for several decades (Fuhrer et al. 1996). However, they are not related to releases of hazardous substances and are therefore not of concern in the context of CERCLA. The chemicals measured frequently in bottom sediments (e.g., trace metals and organic compounds) have not been measured frequently in the water column, primarily due to the high cost of analysis.

This section reviews studies and summarizes data indicative of water quality in the river. Both general water quality (as indicated by routine monitoring conducted by government agencies) and site-specific water quality data are described. This section does not include water quality data collected as part of permitted discharge monitoring or stormwater data (see Section 3 for information on these sources and monitoring requirements).

4.3.1 Historical Water Quality

Conventional Parameters

Prior to 1990, dissolved oxygen (DO) was the conventional parameter of greatest concern in the Willamette River (Fuhrer et al. 1996; Rickert et al. 1977). Most aquatic organisms require adequate DO concentrations to survive, and anadromous cold-water fish are particularly sensitive to DO levels. Late summer, when river flow is lowest and air temperature highest, is historically the most critical period for DO

levels in the LWR. Gleeson (1972) summarized DO data collected from 1929 to 1971. During the summer low-flow periods in the 1940s and 50s, the DO concentrations in Portland Harbor were below the state standard of 5 mg/L. A dramatic increase in DO was evident by the mid-1970s due to upgrading of wastewater discharges to secondary treatment and the release of additional water from the dams during the summer (Fuhrer et al. 1996).

The average temperature in the Willamette River has not changed significantly over time, particularly when compared to the seasonal changes and annual maximum and minimum temperatures (Gleeson 1972). Gleeson reviewed temperature data for 13 of the 41 years from 1929 through 1970. In all years reviewed, at least one station in the river had temperatures greater than 21ºC. As expected, peak temperatures in Portland Harbor corresponded to low water flow and highest air temperatures in July through September. Fuhrer et al. (1996) summarized monthly distributions of daily mean water temperatures in the Willamette River at Portland between 1976 and 1981. Minimum temperatures were consistently observed in January (0.1 - 9.0ºC), and maximum temperatures occurred in July and August (18 - 25.7ºC).

Bacterial concentrations have also been of concern. Methods for measuring and reporting bacterial concentrations have changed over time, and data are not directly comparable. However, Gleeson (1972) described historical trends in bacteria concentrations in the Willamette River. In general, bacterial concentrations during the 1920s and 1930s were elevated in the vicinity of municipalities and were roughly proportional to population, as all cities were discharging raw sewage to the river. By the 1940s, bacterial distribution patterns were the same but concentrations were increased, reflecting increased population. In the 1960s, bacterial concentrations were reported to be 5 to 100 times the limit considered safe for swimming. By the 1970s, bacterial concentrations began to decrease, reflecting improved sewage treatment. From 1962 to 1970, the average summer fecal coliform count dropped by a factor of 10 to 100 (Gleeson 1972).

Chemical Parameters

Tetra Tech et al. (1993) reviewed historical data on chemicals in the water column of the Willamette River and its major tributaries. Tetra Tech found that there are very little water column chemical data prior to 1990. DEQ routinely monitors major metals (e.g., aluminum, iron, manganese) but not chemicals that may be associated with the release of hazardous chemicals. Only one report in DEQ's database contained chemical data collected prior to 1990. Water samples were collected at DEQ Station #402000 (Map 4-39) on August 30 and September 1, 1982, and were analyzed for over 100 volatile and semivolatile organics as well as PCBs and pesticides. Only four compounds were detected at levels that could be quantified: bis(2-ethylhexyl) phthalate, di-n-butyl-phthalate, di-n-octyl phthalate, and trichloroethylene.

4.3.2 Current General Water Quality

General (i.e., not associated with a specific facility) water quality data collected since 1990 in the LWR are summarized in this section. The main sources of data were DEQ and USGS monitoring programs. These data were collected as part of several programs, including DEQ's ambient monitoring program, USGS's National Water Quality Assessment program, and the Willamette River Basin Water Quality Study cooperative program between USGS and DEQ. These data were obtained through the EPA STORET and DEQ's LASAR database.

Nearly all data were collected at four DEQ or USGS monitoring stations in the LWR main stem (Table 4-7; Map 4-39). These stations had the greatest amount of data, most frequent sampling (including all months and flow conditions), and were determined overall to be most representative of general water quality in the lower river. Although there were data for other stations, they were sampled only on a single occasion or were representative of source characteristics rather than water quality in the river. Water quality data from the four DEQ and USGS stations most representative of general water quality in the river were obtained from the STORET and LASAR databases. These data are summarized in Table 4-8a-c. The most complete data are for conventional parameters. The ambient monitoring programs established by DEQ in the Willamette River also routinely monitor for metals, but not for organic pollutants. Recent organic data in the LWR main channel are limited to herbicide and pesticide analyses reported by USGS.

Conventional Parameters

Selected conventional water quality measurements since 1990 that are most relevant to sediment and aquatic life criteria and indicative of general water quality are summarized in Table 4-8a.[7] Temperature remains the water quality parameter of greatest concern in the LWR and is one of the reasons the LWR appears on the State of Oregon's 303(d) list under the Clean Water Act (DEQ 1998). Temperature measurements exceeding 20ºC have been reported in the late summer each year by DEQ. The State of Oregon currently plans to develop a TMDL for temperature in the LWR by 2003 (DEQ 2001a).

DEQ (2000d) reported that water quality in the main stem of the LWR remains poor, but showed significant improvement from 1990 to 1999 based on the Oregon Water Quality Index, a general water quality score incorporating 10 conventional water quality variables. Fecal coliform, elevated nutrients, and biological oxygen demand were cited as contributing factors to the low Oregon Water Quality Index score. DEQ is also developing TMDLs for bacteria, algae, and DO upstream of the LWR because of these persistent problems (DEQ 2001b).

[7] Types of measurements monitored but not included in Table 4-7 include color, conductivity, alkalinity, oxygen demand, and nutrients.

Inorganic Parameters

Although water column data for major metals are available for a limited number of locations, there are fewer trace metal measurements. In general, routine monitoring samples collected by DEQ are analyzed for major metals, including aluminum, iron, and manganese. A few samples collected by DEQ were analyzed for trace metals. However, a greater number of water samples collected by USGS from 1990 to 1999 (Station #14211720, LWR at Portland) were analyzed for over a dozen different dissolved trace metals. These data are also summarized in Table 4-8b. Detectable concentrations of copper, lead, nickel, selenium, and zinc were reported.

Recent studies have prompted the Oregon Department of Health Services (ODHS) to issue an advisory concerning elevated mercury concentrations in several fish species in the LWR. An ODHS (2001) news release states "Mercury in the fish is believed to come from natural volcanic and mineral sources in the headwaters of the river and possibly from a number of human-made sources along the river." Based on samples collected from 1969 through 1997, average mercury concentrations in smallmouth and largemouth bass and northern pikeminnow were 0.63 ppm. EPA's mercury criterion for human health is 0.30 ppm (ODHS 2001). This advisory has resulted in another listing for the LWR on the State's 303(d) list (DEQ 1998). The listing requires the DEQ to determine a TMDL for mercury in the LWR by 2003 (DEQ 2001b).

Organic Parameters

Recent data on water column concentrations of organic pollutants are also limited. No water column data for semivolatile or volatile organics collected during the past decade in the main channel of the LWR were found in the EPA or DEQ databases.

USGS analyzed water samples from the LWR at Portland (Station # 014211720) for approximately 100 organic compounds consisting almost entirely of herbicides and pesticides. Samples were collected between 1993 and 1998, and the results are summarized in Table 4-8c. Thirty compounds were detected. Atrazine, metolachlor, simazine, and deethyl atrazine were the most frequently detected pesticides. Of the pesticides and herbicides included as chemicals of interest in sediments in the LWR (SEA et al. 2002a), only dieldrin (total), DDE, and DDT were detected in water samples. Total PCBs were undetected in nine water samples collected by the USGS between 1994 and 1997.

EPA completed a TMDL assessment and allocation for dioxin in the Willamette River as part of a larger program for the Columbia River basin, and approved the dioxin TMDL in 1991. The TMDL develops waste load allocations for the chlorine bleaching pulp mills, including the Pope and Talbot mill located on the Willamette River at RM 148. The TMDL may be revised if other dioxin sources are identified. The target (i.e., loading capacity) dioxin allocation for the Willamette River (measured at Portland) is 0.54 mg/day.

4.3.3 Current Site-Specific Water Quality

Site-specific water quality data collected since 1990 in the LWR are summarized in this section. These data were collected as part of investigations pertaining to specific facilities, and therefore are not considered representative of overall water quality conditions in the ISA.

The Rhone-Poulenc survey (Woodward-Clyde Consultants 1995) analyzed water samples for 205 chemicals consisting of semivolatile and volatile organics, herbicides, pesticides, and dioxins/furans. Detected results included: 11 dioxins/furans, 5 pesticides, and 2 semivolatile organics (Table 4-8d). The McCormick & Baxter survey (PTI 1992) analyzed water samples for 18 PAHs only. Fluoranthene, fluorine, naphthalene, phenanthrene, and pyrene were detected (Table 4-8e).

A recent investigation at the McCormick & Baxter site (Ecology & Environment 2003) analyzed unfiltered and filtered water samples collected by EPA, DEQ, and Oregon State University (OSU) for PCP, metals (i.e., arsenic, chromium, copper, and zinc), and PAHs. Chromium, copper, zinc, and 15 PAHs were detected in the unfiltered samples, while arsenic, copper, fluoranthene, and pyrene were detected in filtered samples (Table 4-8f).

OSU also deployed passive sampling devices at their surface water grab stations at the McCormick & Baxter site. Semipermeable membrane devices (SPMDs) were used to monitor dissolved bioavailable organic constituents (PCP and PAHs), and diffusive gel thinfilms were used to assess labile metals (arsenic, chromium, copper, and zinc (OSU undated). Chromium, copper, acenaphthalene, anthracene, fluoranthene, fluorene, phenanthrene, and pyrene were detected (Table 4-8g).

4.4 ECOLOGICAL STUDIES

This section contains an overview of previous ecological studies conducted in the ISA. Details of these studies and how they will be used in the risk assessment process are provided in the problem formulation section of the Ecological Risk Assessment (ERA) Approach (Appendix B). The following is a description of the relevant sediment toxicity, benthic community, enzyme induction, histopathology, and tissue residue studies. Additional details, including results, maps, and descriptions of habitat types, fish, amphibians, aquatic plants, birds, and mammals, are found in Appendix B.

4.4.1 Sediment Toxicity

Sediment bioassays are laboratory tests in which benthic or epibenthic organisms are exposed to sediments. After a defined exposure period, organism survival or some

other measure of an adverse biological effect is observed. Sediment toxicity tests are one tool to predict whether sediments have an adverse impact on resident species.

In 1998, the Corps, EPA, Washington State Department of Ecology, DEQ, and Washington State Department of Natural Resources prepared the Dredged Material Evaluation Framework for the Lower Columbia River Management Area (LCRMA) (USACE et al. 1998) to provide guidelines for dredged material sampling and testing. Since completion of the draft, dredging proponents with projects in the LWR have generally performed, when required, two tests to assess the suitability of dredged material for disposal at a freshwater site. These tests include the amphipod (*Hyalella azteca*) 10-day survival test and the midge (*Chironomus tentans*) 10-day survival and growth test.

In studies completed prior to the draft LCRMA guidelines, acute bioassays were performed using *H. azteca*, *Chironomus riparius*, *Daphnia magna* (water flea), and rainbow trout. These older studies also included elutriate testing of *D. magna* and trout. An elutriate test considers the effects of dissolved chemicals and chemicals associated with suspended particulates (after mixing has occurred) on water column organisms. A few studies used the Microtox test, which measures a decrease in bacterial luminescence caused by the presence of chemicals in sediments. Microtox tests are generally not currently used in regulatory programs.

All bioassay data were validated using "QA1" bioassay data validation guidelines (PTI 1989). QA1 is a term used by regulators in the Dredged Material Management Program (the umbrella regulatory agencies overseeing LCRMA) that allows an abbreviated level of review while providing confidence that the data have been adequately checked and approved for regulatory decision making. The QA1 level of review checks completeness, holding conditions, standard reporting methods, and QA/QC results for negative control, reference sediment, positive control (reference toxicant), and measured water quality parameters according to standard testing methods. Information provided in a standard laboratory report is generally adequate for performing a QA1 review.

For this data compilation, if the QA1 review led to questions concerning data quality, the data were categorized as Category 2 (unknown or of suspect quality). Otherwise, the data were placed in Category 1 (of known and acceptable quality). Category 2 data are those generally lacking supporting information to perform a QA1 level of review. One survey had two samples that were analyzed outside of recommended holding times, and those samples received Category 2 classification. Category 1 and Category 2 data designations are provided for each study listed in Table 4-9.

Table 4-10 lists existing bioassay studies for the LWR. Sample collection locations are shown in Map4-40. Bioassay results, including maps, specific to the ISA are listed in Appendix B, Section 3.5.

4.4.2 Benthic Community Structure

Benthic macroinvertebrates utilize various habitat types within a large river ecosystem. These habitats can generally be divided into soft and hard substrates, with soft substrates supporting an infaunal community and hard substrates an epibenthic community. These habitats are typically quite different in community structure and function.

The structure and function of macroinvertebrate communities within the Willamette River basin have been extensively investigated. However, few studies have focused on the LWR. Tetra Tech and Taxon Aquatic Monitoring Co. (1994) reported on the benthic macroinvertebrate community structure at six stations as part of the Willamette River Basin Water Quality Study. Dames & Moore (1998) sampled 16 stations in the Portland Harbor area, and Landau Associates (2000b) collected samples at 10 locations near Ross and Hardtack islands. Hjort et al. (1984) and Ward et al. (1988) conducted other limited investigations. In the summer and fall of 2002, the LWG conducted surveys of the epibenthic and infaunal macroinvertebrate communities found in the ISA as part of the Round 1 assessment of Portland Harbor. Detailed information about benthic communities in these and previous studies in the LWR is found in Appendix B.

4.4.3 Fish Community

Ellis Ecological Services (2000) reviewed the published and unpublished literature relating to the fish community in the LWR. Results from this review and more current research on fish use of the LWR are presented in Appendix B.

4.4.4 Wildlife and Aquatic Plants

Some literature exists that documents bird, mammal, amphibian, and aquatic plant species expected to occur in and around the LWR (Puchy and Marshall 1993; Csuti et al. 1997; Adolfson et al. 2000). In the summer of 2002, the LWG conducted a plant and amphibian survey of the LWR as part of the Round 1 assessment of Portland Harbor. Results from this survey and summaries of the above literature are presented in Appendix B.

4.4.5 Enzyme Induction Studies

Several enzyme induction studies of hepatic cytochrome P450-1A1 have been conducted in fish collected within the ISA and great blue heron embryos collected outside the ISA. These studies are summarized below. Cytochrome P450 enzymes are important in detoxifying exogenous compounds in most fish, birds, and mammals. Induction of cytochrome P450-1A1, which catalyzes ethoxyresorufin O-deethylase (EROD) and aryl hydrocarbon (benzo[a]pyrene) hydrolase activity, has been correlated with toxic potency of contaminants. Per the AOC/SOW, the risk

assessment will only consider effect endpoints associated with growth, reproduction, and mortality. The following studies have been evaluated per requirements of the AOC/SOW. In the ecological risk assessment, these studies will be evaluated to determine if any of the enzyme induction endpoints are appropriate for inclusion in the effects assessment.

Curtis et al. (1993) investigated the sensitivity of cytochrome P450-1A1 induction in fish as a biomarker for distribution of 2,3,7,8-TCDD and 2,3,7,8-tetrachlorodibenzofuran (TCDF) in the Willamette River. This study examined the relationships between TCDD or TCDF and induction of microsomal EROD and total cytochrome P450-1A1 content in muscle tissue from the common carp and the northern pikeminnow. Thomas and Anthony (1997) used both EROD and the H4IIE assays to detect induction of cytochrome P450-dependent enzymes in great blue heron embryos exposed to 2,3,7,8-TCDD and structurally similar compounds at Ross Island (a site upstream of the ISA). The EROD assay determined the impact of chemicals in the egg on a developing embryo, and the H4IIE assay determined the potency of the egg contents to induce enzymatic activity in rat hepatoma cells.

4.4.6 Histopathology

This section summarizes available data in the LWR related to animal histology or histopathology. Histopathology refers to microscopic changes in diseased animal tissues as a result of exposure to chemicals. In the ERA, these studies will be evaluated to determine if any of the histopathological endpoints are appropriate for inclusion in the effects assessment.

Fish Histopathology

DEQ (1994) and Tetra Tech (1993) collected northern pikeminnow and largescale suckers from various sites along the Willamette River. In the Portland Harbor, samples were collected at RM 1 and within the ISA at RM 6.5 (Tetra Tech 1993) and at RM 7 (DEQ 1994). Both studies qualitatively evaluated external and internal features and measured blood parameters using assessment methodology developed for salmonids.

Curtis et al. (1993) conducted a microscopic examination of common carp, cutthroat trout, and northern pikeminnow liver, gills, kidneys, spleen, stomach, and gonads. One station was sampled in the ISA at RM 7.

As part of the McCormick & Baxter RI (PTI 1992), Pastorok et al. (1994) examined 249 largescale sucker livers, including those collected from two stations near RM 7 and one station near RM 6.

Two studies have addressed skeletal deformities in fish collected in the LWR. From 1992 to 1994, Tetra Tech (1993, 1995) examined skeletal abnormalities in juvenile northern pikeminnow collected at RM 3. The incidence of skeletal abnormalities at

RM 3 was consistently low and within a range of 2 to 5% reported for unstressed natural fish populations and laboratory stocks (Tetra Tech 1995). In 1998, EVS Environmental Consultants (2000) determined the incidence of skeletal abnormalities to be 19.7% in 71 chiselmouth collected upstream of the ISA at RM 15.

Avian and Mammalian Histopathology

In general, very few studies have been conducted that address histopathological changes in birds and mammals occurring in the LWR area. One study examined a great blue heron rookery in the LWR upstream of the ISA. Thomas and Anthony (1997) compared eggshell thinning at the Ross Island heronry with that at Fisher and Bachelor islands in the lower Columbia River. Henny et al. (1996) conducted a study in the Portland-Vancouver area of the Columbia River that examined relationships between reproductive tract disorders in river otters and chemical concentrations measured in river otter livers.

4.4.7 Tissue Residue Studies

Very few studies of chemical residues in fish and benthic invertebrates have been undertaken in the LWR. The following discussion summarizes data compiled from various toxicological studies of chemical residues in fish and benthic invertebrates of the Willamette basin, with particular emphasis on studies or portions of studies that have occurred in the LWR. The tissue residue data will be used to assess risks associated with the consumption of fish and benthic invertebrates by birds and mammals, as well as risks to fish species resulting from their chemical exposure within the ISA. Tissue chemistry results are summarized in Table 4-11. When possible, concentration data were converted to wet weight.

Fish and Benthic Invertebrate Tissue Residue Studies

Tissue residue studies were evaluated for data quality in the same manner as the sediment chemistry data (see Appendix F). Of the seven studies identified, none of the data were considered Category 1 due largely to the lack of supporting analytical QA/QC information. However, these studies are briefly summarized below, as they remain valuable in the initial understanding of tissue residue levels in fish and invertebrates from the LWR and in formulating future work efforts. Tables B-3a and B-3b in Appendix B provide the complete set of fish tissue data collected within the ISA.

PTI (1992) collected largescale sucker and crayfish from five locations near the McCormick & Baxter site (at RM 7). PAHs and metals were detected in both the sucker muscle tissue and the whole-body crayfish tissue.

Black crappie, common carp, and smallmouth bass were collected by *The Oregonian* (2000). Organochlorine pesticides (including DDT), PCBs, and mercury were detected in whole-body tissues collected in the Harborton Forest and wetlands, Terminal 4, and RM 5 to 6.

Mercury was detected in muscle fillets of common carp, largemouth bass, northern pikeminnow, largescale sucker, and smallmouth bass collected by DEQ (2000b). No other chemicals were analyzed in this study.

EPA (1992) analyzed fillet and whole-body tissues of common carp and northern pikeminnow collected in the railroad bridge area (at RM 7). Six carp fillets and six northern pikeminnow whole-body samples were analyzed for dioxins and furans. In addition, three carp fillets and three northern pikeminnow whole-body samples were analyzed for pesticides, PCBs, and DDTs.

Finally, one common carp whole-body tissue sample was collected from RM 9 and analyzed for dioxins and furans by Bonn (1998).

Additional Bioaccumulation Studies

In addition to the data cited above and in Appendix F and Table 4-11, other sources of applicable bioaccumulation data have been identified. In November 1999, the Corps (1999) collected five sediment samples from the LWR at locations within and outside the ISA. Sediment samples were submitted for 28-day bioaccumulation testing to evaluate uptake of 4,4'-DDD, 4,4'-DDE, and 4,4'-DDT in *Lumbriculus variegatus*, a freshwater oligochaete. As shown in Table 4-12, 4,4'-DDD and 4,4'-DDE were detected in the oligochaete.

Thomas and Anthony (1997) measured concentrations of pesticides, PCBs, dioxins, and furans in fish tissue and heron eggs at Ross Island to evaluate chemical biomagnification from prey items of the great blue heron.

4.5 SUMMARY OF HUMAN USES

This section describes the current understanding of the physical and biological setting of the ISA as it pertains to potential human uses, including specialized groups that may use the river for various activities. Most of the demographic information relating to the ISA is based on historical background and documented human uses. This information is used to determine potential receptor populations and to develop the general CSM.

Portland Harbor and the Willamette River have served as a major industrial water corridor for more than a century. Industrial use of the ISA and adjacent areas has been extensive. The majority of the ISA is currently zoned for industrial land use and is designated as an "Industrial Sanctuary" on the Portland Comprehensive Plan Map (City of Portland 2001a). The Portland industrial sanctuary policy is designed to encourage the growth of industrial activities in the city by preserving some industrial land primarily for manufacturing purposes. The Guild's Lake Industrial Sanctuary Plan (GLISP) is intended to preserve and enhance industrial land in the area generally bounded by Vaughn Street on the south, the St. Johns Bridge on the north, Highway 30 on the west, and the Willamette River on the east (City of Portland 2001a). Over

many decades, public and private investments in infrastructure, such as marine, rail and highway facilities as well as investments in industrial physical plants, have made the Guild's Lake Industrial Sanctuary one of the premier heavy industrial districts in the Pacific Northwest. The purpose of the GLISP is to maintain and protect this area as a dedicated place for heavy and general industrial uses. The plan's objectives were adopted as part of Portland's Comprehensive Plan to ensure preservation of this land use over the next 20 years.

Much of the shoreline in the ISA includes steeply sloped banks covered with riprap or constructed bulkheads, with human-made structures such as piers and wharves over the water in various locations. A comprehensive update of Portland's Willamette Greenway Plan and related land use policies and zoning is underway, addressing all of the Willamette riverfront in Portland (City of Portland 2001b). The plan update may affect land use practices (e.g., stormwater management) in Portland Harbor, but it will not affect the "Industrial Sanctuary" designation.

Worker activities that may include contact with sediments and surface water at industrial and commercial facilities in the ISA are limited in the shoreline areas due to the sparse beach areas and high docks associated with most of the facilities.

In addition, the LWR provides many natural areas and recreational opportunities, both within the river itself and along the riverbanks. Within the ISA, Cathedral Park, located under the St. Johns Bridge, includes a sandy beach area and public boat ramp and is used for water skiing, occasional swimming, and waterfront recreation. Recreational beach use also may occur within Willamette Cove, which is a riverfront natural area, and in Swan Island Lagoon. Swan Island Lagoon includes a public boat ramp. Additional LWR recreational beach areas exist on Sauvie Island and in Kelly Point Park, both of which are outside of the ISA. Potential recreational beach use areas in the ISA are shown in Map 4-41a-c.

The St. Johns Town Center is a mixed-use district that extends to the waterfront on the east side of the Willamette River at the St. Johns Bridge. Proposals emerging in the recent St. Johns-Lombard Plan project and neighborhood-generated Linnton Neighborhood Plan include redevelopment for areas near the Willamette River. These areas are potential examples of the "vibrant waterfront districts and neighborhoods" theme in the River Renaissance Vision developed by the City of Portland.

The exact extent to which commercial fishing occurs within the ISA is currently not known. No reports of commercial fisheries for anadromous salmonids on the Willamette River have been found. A limited commercial crayfish fishery exists in the Lower Willamette River. However, non-commercial fishing is conducted throughout the LWR basin and within the ISA, both by boaters and from locations along the banks. A news story by *The Oregonian* and the limited interviews by ATSDR suggest that the groups most likely to be catching and eating fish from the LWR include immigrants from Eastern Europe and Asia, African-Americans, and

Hispanics. These same sources also suggest that the most consumed species are carp, bullhead catfish, crappie and small-mouth bass (ATSDR 2002). Other sources (CRITFC 1994) suggest that Native Americans fish in the Willamette River. The LWR provides a ceremonial and subsistence fishery for Pacific lamprey and spring chinook salmon for Native American Tribes. Many areas in the LWR are also important currently for cultural and spiritual uses by local Native Americans.

Transients have been observed along the LWR, including some locations within the ISA. The observation of tents and makeshift dwellings affirms that transients were living along some riverbank areas. Transients are expected to continue to utilize this area in the future.

4.6 USABILITY OF HISTORICAL DATA

A substantial amount of historical data for the LWR have been compiled and presented in earlier sections of this Work Plan. The usability of these data for the risk assessment and FS needs to be ascertained as the distribution of acceptable historical data will affect the development of RI sampling programs. The principal issues related to the usability of historical data include data quality, sediment stability, and the intended use of the data. All of these factors must be acceptable for data to be considered usable.

The quality of the existing data has been evaluated (Section 4.1 and Appendix F) and data have been categorized as Category 1 (data are of known quality and are considered to be acceptable for use in decision making for the Site) or Category 2 (data are of generally unknown or suspect quality). This evaluation focused on individual analyte groups within each survey when possible, and so any given survey may contain all Category 1 data, all Category 2 data, or a combination of Category 1 and 2 data. Overall, the existing data collected within the ISA that qualify as Category 1 data are principally associated with sediment chemistry and toxicity studies using benthic organisms. Category 1 sediment chemistry data will be evaluated for use in determining the distribution of chemicals in the ISA, understanding sources, and identifying remediation areas. As discussed further in this section, it is believed that much of this data will be usable for these purposes; however, those Category 1 data determined to be critical to human health or ecological risk assessments require an EPA-approved level of data validation, comparable to Washington State Department of Ecology's "QA2" evaluation. Currently, there are less than 10 sediment investigations meeting these criteria, rendering most existing Portland Harbor sediment chemistry data unusable for risk assessment. In addition, almost all other types of historical environmental data collected have been determined to be Category 2 data and therefore may be of limited use in the RI/FS, subsequent to project scoping.

Table 4-13 presents the number of post-1990 Category 1 sediment samples in Portland Harbor by river mile for each analyte class. As the table demonstrates, there are considerable existing Category 1 sediment analysis data available for use in the RI/FS, such as the development of sediment management areas. The number of samples analyzed varied for each analyte class: excluding conventionals, up to 507 surface sediment samples and 337 subsurface sediment samples were each analyzed for a given analyte class. PAHs were the most frequently reported analyte class for both surface and subsurface sediment samples. Herbicides and dioxins and furans were the least frequently reported analyte class for both surface and subsurface sediment samples.

The evaluation of sediment stability will continue to determine whether existing chemical concentrations continue to represent conditions at the locations where sampling occurred. Results of the LWG's STA®, SPI, and bathymetry studies (Section 2) suggest that the majority of the ISA has been a relatively stable and depositional physical sediment environment over the last decade. Nearshore areas (i.e., sediment at water depths shallower than –20 feet CRD) are predominantly stable with episodic deposition, apart from localized disturbances by non-flow-related physical processes (e.g., wind-generated waves) and/or anthropogenic disturbances (e.g., prop wash, nearshore construction, dredging) (SEA 2002f). Channel areas from RMs 1.1 to 5.1 and RMs 7 to 9.7 are also predominantly depositional. A sediment transport/non-depositional zone occurs within the channel from RMs 5.1 to 7. The vast majority of Category 1 sediment samples were collected from nearshore areas, while very few (approximately 10) samples were collected from the channel from RMs 5.1 to 7. The evaluation of sediment stability will continue during the RI with the following types of data collections and evaluations:

- A third bathymetric survey has been completed and was provided to EPA in October 2003. An evaluation of the bathymetric changes using this new data set was provided to EPA in the Round 2 sediment and benthic toxicity testing FSP.
- A fourth bathymetry survey was completed in March 2004 following a relatively high flow event (approximately 140,000 cfs). These data will be available in the spring of 2004 to support the modeling effort (next bullet).
- Hydrodynamic and sediment transport modeling will provide important insights into the relative stability of sediment throughout Portland Harbor, including areas that may be expected to either erode or accrete under hydrodynamic conditions that have occurred since 1990 (the date of the earliest historical data used in this project). The technical approach memo for the modeling task is currently under EPA review.
- The Round 2 sediment and benthic toxicity testing FSP includes recommendations for sampling areas that have previously been sampled to assess the level of change in chemical concentrations. Chemical

concentration changes are anticipated due to analytical variability and environmental patchiness. However, if the pattern of chemical concentrations in a region of the ISA changes then the usability of the historic data in that area will need to be assessed.

- Radioisotope dating of sediment cores will likely occur in Round 2 when subsurface cores are collected. These data will provide information on the history of sediment deposition at the sample location.

The LWR is and will continue to be a dynamic river system, and it is inappropriate to assume that one data set may best represent conditions in the river. In fact, a combination of data sets that represent different points in time may best represent the range of conditions that could reasonably be expected to occur in the future. The analysis of sediment stability will help to define the areas that have the highest probability of changing over time.

The final consideration for determining data usability is evaluating the intended use of the data. For example, the historic database contains some samples with undetected concentrations of PCBs at high detection limits. From an analytical perspective, these data are Category 1 and acceptable for use. From a sampling design perspective, these data are not useful because of the uncertainty associated with concentrations below the high detection limits and additional sampling and analysis may be necessary. From a risk assessment perspective, these data are also likely not useful because of the uncertainty associated with concentrations below the high detection limits and therefore the risk associated with these concentrations cannot be defined. As another example, chemical data from areas that have been dredged are useful for assessing potential historic sources but are not useful for assessing current risk.

The majority of information for this assessment will be available following Round 2. This information includes evaluation of the third bathymetric survey, additional surface sediment chemistry, and results of hydrodynamic and sediment transport modeling. All existing Category 1 chemistry data to be used for any purpose during the RI/FS must first be evaluated to determine its suitability for use. Factors to be considered include, but are not limited to:

- The use of appropriate detection limits,
- Sample compositing techniques,
- Analytical methods,
- Age of data,
- Sample depth, and
- Whether the sample is located in an area of scour or deposition.

The comprehensive site characterization summary and data gaps analysis report that is prepared following Round 2 will contain an assessment of data usability based on available information. The RI report, prepared following Round 3, will contain an updated discussion of data usability.

5.0 PRELIMINARY CONCEPTUAL SITE MODEL

This section describes the preliminary conceptual site model (CSM) for the ISA that is based on the current understanding of the physical and biological characteristics of the LWR. The CSM is a written description and graphical presentation of the relationships between chemicals released into the environment and the receptors (human or ecological) that may be exposed. The primary components of a CSM are source(s), release mechanism(s), transport pathway(s), affected exposure media, exposure routes, and receptors. For an adverse effect to occur, each one of the above components must be present. The following sections present a model of the physical system (Section 5.1), including a summary of potential sources and potential release mechanisms, and a summary of the potential transport and exposure pathways to ecological (Section 5.2) and human receptors (Section 5.3). Additional details of the ecological and human health CSMs are found in Appendices B (ERA Approach) and C (HHRA Approach).

The preliminary CSM presented herein will be updated as a stand-alone report (updated CSM). The updated CSM will provide a detailed inventory of sources and pathways for chemicals to impact sediment, the groundwater/surface water Transition Zone, and surface water in the river. A revised CSM will be based on results of further review of upland groundwater and other source and pathway information and will be submitted to EPA in accordance with the project schedule (Section 9.5). The CSM will be further updated as information gathered at the Site triggers revisions or refinements of the CSM.

5.1 PHYSICAL CONCEPTUAL SITE MODEL

Figure 5-1 is the preliminary physical CSM that summarizes potential sources, release mechanisms, transport media, and exposure media in the ISA. Site history and site conditions that support the physical CSM can be found in Section 2 of this Work Plan. Each of these categories is discussed in the sections that follow.

5.1.1 Sources

Potential sources of chemicals to the ISA are detailed in Section 3 of this Work Plan. In total, sources that may affect or have historically affected sediment and water quality in the ISA include all point and nonpoint discharges or releases at the ISA and upstream of the ISA. Potential sources in the ISA include the full range of current and historical industrial and urban activities (see Table 3-1), including overwater activities and discharges from public and private outfalls. Potential sources located upstream and, to a much lesser extent, downstream (due to seasonal, tidally induced flow reversals in the river), include industrial, urban, agricultural, and silvicultural activities that may release chemicals to the river system that eventually are transported to the ISA.

5.1.2 Release Mechanisms

There are several potential release mechanisms by which chemicals may have reached or can reach the surface waters and sediments in the ISA (Figure 5-1). Point source releases include historic and on-going direct industrial discharges, outfalls associated with CSOs, and piped stormwater discharges. Nonpoint source releases include overland stormwater runoff from industrial, commercial, and residential areas adjacent to the ISA, as well as watershed-wide upstream source releases including runoff from agricultural and silvicultural areas in the Willamette basin. Other potential release mechanisms include spills (both land-based and in-water), wind- and precipitation-induced erosion and transport of soils, infiltration of liquids, leaching of buried wastes, chemical leaching from structures and vessels (discussed in Section 3.6), and chemical or biochemical processes that mobilize chemicals such that they migrate from soils and sediments to surface water and groundwater.

Erosion and Transport

Exposed surface soils in upland areas that drain to the river and are exposed along riverbanks can be eroded and transported to the river by runoff. Chemicals present in soils or adhering to soil particles may thereby be translocated to the river. The amount of potentially impacted soils that is exposed in the Portland Harbor area is expected to be relatively small, as the vast majority of the industrial area along the river is paved or covered by buildings. Therefore, erosion of impacted upland soils and transport to the river is not anticipated to be a major ongoing release mechanism at the ISA, although it may have been more significant in the past. Approximately half of the riverbank in the ISA is covered with various engineered materials. Erosion of exposed riverbank soils by episodic high river flows is likely to be a more significant mechanism than erosion of upland soil.

Chemicals in dust, soil, debris, and liquids present on impervious surfaces, such as roadways, parking lots, and building roofs, can be transported to the river by stormwater draining to outfalls within Portland Harbor. These materials collect on the impervious surfaces over time; therefore, it is anticipated that stormwater runoff events occurring after extended dry periods (e.g., early wet-season “first flush” storms) would transport relatively greater amounts of chemicals to the river than would individual, frequently spaced runoff events (e.g., mid-winter storms).

Wind erosion and transportation of chemicals in soil and dust is anticipated to be a relatively minor mechanism for releasing chemicals to the river. As mentioned above, there is little exposed soil in the industrial area along the river. Also, in comparison to other mechanisms, wind is not very effective at transporting significant mass from potential source areas to the river.

Infiltration, Leaching, Dissolution, and Adsorption

Chemicals may be present in soil as solids, dissolved constituents, or non-aqueous phase liquids (NAPLs), including light non-aqueous phase liquids (LNAPLs) and

dense non-aqueous phase liquids (DNAPLs). Liquids released to soil may infiltrate and percolate through the soil column to groundwater as diagrammed in Figure 5-2a.

LNAPLs released to soil will migrate vertically downward to low-permeability zones or to the water table where unrestricted. Thus, the vertical distribution of LNAPLs in the unsaturated zone is controlled by the depth of the water table, as well as by the vertical permeability and sorptive capacity of the sediments. Lateral migration of a LNAPL is controlled by (1) the gradient of the groundwater surface, (2) the presence of permeable layers within the uppermost-saturated unit, which is usually fill or undifferentiated fine-grained sediments, (3) the volume and rate of the release, (4) the presence or absence of human-made or natural preferential pathways, and (5) the physical characteristics of the LNAPL. At the groundwater surface, LNAPLs typically produce a dissolved plume for chemicals, such as aromatic volatile organic compounds (VOCs) [e.g., benzene, toluene, ethylbenzene, xylenes (BTEX)] and other chemicals that may extend some distance downgradient from the LNAPL itself. Attenuation processes, such as biodegradation, adsorption to soil particles, and various geochemical processes, affect the migration of dissolved organic plumes. The degree that these processes naturally attenuate a given plume and limit migration from the source depends on the groundwater conditions, aquifer matrix and the type of organic compound. Aromatic volatile compounds such as BTEX may be strongly attenuated through geochemical and biodegradation processes, whereas attenuation of chlorinated solvents and other recalcitrant compounds along the plume flow path may be minor due to low affinity for partitioning to the aquifer matrix and resistance to degradation under many conditions.

The vertical transport of DNAPLs is controlled by (1) the volume and rate of the release, (2) the specific gravity of the liquid, (3) the relative mobility of the constituent (the viscosity and the relative affinity for sediments), and (4) layering or permeability contrasts within the hydrogeologic units underlying the source area. The presence of laterally extensive, low-permeability materials will tend to mitigate the depth of penetration of a DNAPL. The fill and fine-grained alluvial sediments in the vicinity of the ISA tend to be highly stratified, and the resultant permeability contrasts tend to cause spreading of a DNAPL source along the upper surface of low-permeability layers. However, if the DNAPL release encounters discontinuities in low-permeability layers or coarse-grained alluvial sediments, as is expected in an alluvial system such as the Willamette River, penetration to greater depths may occur, which could result in an ongoing dissolved plume source in the deeper flow systems discharging to the river. Experience at other locations, such as the Port of St. Helens/Pope & Talbot site, has shown that a DNAPL commonly perches and flows on top of the CRBG (see Section 2.1.1) unless or until it encounters a fracture that penetrates the entire basalt flow to the next interflow which allows deeper migration and spreading (GeoEngineers 2000).

Dissolved constituents in groundwater may have a source in a LNAPL or DNAPL mass, in chemicals leaching from soil or buried wastes, or in a spill of a dissolved

solution (e.g., process water). Chemical adsorption to soil (or sediment), partitioning between soil/sediment and water, and dissolution to water are closely related processes. The physico-chemical properties (e.g., soil/water partitioning coefficient: K_d; organic carbon partitioning coefficient: K_{oc}) of individual chemicals control, in part, the degree to which a chemical moves from the source material or soil to groundwater. Some chemicals are strongly held by soil/sediments while others have an affinity for water. These same properties also affect how chemicals partition between soil or sediment and surface water. For organic chemicals, the K_{oc} of the chemical and the organic carbon fraction of the soil or sediment will generally govern the degree to which chemicals are sorbed to soil or sediment. For example, PCBs and HPAHs have relatively high K_{oc} values and are strongly sorbed to soil or sediment while LPAHs and chlorinated solvents have lower K_{oc} values and more readily partition to the water phase. Because soil sources and groundwater (and sediment sources with overlying surface water) are not in equilibrium due to continual dilution with fresh (clean) water and diffusion of chemicals, the dissolution process is ongoing rather than static, and the more mobile constituents will be desorbed and transported away, reducing the overall mobility of the remaining material. Inorganics also undergo leaching and dissolution but unlike organics their soil/water partitioning coefficients (K_d) are not influenced by organic carbon. Instead, metal solubilities and adsorption can vary widely and are controlled by oxidation state, speciation, associated counter ions, water pH and oxidation-reduction potential, soil particle size, the presence of chelating agents and ligands, and type of mineral phases present.

Other release mechanisms include sediment resuspension and transport, sedimentation of suspended particulates from surface water, chemical precipitation of dissolved constituents from surface water, and groundwater discharge to the Transition Zone. These mechanisms are discussed in the next section, because although they can be post-primary release mechanisms, they are mainly inter-media transport mechanisms.

5.1.3 Transport Media and Mechanisms

Sediment, surface water, groundwater, resuspended soil, and airborne particulates (i.e., dust) are the primary media in the ISA by which chemicals are moved from source areas to locations where exposure to receptors occurs. The physical and chemical processes that govern the movement and interactions of these media also control the movement of chemicals into and through the ISA.

Sediment Transport

Sediment transport (deposition, resuspension, redeposition) is an important mechanism in the LWR physical system. Sediments containing chemicals can be resuspended and redeposited many times within the LWR. With each sediment transport cycle, the concentrations of chemicals in the sediment are modified by incorporation of sediment containing concentrations reflective of upstream areas.

This process is anticipated to substantially attenuate chemical concentrations in sediment with increasing distance from sources.

The movement of sediment through the Portland Harbor navigation channel appears to be controlled, in large part, by the physical shape of the river, both the cross-sectional area and anthropogenic factors (borrow pits and dredged areas). Upstream of the ISA from Willamette Falls to about RM 11, the river tends to be narrow with sustained current speeds that apparently prevent all but the coarsest material from being deposited for the long term in the main stem of the river. From RM 11 to RM 10, the river broadens considerably and suspended and bedload material tends to deposit in a depositional reach that extends from about RM 10 to about RM 7, particularly in the deeper depressions. From RMs 7 to 5, the river cross-section again narrows and suspended sediments are likely transported through this reach, while the degree of bedload sediment deposition and transport is likely a function of temporally varying hydrology. The channel in the lower part of the ISA, RMs 5 to 3.5, again widens and appears to be depositional. Downstream of the ISA, the broad, depositional channel continues to around RM 1.5; the river then narrows again and becomes more dynamic as it reaches the Columbia.

In off-channel, nearshore areas, the general trends described above for the channel are altered by local riverbank morphology, bank treatments, and anthropogenic factors. The elevation change maps produced by comparing the winter 2001/2002 and summer 2002 bathymetry surveys (see Map 2-7) indicate that:

- Areas of shoaling and deepening are more widespread in shallow nearshore areas than in the main navigation channel.
- Many areas of nearshore deepening appear to be closely associated with pier structures, berthing areas, or slips and are likely the result of anthropogenic factors (e.g., prop wash).
- Bridge footings create localized areas of deep scour and accretion.
- An apparently natural stretch of nearshore shoaling extends along the west side of the river in the ISA from RMs 4 to 5, while a stretch of natural nearshore scour extends along the west side of the river downstream of the ISA from RMs 0 to 3.

In general, particulates from upstream sources that are transported into the ISA would be expected to accumulate in depositional areas of the ISA. Depositional areas would be expected to contain chemicals that are characteristic of historic and ongoing upstream sources, in addition to any ISA-related sources. Depending on temporally varying flow conditions, some portion of the suspended sediments that enters the Portland Harbor would settle out in depositional areas. Suspended sediments also likely pass through the Portland Harbor, especially during high-flow velocity events.

It is also evident that impacted sediments (originating upstream or from within the ISA) have the potential to be disturbed and resuspended by anthropogenic factors, such as prop wash and dredging. Their subsequent transport and fate would be a function of the LWR flows at the time of disturbance. Finally, despite the apparently dynamic sediment transport environment in the ISA, the relative magnitude and areal extent of impacted sediments near documented contaminated sediment areas have tended to be consistent over time, suggesting that there are subareas in the system that may be relatively stable. The spatial and temporal sediment transport patterns in the ISA will be further evaluated during the RI/FS.

In addition to direct measurements of riverbed elevation change through time-series bathymetry, a hydrodynamic and sediment transport model will be developed as part of the physical CSM refinement process. A major objective of the model will be to supplement this view of sediment transport in the ISA and LWR. In particular, sediment transport patterns in both major flood and non-flood years will be modeled. The modeling results and other Round 2 sampling (surface and subsurface sediment chemistry) will be evaluated, and these data will be used to refine the physical CSM.

Surface Water

Chemicals may be transported in surface water as suspended particulates, dissolved constituents, and oily films. Chemicals in surface water may originate from upstream sources, direct discharges or releases within the ISA (e.g., outfalls, groundwater discharges), deposition from the air, or resuspension of sediment within the ISA (described under Sediment Transport above). Suspended particulates in surface water are most likely to settle from the water column in relatively quiescent areas of the ISA (e.g., Swan Island Lagoon). During higher rates of flow in the LWR, coarser particulate material that is normally deposited as sediment may be temporarily suspended and added to the water column load. Similarly, water column loads during stormwater runoff events will be higher in the vicinity of discharge points, such as outfalls. Dissolved constituents generally remain in the water column except where chemical or biological processes cause precipitation or adsorption. Volatilization and photolysis may also transform some chemicals in the upper portion of the water column.

Groundwater

Groundwater-related components of the RI/FS will focus on understanding the potential for contaminated groundwater to affect sediments and surface water in the Willamette River. Dissolved chemicals in groundwater most likely will be transported toward the river by groundwater flow. As described in Section 2.1.3, groundwater in the vicinity of the ISA discharges via seeps above the water line or to the Transition Zone below the water line (Figure 5-2a; see Section 2.1.4). Transport of dissolved chemicals of interest (COIs) in groundwater is controlled by advective processes related to the physical hydrogeology (i.e., gradient, permeability) and the physicochemical properties of the chemical(s) and materials in the saturated zone, as well as the plume source and initial concentration in the plume.

Impacted groundwater entering the river could affect chemistry in sediments (including Transition Zone water and the sediment matrix) and in the water column. However, due to the large flow volumes in the river, effects of groundwater constituents on the overall surface water column concentrations are expected to be minimal due to dilution, except adjacent to the sediment/surface water interface in groundwater discharge zones. The effect of groundwater discharges on near-sediment surface water will be conservatively assessed through evaluation of chemical concentrations in water within the bioactive zone. The potential effects in the bioactive layer of the Transition Zone are more likely to be important in evaluating the relative risk to aquatic receptors, and to risk management decisions.

Behavior of chemicals in groundwater is important to the evaluation of potential transport and exposure. Chemicals in groundwater may partition to sediments or pass through the sediments to impact the Transition Zone water and/or surface water. The partitioning process is complicated and depends on the geochemistry of the sediment matrix and the groundwater, as well as the type of chemical. Halogenated and aromatic VOCs, low molecular weight (three or fewer aromatic rings) PAHs and certain species of metals generally exhibit a relatively low affinity for sediments and thus will pass through soil and sediment in the absence of other transformation or attenuation processes. However, these more mobile compounds may partition to aquifer materials and sediments under certain conditions (e.g., from anaerobic zones to more oxygenated zones). Other chemicals, such as pesticides, high molecular weight (four or more aromatic rings) PAHs and some metals, tend to adsorb or bind to soils or sediments, particularly where organic carbon is present, and may have lower tendency to be transported in aqueous phases or to partition from sediments to Transition Zone water. However, transport of these types of chemicals may be enhanced, on occasion, under certain geochemical conditions, in the absence of organic carbon, or in certain instances where the presence of another chemical increases the mobility of the chemical, thereby increasing the potential to be transported to the Transition Zone.

The assessment of potential impacts to the Transition Zone water and surface water from chemicals in groundwater will require evaluation of fate and transport characteristics of site-specific contaminants in groundwater on a site-by-site basis. The chemical attributes discussed above are described in more detail in Section 7.2.3 as they relate to the proposed approach for evaluating risk from groundwater COIs.

Four potential groundwater chemical transport scenarios relevant to the project have been identified (see Figure 5-2b). The scenarios are described below:

1. **Impacted groundwater from an upland source that flows through clean sediment:** In this scenario, some portion of the chemicals transported in groundwater partitions to sediments, potentially causing sediment-related impacts, or flows in the dissolved phase to potentially cause impacts to Transition Zone water or the surface water column. The potential impact to

sediment, Transition Zone water, and the water column depends on the concentration(s) of the chemicals in groundwater as well as the affinity of each chemical for the sediments. The greatest impacts to sediments and Transition Zone water occur where a NAPL is transported to the river through sediments or where the source of groundwater constituents is located near the river and high contaminant concentrations in groundwater are observed. In general, an aqueous-phase plume with a long flow path from its source to the river will likely have relatively less effects than a plume with its source near the river, as partitioning and transformation processes will reduce the concentrations prior to reaching the Transition Zone. Section 7.2.3 describes the approach for assessing chemicals in groundwater at concentrations of concern that partition to the solid or aqueous phase within this zone.

2. **Subareal surface seepage of impacted groundwater:** This scenario refers to shallow impacted groundwater that comes to the ground surface above the water line and then discharges to the river as a seep. After the groundwater discharges to the ground surface as a seep, it is available for human contact and is the only groundwater pathway that may result in potentially complete exposure pathways.

3. **Impacted groundwater from an upland source flows through impacted sediments:** In this scenario, impacted groundwater mobilizes chemicals from impacted sediments and advects in the dissolved phase to potentially cause impacts to sediment or water within the Transition Zone.

4. **Clean groundwater flowing through impacted sediments (no upland chemical source):** In this scenario, chemicals present in buried sediments may partition to groundwater flowing through the sediments toward the river. Some chemicals could then repartition to the shallower sediments further along the flow path and/or potentially cause dissolved-phase impacts to water within the Transition Zone. This scenario also is a potential mechanism of contamination to overlying clean sediments (if in a depositional area) or a sediment cap. The impact of this scenario depends on the characteristics of the buried contaminated sediments and groundwater flux rates. In more permeable sediments, the concentrations in groundwater will be limited by partitioning rates from the sediment source. The impacts to overlying sediments under this scenario are expected to be relatively low where sediment sources have been present for several decades and do not include NAPL.

Soil

Resuspended soil is not considered to be a very substantial transport medium in the ISA given the highly developed nature of the harbor area. Runoff and slope processes may transport soil downhill toward the shoreline along the steeper riverbanks that are not vegetated or covered with engineered structures. In limited locations, soil transport may move impacted soil to elevations that are more frequently affected by the river.

Airborne Particulates

The transport of chemicals by airborne particulates is not considered to be a very substantial transport mechanism in ISA.

5.1.4 Exposure Media

As shown in Figure 5-1, the exposure media in the physical CSM are surface water, sediment, water within the Transition Zone, and biota. Chemicals that are either in dissolved or particulate form may be concentrated in surface water, bedload, suspended sediments, or water within the Transition Zone in the ISA. From these physical media, chemical constituents are potentially exposed to ecological (Section 5.2) and human (Section 5.3) receptors of concern, which represent the exposure endpoints in the CSM for the ISA.

5.2 ECOLOGICAL CONCEPTUAL SITE MODEL

This section summarizes the current understanding of the potential exposure routes and pathways from affected media to ecological receptors in the ISA. The preliminary ecological CSM (Figure 5-3) identifies the sources, release mechanisms, exposure media and routes, and potential receptors, and characterizes the various exposure pathways for potential ecological receptors within the ISA. The physical CSM, described in Section 5.1, provides a preliminary identification of sources, release mechanisms, and exposure media. The rationale for selecting the ecological receptors and exposure pathways is included in Appendix B. An understanding of the ecological CSM is needed to complete the ecological risk assessment (ERA).

Data provided by the Round 1 sampling program will facilitate a preliminary understanding of the potential ecological risks associated with exposure to chemicals in sediment and tissue. A preliminary risk evaluation report will be developed following Round 1. Additional data will be collected in subsequent rounds of investigations. This information will advance the current understanding of the ecological CSM, which will continue to be revised based on additional data.

The majority of the ISA is industrialized, with modified shoreline and nearshore areas. Wharves and piers extend into the channel, and bulkheads and riprap revetments armor the riverbank. Dredging has produced a uniform channel with little

habitat diversity. However, some segments of the ISA, as well as areas upstream and downstream of the ISA, are more complex with side channels, shallow water areas, and less shoreline development, providing habitat for a suite of local fauna. A description of the general types of habitat in the LWR available to ecological species is presented in Appendix B.

5.2.1 Potential Ecological Receptors

Various organisms are present in the ISA (see Appendix B), with each organism relating to its environment in unique ways that determine its exposure to chemicals. Though each species has unique habitat requirements and behavior, several species are often similar in their use of resources and potential exposure to chemicals. Thus, representative species from each group are selected to typify other species with similar exposure. In this preliminary ecological CSM, potential ecological receptors are grouped into aquatic plants, benthic invertebrates, fish species, amphibians, reptiles, birds, and mammals.

The rationale for selection of representative species is presented in Appendix B. Example food web diagrams for fish and wildlife are presented in Figures 5-4 and 5-5, respectively. A summary of the potential receptor groups is provided below.

Aquatic Plants

Aquatic plants were identified within the ISA in the Round 1 reconnaissance survey (see Appendix B, Attachment B2). Therefore, aquatic plants are exposed to potentially impacted sediment and surface water and will be assessed as a population to the extent possible. A discussion of aquatic plants is presented in Appendix B.

Benthic Invertebrates

Benthic invertebrates are typically evaluated at the community level because many species are collocated in a localized “community” with little to no movement occurring within the habitat. Therefore, a community-level assessment of benthic invertebrates will be conducted in Portland Harbor. A population-level assessment will also be conducted, as feasible. However, due to practical limitations and the available exposure and toxicity information, the population assessment will likely be more qualitative. Remedial decisions will be based on a community assessment.

The details of the epibenthic and infaunal invertebrate community assessment are presented in Appendix B, Attachment B4. In addition, as representative macrofauna, crayfish will be assessed separately in the preliminary and baseline risk assessments because they have relatively longer life spans than other invertebrates and they consume detrital material. Likewise, mollusks will be assessed, but separately

Fish Species

Consistent with the criteria and rationale presented in Appendix B and with EPA (1998) guidance, representative fish species were selected and approved by EPA for the baseline ERA. The representative species are presented below by feeding guild:

- **Herbivores/Omnivores:** The largescale sucker was selected to represent omnivorous and herbivorous fishes because of its close association with sediments.
- **Invertivores:** Juvenile chinook salmon was selected to represent anadromous invertivorous fish species because it is a federally listed threatened species occurring in the ISA. Sculpin was selected to represent resident invertivorous fish species because of its close association with sediments and small home range. In addition, the peamouth was selected to represent resident insectivorous fishes, feeding similarly to the juvenile salmon, but spending more time in the ISA.
- **Piscivores:** The northern pikeminnow was selected as a representative of piscivores because it is long-lived and feeds at the top of the food chain. Smallmouth bass was also selected as a representative species for piscivores because of their smaller home-range size relative to northern pikeminnow.
- **Detritivores:** Juveniles (ammocoetes) of the Pacific lamprey were chosen as the representative species for detritivorous fish species. The ammocoete also represents a sensitive life-stage.

Amphibians and Reptiles

Amphibians were identified in selected locations within the ISA during the Round 1 reconnaissance survey (see Appendix B, Attachment B2) and were selected as a receptor group. Amphibians will be evaluated in areas where they may breed within the ISA (e.g., where a sensitive life-stage may be exposed). Amphibians have been selected as a surrogate for reptiles because amphibian exposure to chemicals is expected to be higher than reptiles, amphibians tend to be more sensitive, and toxicity information for reptiles is less abundant than for amphibians.

Birds

The osprey was chosen as the representative species for the piscivorous birds. Additionally, the bald eagle will be evaluated at the individual level because it is a federally listed threatened species occurring in the ISA. Sediment-probing invertivorous birds are represented by the spotted sandpiper. The spotted sandpiper is also considered a conservative surrogate species for omnivorous birds. The hooded merganser was chosen to represent diving birds. Herbivorous birds have limited exposure to chemical constituents in the LWR, and estimated total exposure for sediment-probing invertivores is assumed to be a conservative estimate of total exposure to herbivorous birds.

Mammals

Mink were selected to represent carnivorous mammals that may use the ISA.

5.2.2 Potential Exposure Pathways

This section describes the potential chemical exposure pathways to species in the ISA and discusses which pathways will be evaluated for the various receptor species in the ERA. Representative species can be exposed to chemicals in water or sediment in the ISA either directly through contact with sediments, water within the Transition Zone, or surface water or indirectly through the food chain. The CSM (Figure 5-3) illustrates the pathways that chemicals may follow from primary sources to the ecological species. Exposure pathways were designated as follows:

- **Complete and Major:** Pathway is complete and expected to be a significant contributor to total exposure. This pathway will be quantitatively assessed, when possible, in the preliminary risk evaluation or baseline risk assessment.
- **Complete and Minor:** The pathway is complete and expected to be a minor component of total exposure. In relation to other complete pathways, chemical exposure is expected to be minimal. This pathway will not be quantitatively evaluated in the preliminary risk evaluation or baseline risk assessment unless sufficient data are available, but will be discussed qualitatively to a level of certainty dependent on available studies. If the data are insufficient, additional information will be gathered through an interim sampling process and the risk evaluated if the pathway is believed to potentially contribute significantly to overall risk.
- **Complete and Uncertain:** The pathway is complete but of undetermined significance. If there are insufficient toxicological data, this pathway will not be quantitatively evaluated in the preliminary risk evaluation or baseline risk assessment, but will be discussed qualitatively to a level of certainty dependent on available studies. However, if the uncertainty is due to lack of site-specific data, appropriate information will be collected and a determination made whether the pathway is major or minor. If sufficient toxicological data exist, the pathway will be evaluated using multiple lines of evidence, including sediment chemistry, bioassays and an evaluation of groundwater contribution.
- **Incomplete:** The pathway is incomplete; therefore, it will not be evaluated in the preliminary risk evaluation or baseline risk assessment.

The specific exposure pathway assignments are summarized by receptor in the remainder of this section.

Aquatic Receptors

Aquatic Plants

Aquatic plants actively and passively transfer chemicals from surface water and sediments; therefore, these contact pathways are considered the only complete pathways of exposure to these receptors in the ISA.

Benthic Invertebrates

Infaunal and Epibenthic Invertebrates

Infaunal and epifaunal benthic invertebrates are generally in direct contact with sediments and surface waters. Therefore, direct sediment and water contact are considered complete and major pathways of exposure (Figure 5-3). Surface water ingestion is considered a complete and minor pathway of exposure for infaunal and epifaunal invertebrates. The sediment ingestion pathway is considered complete and major. Biota ingestion for infaunal and epifaunal organisms is also considered a complete and major pathway of exposure.

The influence of groundwater on Transition Zone water quality in the ISA cannot be determined at this time due to lack of Transition Zone water data within the ISA. Direct contact with water within the Transition Zone is considered a complete and uncertain pathway for benthic infauna. The Transition Zone water pathway will be assessed if the results of the groundwater evaluation indicate effects on water quality within the Transition Zone and potentially complete pathway to benthic infauna (see Section 7.3). The Transition Zone water pathway would only potentially affect benthic infauna in the biologically active zone. For all other receptors, this pathway is considered incomplete.

Mollusks

Direct sediment, Transition Zone water, and surface water contact are considered complete and major pathways of exposure for mollusks (Figure 5-3). Sediment ingestion is also considered a complete and major pathway of exposure for mollusks because they are known to routinely ingest sediment. Water ingestion is considered a complete and minor pathway. Biota ingestion is considered a complete and major pathway because mollusks' diets can consist of other benthic organisms and detritus.

Epibenthic Macrofauna

Crayfish are in direct contact with surface water and sediments, and this pathway is considered complete and major (Figure 5-3). Crayfish ingest sediments directly and indirectly; therefore, this pathway is considered complete and major. Surface water ingestion is considered a complete and minor pathway of exposure. Finally, crayfish diets consist of other benthic organisms, detritus, and dead fish. Therefore, biota ingestion is considered a complete and major pathway of exposure.

Fish

Omnivore/Herbivore - Largescale Sucker

Direct contact with sediments, sediment ingestion, and ingestion of benthic biota are considered to be complete and major pathways of exposure for the largescale sucker (Figure 5-3). In addition, largescale suckers are in direct contact with surface water, thus, this pathway is also considered a complete and major pathway of exposure for this receptor. Incidental ingestion of water may occur for the largescale sucker, as for all the fish species; however, this pathway is considered complete and minor.

Invertivore - Sculpin Species

Direct sediment and surface water contact are considered complete and major pathways of exposure for sculpin (Figure 5-3). Water ingestion is considered a complete and minor pathway. Because sculpin may prey upon sediment-ingesting organisms such as epibenthic invertebrates, sediment and biota ingestion are also considered complete and major pathways of exposure.

Invertivore - Peamouth

Peamouth are in constant contact with surface water and this pathway is considered complete and major (Figure 5-3). Ingestion of surface water is a complete and minor pathway. The diet of the peamouth consists of benthic invertebrates, crustaceans, and small fish. Therefore, the ingestion of biota is a complete and major pathway. While feeding, peamouth may ingest sediments directly through their mouth or indirectly through their prey. The amount of sediments ingested with prey could be significant when peamouth feed on benthic organisms. However, fish species are also a portion of the peamouth diet. Therefore, this pathway is considered complete and uncertain. Peamouth are benthopelagic species and direct contact with sediment will occur when feeding on benthic prey. However, benthic species comprise only a part of the peamouth diet, and peamouth spend a significant portion of time in the pelagic zone. Therefore, direct contact with sediments is considered a complete and minor pathway.

Invertivore - Juvenile Chinook Salmon

Surface water contact is considered a complete and major pathway of exposure (Figure 5-3) for juvenile chinook salmon. Ingestion of prey is also considered a complete and major exposure pathway. The sediment ingestion pathway is considered complete and uncertain. The sediment ingestion pathway for metabolized chemicals will be addressed qualitatively. Direct contact between juvenile chinook salmon and sediments, and ingestion of surface water, are assumed to be complete and minor pathways.

Piscivore - Smallmouth Bass

Ingestion of biota is considered a complete and major pathway of exposure (Figure 5-3) for the smallmouth bass. The ingestion of water is considered a complete and minor pathway of exposure. Smallmouth bass are in constant contact with water. Thus, direct contact with surface water is a complete and major pathway of exposure. Direct sediment contact and ingestion are considered complete and minor pathways.

Piscivore - Northern Pikeminnow
Northern pikeminnow are in constant contact with surface water, and this pathway of exposure is considered complete and major (Figure 5-3). Adult northern pikeminnow primarily consume fish. Thus, ingestion of biota is considered a complete and major pathway of exposure. Northern pikeminnow, like smallmouth bass, is a benthic-pelagic species and will be occasionally in direct contact with the sediment and may ingest some sediment directly and indirectly from their prey. Ingestion of surface water and sediment and direct contact with sediment are all considered complete and minor exposure pathways.

Detritivore - Pacific Lamprey Ammocoetes
Pacific lamprey ammocoetes live in direct contact with sediments and often filter food (e.g., detritus, diatoms) directly from sediment. Therefore, direct sediment contact and ingestion of sediments and biota are considered to be complete and major pathways of exposure for Pacific lamprey ammocoetes (Figure 5-3). In addition, surface water contact is also considered complete and major pathways of exposure for this species. Ingestion of surface water is a complete and minor pathway.

Amphibians and Reptiles

Direct contact with surface water is considered a complete and major pathway to amphibians. Direct contact with sediment is considered a complete and uncertain pathway to amphibians and reptiles. The food ingestion pathway is considered complete and major for both amphibians and reptiles. Surface water ingestion is considered a complete but minor pathway for amphibians and reptiles.

Wildlife Receptors

Birds

Piscivore - Osprey and Bald Eagle
Food ingestion is considered a complete and major pathway of exposure for the osprey and bald eagle (Figure 5-3). Sediment ingestion is considered a complete and minor pathway of exposure for bald eagle. Because surface water contact and ingestion and direct sediment contact are likely to be minimal, these pathways are considered to be complete but minor pathways.

Diving Carnivore/Omnivore - Hooded Merganser
Food ingestion is considered a complete and major pathway of exposure for the hooded merganser (Figure 5-3). Sediment ingestion is also considered a complete and major pathway. Surface water contact and ingestion and direct sediment contact are considered incidental occurrences and complete but minor pathways of exposure.

Sediment-probing Invertivore/Omnivore - Spotted Sandpiper
Food ingestion is considered a complete and major pathway of exposure for the spotted sandpiper (Figure 5-3). In addition, sediment ingestion is considered a complete and major pathway of exposure. Surface water contact and ingestion are

considered complete but minor pathways. Direct sediment contact is considered a complete but uncertain pathway.

Mammals

Carnivore - Mink

Food ingestion by mink is considered a complete and major pathway of exposure (Figure 5-3). Sediment ingestion is considered a complete and major pathway of exposure for carnivorous mammals. Surface water contact by swimming and ingestion is considered complete and minor. Direct contact with sediment is considered complete and minor.

Additional data provided by Round 1 and later sampling programs will be used to further characterize the ecological risks associated with exposure to chemicals in sediments, water, and tissues and to refine the ecological CSM.

5.3 HUMAN HEALTH CONCEPTUAL SITE MODEL

This section summarizes the current understanding of the physical and biological setting of the ISA as it pertains to potential impacts to human health. The CSM for human exposures, based on the current understanding of conditions in the ISA, is presented in Figure 5-6. The rationale for selecting human receptors and exposure pathways is included in Appendix C.

The CSM graphically depicts possible sources of chemicals, possible chemical-affected media, mechanisms of chemical transfer between media, receptors that may be exposed to chemicals associated with the ISA, and potential exposure pathways. Possible sources of chemicals and possible mechanisms of chemical migration and transfer are described in the physical CSM (see Section 5.1). The human health CSM focuses on potential human receptors and potential exposure pathways to those receptors. Only exposure pathways that are theoretically complete and potentially significant (including those pathways of uncertain significance) will be evaluated quantitatively in the baseline human health risk assessment (HHRA).

Data provided by the Round 1 sampling program will allow a preliminary understanding of the human health risks associated with exposure to chemicals in beach sediment and tissue. Additional data will be collected in subsequent rounds of investigations. This information will advance the current understanding of the human health CSM, which will continue to be revised based on additional data.

5.3.1 Potential Human Receptors

Potentially exposed populations were identified based on consideration of current and future uses of the Site and EPA (1989) guidance. The potential current and future human receptors identified below represent those receptors that are anticipated to be

present under current and reasonably foreseeable future conditions. The selected receptors are anticipated to be protective of other potential receptors that will not be evaluated quantitatively in the baseline HHRA. As shown in the CSM, the receptors for current and future uses include the following:

- Dockside worker
- Transient
- Recreational beach user
- Recreational fisher
- Native American consumption fisher
- Non-Tribal high consumption fisher.

The receptors were identified based on human activities that are known to occur within the ISA. It is assumed that the recreational beach user, which includes exposure to surface water during swimming activities, will be protective of divers in Portland Harbor. This assumption will be reassessed when additional information regarding divers in Portland Harbor becomes available, and, if needed, a diver receptor may be included in the HHRA.

5.3.2 Potential Exposure Pathways

Exposure pathways are defined as the physical ways in which chemicals may enter the human body (e.g., ingestion, inhalation, dermal absorption). A complete exposure pathway consists of the following four elements:

- A source of chemical release
- A retention or transport medium (or media in cases involving media transfer)
- An exposure point (a point of potential human contact with the contaminated medium)
- An exposure route (e.g., ingestion, dermal contact) at the exposure point.

If any of the above elements is missing, the pathway is considered incomplete and exposure does not occur.

As discussed in Section 4, the currently known and identified affected media in the ISA are sediment and water. In addition, some chemicals in sediment may be taken up by bottom-dwelling organisms. As fish species feed on these organisms, the chemicals may bioaccumulate in the fish tissue. The potential exposure pathways identified are:

- Ingestion of sediment and surface water
- Dermal contact with sediment and surface water
- Ingestion of fish and shellfish.

The baseline HHRA will focus on potential exposures occurring within the ISA, and areas outside the ISA that are identified by the RI process, to quantify risks to human receptors. However, certain receptors may also be exposed to media at upland sites adjacent to the ISA. The baseline HHRA will acknowledge that additional upland exposures may occur, and these potential risks will be addressed by DEQ through upland activities.

Each scenario is described in detail in Section 3 of Appendix C. Potentially complete and significant or potentially complete and significance unknown exposure pathways shown in Figure 5-6 will be evaluated quantitatively. Pathway designations and the rationale for each pathway for each receptor are also explained in Section 3 of Appendix C.

Current and Future Dockside Worker

Industrial and commercial workers at facilities near the river are exposed to sediments and water only when they are conducting site-specific activities within natural river beach areas. These activities generally occur infrequently, but they may provide opportunities for industrial and commercial workers to have dermal contact with and/or incidental ingestion of intertidal sediments (river beach sediments located between the high- and low-water lines). Dermal contact with or ingestion of water that may occur during occupational activities would be unintentional and infrequent. Dockside workers do not consume fish through occupational activities.

Current and Future Transients

During past site tours, tents and makeshift dwellings were observed as evidence that individuals were occupying some riverbank areas. These transients may have dermal contact with water and intertidal sediments within natural river beach areas they are utilizing. Incidental ingestion of surface water and intertidal sediments may also occur through activities of these transients, and transients may be using the river as a source of drinking water. Transients may also be consuming fish and shellfish; however, no information is available regarding this potential exposure pathway, and it will not be evaluated under this scenario, but is considered a potential data gap.

Current and Future Recreational Beach User

Adults and children use the LWR for boating, water skiing, swimming, and other water activities. Ongoing, long-term, repetitive beach use will be the focus of the baseline HHRA, as it is anticipated to result in the greatest risk as compared with other recreational receptors. Recreational beach users may have dermal contact with, and incidental ingestion of, water and intertidal sediments during activities within river beach areas. Recreational beach users do not consume fish through beach use activities.

Current and Future Fishers

Three fisher receptors (recreational fishers, Native American consumption fishers, and non-Tribal high consumption fishers) will be evaluated in the baseline HHRA. The fisher categories are differentiated by the frequency of fishing and by the amount of fish consumed. Each scenario is described in detail in Section 3 of Appendix C. Fishers may consume fish and shellfish that are caught from the Site and may also have dermal contact with, and incidental ingestion of, sediments at banks within the Site where fishing occurs, and in water. Dermal contact with or ingestion of water that may occur during fishing activities within the Site would be infrequent.

Potentially Overlapping Scenarios

Potential risks will be quantified for each receptor; however, certain individuals may participate in activities resulting in potential exposures under more than one category (e.g., recreational beach users may also be recreational fishers). The combination of exposures for an individual through different receptor categories will be evaluated further in the baseline HHRA.

6.0 OVERVIEW OF PORTLAND HARBOR RI/FS PROCESS

This section presents the overall process for completing the RI/FS and ultimately obtaining a Record of Decision (ROD) for the Site. It describes in general terms the major milestones that will be achieved during the RI/FS process. While this section provides the general accomplishments for each of the major milestones and how the milestones relate to each other, the specifics of how these milestones will be achieved are presented in Sections 7 and 8.

In order to develop an approach for obtaining a ROD, the LWG and EPA first defined the objectives for the ROD and the major issues that the ROD may address. Next, the LWG identified the types of information needed to accomplish those objectives and address the issues. Finally, the LWG grouped information needs into logical sequences or phases of work. These work phases support major milestones such as the RI, ERA, HHRA, and FS. The LWG and EPA refer to this process as a "road map," as it details the paths and tasks along those paths necessary for completing the RI/FS and ROD.

It is anticipated that four rounds of data collection efforts conducted by the LWG will be used in conjunction with the Category 1 historic information to provide the site-specific data needs to complete the RI, baseline risk assessment, and FS reports:

- Data collected prior to signing of the AOC (pre-AOC)
- Data collected in Round 1
- Data to be collected in Round 2
- Data to be collected in Round 3.

However, additional sampling rounds may be required to address data gaps identified as a result of technical memorandum development, review of Round 1 data, Round 2 data, or review of relevant new data or information.

The objectives of these sampling efforts, described in Section 6.2, generally include obtaining sufficient information to assess site-wide risk and understand the distribution of chemical constituents sufficient to support the development of the RI and baseline risk assessment reports. As with most CERCLA projects, these documents will be the transition point to the FS. The fourth round of data collection (referred to as Round 3) will focus on providing information for the FS, but will also serve as a final opportunity to address any outstanding site characterization or risk characterization issues. The completion of the Round 3 sampling effort will lead to the draft FS report.

Several important procedural steps are required prior to the ROD, such as approval of the FS, development of a draft proposed plan for public review and comment, and completion of a final proposed plan. For this road map to be successful, it is important that all of the parties understand the objectives of each sampling and data

evaluation round and how these objectives will be accomplished (i.e., what data will be collected and how those data will be evaluated).

6.1 PRELIMINARY REMEDIAL ACTION OBJECTIVES

Data needs for assessing the distribution of in-river chemicals, human health and ecological risks, and for developing remedial alternatives for the ISA were identified based on a review of preliminary remedial action objectives (RAOs) historical data and information developed as part of EPA's (2000a) DQO process. A technical memorandum that presents preliminary RAOs for this site is summarized in Section 8.2 and found in Appendix A, Attachment A1. Specific definitions of the terms used in the preliminary RAOs are provided in Section 8.2 and the attachment.

Preliminary RAOs that were used to identify the categories of data that will be needed to fulfill project objectives include the following:

1. Reduce human health risks from direct contact with and incidental ingestion of chemicals of concern (COCs) in sediments in the Site to acceptable levels.
2. Reduce COC concentrations in sediments in the Site to levels that will result in acceptable risks to humans that eat fish and shellfish from the Site.
3. Reduce human health risks from direct contact with and incidental ingestion of COCs in water in the Site to acceptable levels.
4. Reduce ecological risks from contact with and ingestion of COCs in sediments or prey in the Site to acceptable levels.
5. Reduce ecological risks from contact with and ingestion of COCs in water in the Site to acceptable levels.

It is anticipated that these preliminary RAOs will be refined throughout the data collection and evaluation phases of the project; however, the preliminary RAOs are considered sufficient to identify the needed data types for Round 2 sampling. Round 3 data types will also be developed using these RAOs and the results of the Round 2 sampling effort. The categories of data that will be required to complete the RI/FS include sediment and tissue chemistry, sediment toxicity data, physical sediment characteristics, surface water chemistry and conventional parameters, habitat type and distribution, species occurrence, , hydrodynamic/sediment transport processes, sources (including upland and outside of the ISA), and source control status.

6.2 OBJECTIVES OF THE RI/FS

The Site is complex and includes multiple potentially responsible parties (PRPs), potential ongoing sources both upstream and within the ISA, potential locations that could become early remedial actions implemented as non-time critical removal actions under their own AOCs (i.e., Early Actions), and an existing PRP group (the LWG) that is funding the RI/FS required by the current AOC. As a result, the ROD must anticipate how a remedial action can be determined and implemented given all of the complexities associated with the Site.

Sources of contamination to Portland Harbor may contribute localized areas of risk exceeding acceptable levels. Sources include stormwater discharges, groundwater discharges, atmospheric deposition, and non-point source runoff. If it is determined that these sources contribute to unacceptable risk to the site, a combination of upland source control measures and/or in-water remediation measures may be required. The RI/FS must gather sufficient data for the human health and ecological risk assessments to evaluate the risks associated with the release, discharge, or emission of these sources to Portland Harbor.

Consistent with EPA's memorandum, Principles for Managing Contaminated Sediment Risks at Hazardous Waste Sites [OSWER Directive 9285.6-08 (EPA 2002b)], a risk-based framework for characterizing the Site, evaluating options for sediment remediation, and developing the ROD forms the basis of this Work Plan.

First of all, it is important to note that the RI will not be considered complete until:

1. Potential sources have been identified,
2. The nature and distribution of chemical constituents (vertical and lateral) that pose risk is defined for both river-wide and localized areas of contamination, and
3. River dynamics and contaminant transport are understood in sufficient detail to evaluate sediment stability and potential impacts associated with individual sites and their contribution to Portland Harbor.

Based on information collected to understand the distribution of chemical constituents, risk assessments and evaluations will provide important input to the ROD. The baseline ecological and human health risk assessments will estimate risks to ecological receptors and human health. The results of the baseline risk assessments will be used to identify and delineate preliminary SMAs in which sediments may present unacceptable risks. (Section 8.6 describes how SMAs will be delineated in more detail.) After preliminary SMAs are identified, the FS will develop a list of potential remedial alternatives. The evaluation of remedial alternatives may include an evaluation of relative risks associated with each alternative. The overall risk-based approach to the RI/FS is summarized in Figure 6-1.

According to the National Contingency Plan, the overall goal of the RI/FS process is protection of human health and the environment from adverse effects of hazardous substances. Risk assessment plays a central role in the site characterization and potential cleanup associated with any RI/FS project. The purpose of a risk assessment is to characterize the risks posed by hazardous substances. This information is required to make risk management decisions related to the Site. The results of the risk assessment are then used to evaluate remedial alternatives and to establish cleanup goals, as appropriate.

In accordance with EPA guidance (1988, 1997, 2002b), the RI/FS for the Portland Harbor Superfund Site will be an iterative process using a risk-based framework for determining risk to human health and the environment from site-related chemicals and for evaluating options for risk reduction from exposure to chemicals in sediment. Interim risk evaluations will be used to focus the remedial investigation. These interim risk evaluations will be based on conservative exposure assumptions and will consider all relevant RI/FS data to understand if (and under what conditions) receptors may be exposed to contaminated subsurface sediment above acceptable risk-based levels.

At the end of the RI/FS, available data must be adequate to allow EPA to make risk management decisions for the Site. Multiple iterations of sampling and analyses are anticipated to allow sufficient characterization of risks to support risk management decisions for the Site. Sampling for each iteration will be determined, in part, based on interim risk evaluations and will be documented in subsequent field sampling plans. Interim risk evaluations will be used to identify additional data needs for the risk assessment, which will be incorporated into the Work Plan and subsequent field sampling plans. These interim risk evaluations will also be used to provide a more complete understanding of exposure pathways and the magnitude of potential exposure and to update the conceptual site model. Additional data collection will be focused on data needed to reduce uncertainties associated with preliminary estimates of risk. Additional data collection may also be required to address data needs identified in subsequent technical memoranda, data gaps identified during sampling rounds 2A and 2B and/or new information relevant to the RI/FS. Exposure estimates per medium will be derived following adequate characterization of that particular medium. The final HHRA and ERA reports will be included in the final RI report.

Once the site has been adequately characterized relative to the nature and distribution of chemical constituents, the media, pathways, and chemicals driving unacceptable risk will be identified in the baseline risk assessment. Prior to development of remedial goals and strategies, an evaluation of potential sources of chemicals driving unacceptable risks will be conducted. Chemicals may be entering the ISA from sources located within the ISA or upstream of the ISA, and some chemicals may be contributed from both ISA and upstream sources. Background levels will be established in accordance with EPA (2002c) and other relevant guidance and will be used in the overall remedial decision-making for the Site. The approach that will be

used to establish background levels will be submitted as a technical memorandum to EPA for review. Consideration of background conditions will follow EPA guidance (2002c) as well as other relevant EPA Superfund guidance and regulatory and statutory requirements.

After the evaluation of sources is completed, development of site-specific preliminary remediation goals (PRGs) will occur. PRGs will be developed for those chemicals driving unacceptable risks and having sources within the ISA. PRGs will be used in the delineation of potential remediation areas and will be developed for both ecological and human receptors. The methods and assumptions that will be used to derive the PRGs for both ecological and human health endpoints will be submitted as a technical memorandum to EPA prior to submittal of the baseline risk assessment.

Direct and indirect pathways from sediment will likely be the primary drivers of ecological risks at the Site. Based on the benthic risk approach, sediment PRGs will be derived directly from the predictive effects model and, if possible, the crayfish-to-sediment regression relationship. As a tool for developing sediment PRGs for fish, an approach to estimate the relationship between COI concentrations in sediment and associated tissue will be developed in collaboration with EPA and its partners. A technical memorandum will be submitted to EPA describing the modeling approach to be used for developing PRGs. The possible approaches range from deriving site-specific biota sediment accumulation factors (BSAFs) to adapting a generic aquatic food web model. The model will be calibrated using site-specific data for those parameters that are highly variable between aquatic systems and/or contribute significantly to the output. Literature-derived values will be used to parameterize the model, when necessary. Wildlife PRGs will be based on probable risk levels, using site-specific assumptions regarding wildlife exposure.

For human health, fish consumption will likely be one of the primary risk drivers at the Site. Similar to the approach for ecological risks, a model will be used to develop sediment PRGs based on fish tissue concentrations that result in unacceptable risks to human health. The same model selected to develop the sediment PRGs for the ecological risks will be used to develop sediment PRGs for human health risks resulting from fish consumption. Sediment PRGs will be developed for each of the fish or shellfish species that pose unacceptable risks for human consumption. If needed, sediment PRGs will also be back-calculated for beach areas where direct contact with sediment results in unacceptable risks to human health.

To examine spatial distributions of risk, map layers will be created for each ecological and human health endpoint, depicting areas with sediment concentrations that pose unacceptable risks. Areas of unacceptable risk will be defined using calculated sediment PRGs. The maps will be based on available sediment data of acceptable quality. The maps for each ecological endpoint will be overlaid to define preliminary areas for potential remediation for the purpose of protecting ecological receptors. The maps for target fish and shellfish species for human consumption also

will be overlaid to define preliminary areas for potential remediation for protection of human receptors.

The ecological risk-based PRGs and map overlays will be combined with the human health-based PRGs and map overlays to examine differences and similarities in spatial distribution of areas that pose unacceptable risks to ecological and human receptors. Where overlap exists, the lowest PRG will be identified as the target concentration. The areas resulting in unacceptable risks will be identified as preliminary areas of concern to be evaluated in the FS.

This information on sediments will be combined with identified risks from other media, including groundwater present in sediments (or Transition Zone water) and surface water. Risk based-PRGs will also be developed for these media and will be displayed in mapping approaches, as appropriate.

The RI/FS will develop the information to support the following elements for EPA's consideration in developing the proposed plan and ROD:

1. **Sediment Management Areas.** It is recommended that the ROD delineate SMAs based on unacceptable risk to human health or the environment. The delineation will include an estimate of the areal extent based on unacceptable risk. Volumes of sediment with unacceptable risk will also be determined, where appropriate (see below for more detail). The boundaries of the required remediation areas will be refined following the ROD as additional data are collected by responsible parties in the RD/RA phase of work. The process for determining site-specific risk will follow the same rules and processes used in the site-wide risk assessment. It should be noted that contaminated sediments may present area- or site-wide risks that will also be addressed in the FS. It is anticipated that some unacceptable risks determined by the risk assessments will be restricted to generally well-defined sources and areas of relatively high contaminant concentrations (and associated risk), and will be defined as SMAs. It is also anticipated that unacceptable risks will exist over more widespread areas (e.g., chemicals contributing to bioaccumulation risks) and the contribution of each SMA to these site-wide risks will be recognized and described for each SMA.
2. **Early Actions and Operable Units.** It is recommended that the ROD provide the regulatory mechanism to acknowledge and account for the environmental benefit of any Early Actions that have been implemented earlier or that have been approved by EPA at the time of the ROD. Some areas within the Site might be suited for designation as separate operable units where subsequently distinct RD/RA and related tasks would be completed for the particular unit(s).
3. **Remediation Recommendations.** It is recommended that the ROD identify the type of remediation by SMA, according to the conclusions of the FS. For some SMAs, this will likely lead to a suite of remedies that includes dredging,

capping, natural recovery, and institutional controls that are applied in combination across the SMA.

4. **Disposal Options.** For those areas targeted for dredging in the remediation recommendations described above, it is recommended that the ROD identify a menu of viable sediment disposal options and locations. Because the dredging actions may occur over a broad period of time and the volumes will likely vary substantially by SMA, it is advantageous identify a variety of disposal options. To the extent that these options include yet-to-be-constructed or permitted facilities, such as in-water confined aquatic disposal or nearshore disposal facilities, the ROD will rely on the analyses presented in the FS report to substantiate the acceptance of each disposal option. For existing privately or publicly operated landfills, the ROD will rely on a combination of the existing regulatory mechanisms that those facilities have for accepting contaminated dredged material as well as the analyses presented in the FS report.
5. **Sources of Recontamination (Upstream of the Site and Within the Site).** It is recommended that the ROD identify potential sources that are contributing to unacceptable risk. These sources may include inputs from upstream of the Site, within the Site, or in upland areas that may be sources of recontamination of remedies proposed for the Site. Sources of risk within the Site will be identified, and decisions regarding cleanup in the ROD will take into account any necessary source control actions to ensure long-term effectiveness of the remedy.
6. **Integration of ROD with NRDA.** To create efficiencies between the CERCLA and the National Resource Damage Assessment (NRDA) processes, it is recommended that the ROD be integrated with the NRDA, to the extent practicable.

In addition to the above objectives, the LWG believes the RI/FS process and resulting ROD will need to provide practical solutions to cleanup while considering other regulatory efforts and a multiuse harbor. Therefore, the LWG has the following general objectives for remedial actions:

1. Promote remedial actions that do not limit current or planned waterway, municipal, commercial, industrial, recreational, or tribal ceremonial uses.
2. Promote remedial actions that are feasible for the physical system of the river.
3. Integrate remedial actions with NRDA findings and restoration plans.

6.3 GENERAL INVESTIGATION APPROACHES

This section defines how the proposed RI work will specifically address selected project issues raised by EPA.

6.3.1 Determine Scope of RI/FS Upstream and Downstream Sampling

EPA and the LWG will work cooperatively to determine the data and analyses needed upstream and downstream of the ISA for EPA to determine site boundaries. A technical memorandum will be submitted that describes the general approach to this issue. This memorandum will be combined with the background approach technical memorandum, described in Section 6.3.2.

6.3.2 Define Background Conditions

Background conditions are typically evaluated to make appropriate risk management decisions, and will be considered in the FS. Evaluation of background conditions will be performed in conjunction with EPA and EPA guidance on this subject (EPA 2002c) and other relevant EPA Superfund guidance. Site-specific background conditions for various data types (e.g., sediment chemistry, fish tissue, sediment toxicity, surface water chemistry) will be identified in the technical memorandum, Approach to Determining Background for the Portland Harbor Superfund Site / Process for Delineating Upstream and Downstream Extent of Contamination. This technical memorandum will describe the definition and approach for determining background levels for the Site. This information will be used, following the risk characterization in the risk assessment, as a risk management tool, consistent with EPA guidelines (EPA 2002c).and. This memorandum will also describe the process for delineating the extent of contamination upstream and downstream of the ISA.

6.3.3 Delineate "Hot Spots"

The overall sampling approach for delineating "hot spots" or principal threat areas involves focusing surface and subsurface sediment sampling in areas where known sources are present and in areas where existing sediment chemistry data indicate elevated concentrations of COIs occur. Round 1 and historical sediment chemistry data will be compared to appropriate sediment screening values for "hot spots," identified in collaboration with EPA and its partners, to identify locations with potentially "high" risk. Additional sediment samples will be placed to better define the extent of the identified areas. The data evaluation process will be repeated with Round 2 sampling results to determine whether new areas can be classified as "hot spots." Additional sampling will be conducted, as necessary, in Round 3 to delineate any "hot spot" areas identified in Round 2.

6.3.4 Define Sediment Management Areas

As discussed in detail in Section 8.6, results from sediment sampling conducted to define the nature and extent of chemical constituents will be combined with baseline risk assessment results, physical environmental data, physical modeling results, habitat data, river and land use data, and source information to define SMAs.

6.3.5 Identify Additional Sources

Existing historical upland information has been reviewed and evaluated to identify suspected historic and ongoing sources; this evaluation will be documented in the updated CSM report. Sediment samples will be located in those areas where existing sediment chemistry data are sparse and historic upland data indicate pathways from suspect sources most likely to impact the river. Sediment transport modeling results and other physical river system data and source information will be used to help locate sediment samples in those areas where sources are expected to impact the river. Also, a limited number of sediment samples will be placed in previously uncharacterized areas that are not associated with any known ongoing or historic sources to reduce uncertainty related to the potential occurrence of impacted sediments from unrecognized or transient historic sources. Each time sediment data are analyzed, the distributions of chemicals will be evaluated to ascertain whether other unrecognized sources may be or may have been present.

6.4 MAJOR PHASES OF WORK

The major tasks of the RI/FS are briefly described below. As noted previously, the intent of this section is to provide an overview of the major milestones to complete the RI/FS, how those milestones relate to each other, and how they fit into overall data collection, evaluation, and RI/FS needs. For clarity, many important smaller tasks are not reflected in this overview, but are discussed in Sections 7 and 8, and Appendices A, B, and C.

6.4.1 Pre-AOC Tasks

Prior to execution of the AOC, a stipulated agreement was signed by the LWG (EPA 2001b) to conduct some significant and time-critical data collection tasks. It was agreed that this information would be necessary for the RI and could be collected prior to Work Plan development. The four tasks listed below were completed under the stipulated agreement:

1. Sediment profile imaging
2. Multibeam bathymetry – high water
3. Juvenile salmonid residence time
4. Integrated evaluation of historical navigation channel bathymetry and a sediment trend analysis.

Of these four tasks, the first three involved fieldwork undertaken by the LWG. The fourth task involved analysis of two pre-existing data sets. Another field effort not included in the stipulated agreement was conducted by the LWG in spring 2002 and involved the collection of water current profiles at 10 transects across the Portland Harbor during a high-flow event (see Section 2.2.3).

These tasks provide fundamental information that is useful in various future RI/FS tasks. In general, they are useful in developing and refining the CSM from physical as well as biological perspectives (see Section 5). An accurate CSM helps define future rounds of sampling and frames needed risk assessment work.

6.4.2 Round 1 Work

Round 1 sampling was conducted in the summer and fall of 2002, and included data collection for clearly apparent needs or exploratory data collection and surveys used to more completely identify future data needs. In addition, the data collection efforts were seasonally dependent tasks, and the LWG did not want to wait another year to initiate them. The LWG prepared a Round 1A FSP (SEA et al. 2002b) for these initial tasks. Round 1A sampling work, approved by EPA in May 2002, included the following activities:

- Collection of fish and shellfish tissue for chemical analysis
- Evaluation of epibenthic colonization using multiplates
- Reconnaissance survey of plants and amphibians
- Reconnaissance survey of adult lamprey
- Measurement of riverbank erosion and accretion using sediment stakes
- Multibeam bathymetry – low water.

A pilot mark/recapture study of juvenile salmonids was also authorized as an additional Round 1A task, but was not completed because the water temperatures were too high by the time the task was authorized, which would have caused unacceptable stress on the fish. Additional sample collection tasks for 2002 were proposed in the Round 1 FSP submitted to EPA in June 2002 (SEA et al. 2002c). A subset of these tasks was approved by EPA in September 2002:

- Beach sediment chemistry
- Reconnaissance-level benthic infauna community analysis
- Collocated sediment chemistry at sculpin, crayfish, and benthic infauna stations.

The LWG also undertook a reconnaissance survey of juvenile lamprey and benthic infauna for potential tissue analysis in September 2002.

Results of each of these sampling tasks will be submitted to EPA either as stand-alone data reports or as part of the Round 1 site characterization summary report that will be provided to EPA within 120 days following completion of Round 1 sampling and analysis.

The data collected in Round 1 meet various RI/FS data needs, including:

- **Fish and Shellfish Tissue and Sediment Chemistry.** Provides critical information for both ecological and human health risk pathways that had little or no pre-existing information. This allows direct measurement of site-specific concentrations to which wildlife and humans may be exposed via fish and shellfish consumption.
- **Multiplates, Reconnaissance Surveys, Benthic Infauna.** Provides information to identify ecological and human health exposure pathways and receptors likely to be present at the Site. This information assists the CSM development and determination of significant pathways and receptors included in the risk assessments.
- **Sediment Stakes and Bathymetry.** Provides time-series data on riverbed changes. These data assist the development of the physical CSM and selection of sampling locations and methods related to issues such as sediment and chemical stability, sedimentation/scour areas, and surface layer depth determination. These data also supplement the STA®, SPI, bathymetric, and other physical system data described in Section 2.

These data will be used in the ecological preliminary risk evaluation report and in both the baseline risk assessment and RI reports. The ecological preliminary risk evaluation report will evaluate and interpret the historic (Category 1), pre-AOC, and Round 1 data (see Section 6.4.3).

In addition to field data collection, existing information is being reviewed during the Round 1 period for the purpose of updating the CSM. Specifically, existing upland site information is being evaluated for potential sources and source-related data as well as data on potential past and/or current pathways to sediment, surface water, and Transition Zone water, from groundwater, storm and wastewater discharges, erosion, and over-water activities.

This information will be used to help categorize potential upland sources of COIs based on the extent to which they have been characterized, their regulatory status, and their potential for affecting sediments or river water. Known or suspected sources will be characterized as:

- Historical, ongoing, or controlled
- Identified and need no further source characterization
- Identified and require further source characterization.

In addition, this process will help identify areas of the river where reviews of historical information indicate the probability of COI sources, but existing information is insufficient to confirm the absence or presence of a source. The information from this review will be evaluated in the context of potential impacts to water and sediments in the river and will be incorporated into updates to the physical and chemical aspects of the CSM presented in this Work Plan.

The results of the information review also will be provided to DEQ so that further upland source identification, characterization, or source control work can be implemented by upland facilities on a site-specific basis.

6.4.3 Additional Project Scoping Activities

Several technical memoranda will be developed to complete project scoping activities that have not been fully documented in this Work Plan, including: 1) Process to Identify COPCs, 2) Derivation of PRGs, and 3) Ecological and Human Health Groundwater Pathways Assessment/Groundwater Sampling Approach. The contents of these technical memoranda are described in Table 6-1:

Technical memoranda also will be completed specifically in support of the ecological risk assessment to more clearly define the scope and methods for ecological risk assessment activities: 1) toxicity reference value (TRV) selection, 2) benthic assessment interpretive approach, 3) comprehensive ERA approach, and 4) food web model. The contents of each technical memorandum also are described in Table 6-1.

An ecological preliminary risk evaluation (PRE) report will be prepared and submitted to EPA and its partners after EPA approval of the TRV technical memorandum. The PRE will include a risk characterization based on historical, pre-AOC, and Round 1 data for benthic invertebrates using the tissue-residue approach, fish, and wildlife. Results will be used, in part, to help identify COPCs related to contaminant concentrations in fish and invertebrate tissue. This applies primarily to risks to aquatic-feeding wildlife that consume fish or invertebrates from the river, and risks to invertebrates and fish containing the compounds. This COPC identification is narrowly focused because sediment data from Round 2 are needed to identify a comprehensive list of COPCs. The PRE will not rely on the benthic assessment technical memorandum, which addresses the analysis framework for the sediment toxicity data to be collected during Round 2. The preliminary risk estimates and the associated uncertainty will help to identify ERA data and information gaps that may be filled during subsequent investigations/evaluations prior to the baseline ERA.

6.4.4 Round 2 Work

Round 2 sampling is intended to gather the majority of the remaining data for the RI and risk assessments as well as initiate the collection of data for the FS. Once Round

2 data are collected, they will be combined with Round 1, pre-AOC, and historic (Category 1) data in a comprehensive site characterization summary to evaluate data gaps and the need for additional sampling efforts. The majority of FS data collection will occur in Round 3. Round 2 is described in more detail in Section 7. It is anticipated that Round 2 will require multiple field efforts. This multiple effort is necessary so that EPA and the LWG have sufficient time to review and agree upon appropriate sampling methods and locations for each type of sampling, and because information needed to develop sampling plans will become available throughout Round 2. For each sampling effort, the procedures will be described in an FSP and approved by EPA prior to initiating that sampling work.

The following data types will be collected during Round 2:

- **Surface Sediment Chemistry**. These data will support the ERA and characterize contaminant distribution and source effects to the river.
- **Sediment Bioassays.** These data will support the assessment of benthic risks for the ERA.
- **Beach Sediment Chemistry**. These data will support the HHRA beach exposure scenario, if needed, based on evaluation of Round 1 results.
- **Surface Water Chemistry.** These data will evaluate potential effects of sources on the river system and support the HHRA and ERA.
- **Physical System.** These additional data, including bathymetry and sediment stake measurements, will be used to define SMAs.
- **Groundwater Impacts from Upland Sources.** Data will be collected to evaluate the impact to sediments and environmental receptors from groundwater chemicals discharging from upland areas to the river
- **Natural Attenuation as a Potential Remedial Alternative**. Limited data will be collected to assess the general feasibility of natural attenuation as a potential remedial alternative, including data collection for natural attenuation model calibration, parameterization, and verification
- **Hydrodynamic/Sedimentation Model.** These data will be used to calibrate, parameterize, and verify models used in the RI.

General types of samples that will be used to evaluate impacts to sediments and environmental receptors from COIs discharging from groundwater include bulk sediment samples and bioassays, Transition Zone water quality samples, groundwater gradient and flux measurements, and surface water (including seep) samples. These types of samples are discussed in more detail in Section 7.

In particular, subsurface sediment sampling will be performed to:

- Define the nature and extent of contaminant releases

- Verify assumptions regarding subsurface stratigraphy used for developing the hydrodynamic model
- Validate the site conceptual model
- Evaluate sediment quality in areas where the hydrodynamic model or bathymetric change assessment indicates sediment scour may occur
- Evaluate sediment quality is areas where potential prop wash, boat wakes, or wind waves may result in erosion of surface sediments and expose underlying sediments
- Evaluate potential dredging or shoreline development areas.

These data collection efforts will provide the basic information needed to refine and validate the CSM, answer questions about the physical system, and identify source effects to the river and the distribution of chemical constituents that may pose unacceptable risks to ecological receptors and human health. Refinement of the CSM will be conducted through examination of data collected during Rounds 1 and 2 to understand the links between chemicals found in various matrices (water, sediments, tissues), the link between sources and chemicals in various matrices, the relationship between physical stability issues and chemical distributions, as well as the relationship between all these parameters and pathways/receptors defined in the preliminary CSM. Where new data indicate the conceptual model was in error or incomplete, the CSM will be revised accordingly. Where new data indicate potential gaps in the understanding of the CSM, additional data collection to fill these data gaps and better define the CSM will be proposed for Round 3 work.

The process for selecting subsurface chemistry sampling locations will be based on information collected in previous rounds or efforts. However, hydrodynamic modeling is an additional task that will be conducted during the course of Round 2 to better understand the physical system of the river. The modeling approach and objectives are detailed in a modeling technical memorandum (West Consultants 2004). This modeling will be confined to understanding river water flows, currents, and resulting sediment transport patterns (e.g., where surface and subsurface sediments are stable over time versus where they are unstable or likely to move or be exposed over time). This model is not intended to predict chemical fate and transport.

Finally, some additional FS-related data evaluations are proposed during Round 2, including a literature review of potential treatment methods and a disposal facility siting evaluation. Conducting these evaluations during Round 2 will allow treatment and disposal alternatives to be considered without delay of the FS process (see Section 6.4.9).

Along with previous rounds of sampling data, the Round 2 information will input directly into the baseline risk assessments discussed in Section 6.4.7.

Based on the results of Round 2 sampling, two reports will be completed in support of the ecological baseline risk assessment: 1) results and interpretation of Round 2 benthic assessment, and 2) food web modeling results. The report on the Round 2 benthic assessment will use the results of Round 2 sediment bioassays to develop and apply a predictive relationship model between chemical concentrations in the sediment and bioassay responses, and confirm toxicity in high priority areas. The food web modeling results report will use data collected in Round 1 and selected results from Round 2 to help develop sediment cleanup goals.

6.4.5 Round 3 Work

The primary purpose of Round 3 work is to gather data for the evaluation of FS alternatives. This work may include collecting some sediment or related data to better define SMAs (and any related principal threat areas). However, in many cases refinement of SMAs may be conducted as part of the RD/RA phase after the ROD. In addition, if there are substantial data gaps identified in the preliminary risk assessments, these may also be filled in some cases during Round 3. As with Round 2, Round 3 may be adapted to one or more sampling efforts, each with an approved FSP, as project developments warrant.

The following data will be collected during Round 3:

- **Surface and Subsurface Sediment Chemistry.** These data will be collected to further refine SMAs and volumes if needed to complete the FS. (In some cases, this information may not be needed to complete the FS, and some areas may be appropriately refined during the RD/RA process that follows the ROD).
- **Surface and Subsurface Physical Characteristics.** These characteristics (e.g., consolidation potential, sheer stress, Atterberg limits, grain size, water content, specific gravity) will be ascertained relevant to potential remedial alternatives.
- **Natural Attenuation Sampling.** This sampling effort (e.g., radioisotope cores, sediment traps, water sampling) will be targeted for areas found in Round 2 to have potential processes that may support this alternative.
- **Potential Disposal Site Sampling**. Sampling at potential disposal sites will be performed, as necessary, to support evaluation of remedial alternatives.
- **Baseline Risk Assessment Data Gaps**. Data will be collected to fill substantial baseline risk assessment data gaps or uncertainties.

- **Uncertainty Analysis**. Data will be collected to fill substantial nature, extent, or source effect uncertainties.
- **Residual Risk Assessment.** Data will be collected to conduct residual risk assessments related to evaluation, comparison, and support of potential remedial alternatives.

These data will be used to prepare the RI and baseline risk assessments and develop the FS. The FS will use the refined SMAs to develop a list of potential remedial alternatives that could be applicable to each area.

6.4.6 Integration of Non-AOC Studies Data

Data from non-AOC studies being conducted in Portland Harbor over the course of the RI/FS will be reviewed for appropriateness following the methods described in Section 4.1.1 and will be incorporated into the project data set as the data become available. Several facility-specific, in-water sampling investigations are ongoing within the ISA. For example, the City of Portland is conducting sediment sampling investigations at its outfalls located in the ISA. Results of the City's outfalls investigations will be made available to the LWG for incorporation into the RI/FS.

6.4.7 Baseline Risk Assessments

At the end of Round 3, two baseline risk assessments will be conducted: one addressing ecological receptors and the other human health. These risk assessments will rely on the information collected through Round 3 and will be presented in the risk assessment reports that will be issued along with the RI report (see Section 6.4.8). The approaches used to conduct these risk assessments are described in more detail in Appendices B and C.

Ecological

The baseline ERA is being designed and performed consistent with EPA (1997, 1998) guidance. ERAs are typically conducted in an iterative or "tiered" manner that increasingly focuses on those exposure scenarios that are the greatest contributors of risk. The risk assessment is complete when the risk managers have enough confidence in the results to make a decision they can scientifically defend (EPA 1998). A tiered process is advantageous because it typically results in refined lists of pathways and receptors that will require application of risk reduction measures. Consistent with this tiered process, the ecological preliminary risk evaluation report will help identify data and information gaps to be filled for a more complete baseline risk assessment.

For both the preliminary ecological risk evaluation and the baseline ERA, the following steps will be completed, consistent with regulatory guidance:

- Describe the results of the problem formulation, including any updates to the CSM.
- Conduct an analysis, including characterization of exposure, characterization of effects, and identification of ecosystem and receptor characteristics.
- Complete the risk characterization, including an estimation of risk, a description of risk, and an evaluation of the uncertainties.
- Communicate the final product to managers and interested parties for risk management decisions.

The risk assessment procedures for each step in this process are detailed in Appendix B.

Human Health

The baseline HHRA will be conducted following Round 3 and will be based on EPA (1989, 1998) guidance. Prior to submittal of the baseline HHRA, a series of interim deliverables will be produced as data become available, these deliverables are described in Table 6-1. Data available at the time of the baseline HHRA will be used to estimate potential human health risks associated with the Site.

Consistent with guidance from EPA (1989) and DEQ (2000c), the baseline HHRA will incorporate the following steps:

- Prepare an analysis plan to identify data needed to adequately assess risks to human health in accordance with state and federal guidance.
- Develop an exposure assessment, which estimates the magnitude and frequency of potential human exposures and the pathways by which humans may be exposed.
- Develop a toxicity assessment, which estimates the probability of adverse health effects that may occur as a result of exposure to a chemical.
- Develop a risk characterization, which estimates the potential for adverse health effects to occur and evaluates the uncertainties associated with the risk estimates.

Following collection of data in Round 3 of the RI, the baseline HHRA will be completed. The results of the HHRA will be used to establish risk-based concentrations that will be protective of human receptors at the Site and to provide input to risk management decisions that address remedial action objectives for the Site. The risk assessment procedures for the HHRA are presented in Section 7 and Appendix C.

6.4.8 Site Characterization Reporting

Validated analytical data will be provided to EPA within 90 days of each sampling activity (e.g., Round 2 surface sediment sampling, Round 2A sediment coring, Round 2B sediment coring, sediment beach sampling, surface water sampling, groundwater pathways sampling). Data will be provided in electronic format showing locations, media, and results. As specified in the AOC, and upon request, analytical data will be made available to EPA within 60 days of each sampling activity.

The following site characterization deliverables will be prepared:

- Field sampling reports
- Site characterization summary reports
- Bioassay data report
- Comprehensive Round 2 site characterization summary and data gaps analysis report
- RI report
- Baseline risk assessment reports.

The contents of each deliverable are described in Table 6-1.

Round 2 and Round 3 information and data evaluations, described above, will be used in combination with Category 1, pre-AOC, and Round 1 data to complete the draft baseline risk assessments (see Section 6.4.7) and an RI report. The baseline risk assessments and RI will include:

- A characterization of the distribution of chemicals and sources that affect the river
- An assessment of ecological risk including risks to benthos, fish, wildlife, and other receptors of concern
- An assessment of human health risks from contact with sediment and water, and fish and shellfish ingestion
- A preliminary delineation of SMAs and sediment volumes that pose unacceptable risks
- A preliminary delineation of principal threat areas
- A preliminary understanding of the potential for natural attenuation as a remedial alternative.

This information will be necessary for the development of remedial alternatives for the FS. Nature, extent, and source characterization results and risk assessment results will be combined with the data and modeling of physical conditions within the river to define preliminary SMAs (i.e., areas that require some type of remedial action) and

volumes of sediments that pose unacceptable risks. The delineation of SMAs will consider issues such as:

- Risks for each receptor category (e.g., benthos, wildlife, human health)
- Estimated level of risks (e.g., higher risk areas like principal threats and lower risk areas)
- Types of physical environments relevant to changes in risk and remedial alternatives (e.g., erosive areas, natural attenuation processes, capping)
- Types of river uses that affect remedial alternatives (e.g., navigation channel, slips, docking areas)
- Areas that may be impacted by ongoing sources, upstream or in the ISA.

By integrating these issues, SMAs will define areas that can be used to develop remedial alternatives for the FS. Sediment management areas with relatively high risks will be evaluated for their potential as principal threats. The delineation of SMAs, including areas of "higher" and "lower" risk, is described in more detail in Section 8.6

Following the risk assessment, potential upland and upstream sources will be evaluated for those pathways and COPCs driving risk. Where this information indicates that unacceptable risks may be caused by these ongoing sources, additional source identification and control activities may be warranted.

In the case of potential ongoing upland sources within the ISA, this information will be provided to DEQ so that further upland source identification, characterization, and/or control work can be implemented on a site-specific basis. Given that there is an ongoing DEQ-led effort to identify ongoing sources along the ISA, the LWG does not see the need for extensive independent evaluations of groundwater sources through this RI/FS. However, the LWG will evaluate the in-water impacts of contaminants in groundwater discharging to the river where information gathered by the LWG, DEQ, or other parties indicates the potential for this to occur. The process for focusing the evaluation of potential impacts to sediment, Transition Zone water, and surface water from chemicals in groundwater discharging to the river will be proposed and negotiated with EPA prior to implementation.

Information collected by LWG regarding substantial upstream sources that may influence the risk estimate will be referred to EPA. It is anticipated that EPA review of this information could result in several potential approaches by EPA to identify and control upstream sources, including:

- Identification by EPA of PRPs related to these sources and initiation of site-specific source control efforts through DEQ or EPA-led enforcement with those PRPs
- Identification of another upstream Superfund site or operable units with an appropriate group of new PRPs relevant to that area
- Expansion of the existing Superfund site
- Control of upstream sources by EPA, DEQ, or other agencies through other applicable regulatory mechanisms such as the Clean Water Act, TMDL studies, watershed planning efforts, and NPDES permits.

The information on sources will also be used to assess the potential for recontamination under various remedial alternatives in the FS (see Section 6.4.9).

6.4.9 Feasibility Study Report

The primary purpose of the FS report is to determine appropriate remediation scenarios for sediments that have been shown to pose unacceptable risks through the baseline risk assessments and RI reports. The FS report is discussed in detail in Section 8 and Appendix A. FS-related deliverables are described in Table 6-1. In general, using the information developed from the four rounds of data collection, the FS steps include the following:

- Refine remedial action objectives defined early in the RI/FS process (Appendix A)
- Refine areas and volumes of sediments requiring remediation
- Finalize SMAs
- Develop a range of remedial alternatives that apply to the SMAs in various geographic and physical areas of the river
- Develop a list of remedial alternatives to be evaluated for each SMA
- Conduct a screening and detailed evaluation of those alternatives against the nine CERCLA evaluation criteria
- Conduct a comparative evaluation of those alternatives
- Recommend the most appropriate alternatives for each SMA.

The assessment of remedial alternatives may include evaluations to determine the relative risks posed by each alternative. Depending on the eventual content of the

baseline risk assessments, this may include reference to preliminary remedial goals such as sediment chemical concentrations.

In addition to the previous four rounds of data collection already described, several types of data evaluations that support the FS analysis will have been conducted during Round 3:

- Natural attenuation modeling based on Rounds 2 and 3 data collected specifically to assess the potential for natural attenuation
- Refinement, if warranted, of the hydrodynamic/sediment transport model based on Round 2 data inputs
- Recontamination modeling based on source information available through Round 3
- Literature survey to determine the need for treatability studies
- Treatability studies, if necessary, as determined by literature survey
- Disposal facility siting investigations (identifying potential candidate sites for the disposal of contaminated sediments).

These studies will be conducted prior to the actual start of the FS report to ensure that when Round 3 is complete the FS report can be initiated without delay or the need for further data collection or evaluations. Any Early Actions that are proceeding or have been completed under separate agreements with EPA will not be included in the FS report.

Substantial ongoing sources must be controlled before effective sediment remediation can take place. The effects of upland and upstream sources on river sediments and water in the ISA will be addressed by data collection and evaluation efforts (as described above). The FS report will include an assessment of the potential for recontamination for each remedial alternative given current conditions in the river as indicated by data from sampling rounds. This will determine whether effective remediation can proceed without delay given the level and extent of ongoing sources.

7.0 SITE CHARACTERIZATION APPROACH

This section describes the overall technical approach to data collection and analysis for the RI and risk assessments. The approach for the FS is presented in Section 8. Details of sampling and analysis are to be developed with the regulatory agencies based on approval of the framework presented herein, and documented in field sampling plans that will become attachments to this document. Some details of data analysis, such as that for the ecological and human health risk assessments, are presented in appendices and summarized in this section.

A significant amount of information, both quantitative and qualitative, exists for the ISA, yet additional data are needed to support the RI/FS. Historical quantitative data of sufficient quality to support the RI/FS were compiled in the project database and reviewed to identify specific data needs relative to the design of RI/FS field investigations and development of potential remedies. All data classified as Category 1 (see Section 4) were considered appropriate for use as part of the risk assessment process. Both Category 1 and Category 2 data were used for project scoping.

EPA's (2000a) DQO process was applied as part of the historical data evaluation to refine the specific data types needed to complete the RI/FS. The seven-step DQO process is designed to ensure that any data gaps, when filled, will meet the needs of the project. The seven-step DQO process documents the following:

1. Problems or issues that led to the investigation.
2. Decisions to be made or questions to be answered.
3. Inputs (i.e., types and source of data or information) to that decision.
4. Spatial and temporal boundaries of the project.
5. Decision rules or performance criteria used to evaluate the quality of the data and determine the outcome of the decision.
6. Tolerable error relative to the decision rule.
7. A sampling design and analysis plan that will collect the appropriate type and quality of data to meet the project objectives.

The LWG has applied the DQO process and identified a number of field programs needed to complete the RI/FS. The results of this process are described in the remainder of this Work Plan section, and the programs are summarized in Table 7-1. Note that the vast majority of data collected will be used to meet more than one objective of the RI/FS. Additional data needs beyond those shown in Table 7-1 may be identified later in the RI/FS through application of the DQO process.

Table 7-1 also shows the relationship between identified data gaps and the proposed sampling approach. Specific sampling locations will be provided in the Round 2 FSPs.

The following sections describe the issues, questions, decisions, data needs, and RI/FS tasks associated with each data type necessary to understand the physical attributes of the river system and determine chemical distributions, sources, risks and remedies for the ISA, consistent with OSWER Directive 9285.6-08 (EPA 2002b). Data needs that ensue from the DQO process form the basis of the RI/FS sampling program.

7.1 UNDERSTANDING THE PHYSICAL SYSTEM

The physical system of the ISA (e.g., hydrology, sediment movement) will be further investigated as a key element of the RI/FS because it influences the distribution of chemicals as they relate to ecological and human health risk, and finally, any remedial decisions for the Site. This section describes efforts conducted to date and those planned that are designed to gain an understanding of the ISA physical system sufficient to support site characterization efforts, ERA, HHRA, and the FS. A large amount of physical system data has already been collected and evaluated during pre-AOC and Round 1 efforts. A compilation of LWG physical system information is presented in Section 2, and a summary of the physical CSM is provided in Section 5.

The DQO process for understanding the river physical system is summarized in Table 7-2.

7.1.1 Problem Description

The LWR through the ISA is a large river with a complex flow regime and sediment movement patterns. The spatial and temporal scales of sediment movement must be understood at a level that allows accurate characterization of the distribution of chemical constituents, understanding of whether and how ongoing sources are manifested in sediment concentrations, accurate estimates of exposure concentrations for the risk assessments, and an understanding of how sediments move within the system. Hydrodynamic and sediment transport patterns must also be understood to develop and evaluate remedial alternatives for the Site.

7.1.2 Data Uses

Data from the river physical system investigations will be used in conjunction with other data (e.g., chemical distribution in sediment) to determine the following:

- The distribution and magnitude of shoaling and scouring in the ISA as measured directly from time-series bathymetric surveys in Round 1 and Round 2

- The pattern of shoaling and scouring areas in specific bank areas in the ISA as measured directly from sediment stake observations in Round 1 and Round 2
- Sediment movement patterns during major flood years and non-flood years as predicted by the hydrodynamic/sediment transport model.

7.1.3 Data Needs

A third bathymetric was conducted in May 2003 to extend the time series of observed riverbed changes. Also, following a relatively high flow event (about 140,000 cfs) in the LWR in Febraury 2004, a fourth bathymetric survey, including current flow measurements, was performed. The time-series bathymetric change data will be used to calibrate/validate the hydrodynamic/sediment transport model that will be developed as part of the RI physical system investigations (Table 7-2). Low-water and high-flow data (ADCP) from within the ISA were also collected in May 2003 and February 2004, respectively, to support the modeling effort (West Consultants 2004). Surface sediment chemistry, both physical characteristics (e.g., grain-size) and chemical constituent levels, will be collected as part of the Round 2 site characterization program and compared with Round 1 and historic sediment data. These comparisons will be used to support the evaluation of riverbed changes observed or predicted by the physical investigations. Data on regional weather, sediment inflows, river stage, and flows are also needed for the model and are available on public web sites (e.g., USGS, USACE). These data will be compiled as part of the hydrodynamic modeling effort. Finally, additional data needs (e.g., site-specific critical erosion velocities, suspended sediment loads) may be identified during model development following Round 2 that are needed to refine or improve model accuracy. These data would be collected as part of Round 3.

7.1.4 RI/FS Tasks

Physical system investigations completed as part of pre-AOC RI/FS studies or during Round 1 include a compilation of previously existing information and the following efforts:

- Integration of the Sediment Trend Analysis (STA®) (GeoSea Consulting 2001) survey data from Portland Harbor (September 2000), with an evaluation of historical changes in navigation channel depths based on Corps hydrosurvey data
- Sediment-profile imaging survey of the LWR from RM 0 to 15.7 in December 2001 (SEA 2002f)
- Precision multibeam bathymetric surveys from RM 0 to 15.7 in winter 2001 and the summer of 2002 (DEA 2002a, 2003)

- ADCP current profiling during a high-river stage event on April 19, 2002
- Deployment and monitoring of sediment stakes.

The preliminary physical CSM model based on these surveys and data evaluations is provided in Section 5.

Physical investigations also have included a third bathymetric survey of the Portland Harbor and a short-term ADCP survey during a low-water/high-tidal influence period conducted in the spring of 2003 and a fourth bathymetric and ADCP survey during and immediately following a high flow event on the Lower Willamette in February 2004. The development, calibration, and validation of a hydrodynamic/sediment transport model of the LWR are planned in Round 2. If the hydrodynamic modeling process identifies other physical system data needs (e.g., site-specific erodibility measurements), these data will be collected late in Round 2 or in Round 3.

Hydrodynamic Modeling: The proposed modeling approach is fully detailed in the revised technical memorandum submitted to EPA in February 2004 (West Consultants 2004). As stated in the technical memo, the objectives of the modeling effort are to:

- Determine the spatial and temporal sediment transport patterns so that surface contaminant distributions and risks to ecological and human receptors in the Lower Willamette River can be adequately characterized.
- Determine whether physical processes expose previously buried contaminated sediment, including during major flood events.
- Determine whether physical processes result in burial of contaminated sediment.
- Quantify the rates and locations of sediment accretion and erosion associated with various flows, including extreme events.

The model is designed to provide both an assessment of more short-term or "typical" sediment transport regimes in the river and estimates of flow velocities and sediment transport under rare high-flow events. Along with grain size, bathymetry, sediment stake, and flow data, the modeling will help identify sediment transport regimes within the river, such as depositional, erosional, and transitional areas. This information will be valuable in understanding the existing distribution of chemicals, as well as potential source transport, recontamination, and natural attenuation issues. The modeling of high flow events will identify potential scour areas that might expose subsurface contaminated sediments in extreme high flows and will predict design parameters, such as bed velocities, that are required to evaluate remedial alternatives (e.g., capping or confined aquatic disposal).

Pending approval by EPA of the proposed modeling approach in early 2004, the initial modeling effort will be completed in the summer/fall of 2004. Sediment and other data collected in 2004 will be used to refine the model in 2005. As warranted, the model results will be used to focus Round 3 data collections, e.g., indicating a need for additional subsurface sediment data in an unstable area. Also, any data gaps identified by the modelers as critical to model performance will be targeted for collection as part of Round 3. Table 7-2 provides additional details on how the modeling effort fits into the physical system investigations and how model output will be used to support the RI/FS.

7.2 UNDERSTANDING CHEMICAL DISTRIBUTIONS AND SOURCES

As part of a comprehensive CSM, it is critical to identify potential sources and the distribution of chemicals resulting from those sources. In the ISA, the sediment itself may act as a source. There may also be surface water and groundwater inputs to the system, in addition to the other sources presented in Sections 3 and 5. These potential sources and the process for understanding the distribution of chemicals related to these sources are discussed below.

To understand the distributions of chemicals, a list of chemicals was developed for the Round 1 sampling program based on historic data, current and historic activities, and laboratory reporting capabilities. The initial list of chemicals, which is included in the EPA-approved Round 1 QAPP (SEA 2002e), may be revised in later rounds of investigation (e.g., following EPA approval of the Round 2 QAPP). The process that will be used to limit chemicals from future investigations through identification of COPCs will be submitted to EPA as a technical memorandum.

7.2.1 Sediment

Sediment samples will be collected to identify potential sources, understand the distribution of chemicals resulting in potentially unacceptable ecological and human health risks (described in Sections 7.3 and 7.4), and to evaluate natural attenuation for the FS (described in Section 8). A systematic and iterative approach will be used, as described below, for implementation of sediment sampling events. This approach will allow identification of any significant new sediment sources and characterization of the nature and extent of sediment contamination associated with existing sources, as needed for risk and remedial alternative evaluations.

The DQO process for understanding chemical distributions in sediments and sources is summarized in Table 7-3.

Problem Description

Although there is a considerable amount of historical sediment data for Portland Harbor, additional data are needed to generally describe areas that pose unacceptable

risk (i.e., SMAs). Additionally, surface and subsurface sediments may act as sources to other parts of the Portland Harbor.

Data Uses

Data from the sediment investigation will be used in conjunction with Category 1 historical data to:

- Characterize the distribution of chemical constituents in surface sediments in potential exposure areas
- Characterize the distribution of chemical constituents in subsurface sediments that have the potential to act as sources or that are located in potential remediation or navigation/maintenance dredge areas
- Characterize the potential inputs from upland sources to the ISA
- Complete the baseline risk assessments
- Complete the FS.

Data Needs

Sediment chemistry data are needed for chemicals and conventional parameters listed in the QAPP. Sampling and analytical methods will be adequate to achieve analytical concentration goals listed in the QAPP, when feasible (i.e., analytical concentration goals, which are developed based on risk screening, may be below the concentrations that can be achieved using available analytical instrumentation, especially in samples with matrix interferences). Surface sediment data are required to understand the distribution of chemicals resulting in potentially unacceptable risk; subsurface sediment data are required in areas where subsurface chemicals may act as potential sources including near some historic sources, in navigation/maintenance dredge areas, and in berthing site areas that may scour. Finally, subsurface data will be used in the FS to assess sediment volumes in SMAs requiring cleanup.

RI/FS Tasks

Phasing of Sediment Investigations

The generation of sediment data to support the RI/FS will follow an iterative process. Sediment sampling was conducted in Round 1 and will be conducted in Rounds 2 and 3 of the RI/FS. Composite samples were collected in Round 1 at numerous beaches to evaluate potential human health risks to beach users. To support the ERA, additional Round 1 sediment samples were collected at selected locations where sculpin, crayfish, clams, and other benthic infauna were found, and in selected potential wildlife exposure areas. Clams and other benthic infauna were not collected at most stations in Round 1 because they were not found in these locations at

sufficient volumes for the entire list of analytes. More tissue and/or sediment may be needed based on the results of the preliminary ecological risk evaluation.

Round 2 sampling is envisioned to include multiple sampling efforts, including the collection of surface sediments to aid the understanding of sources and to support the ERA. Concurrent bioassay testing will occur in Round 2 at a significant number of these stations to support the benthic assessment for the ERA. Round 2 also will involve collection of subsurface cores to evaluate subsurface distributions of chemicals in areas where those sediments could act as sources and in navigation or maintenance dredge areas. Identification of actual core locations will occur in the various Round 2 FSPs. Hydrodynamic modeling and bathymetry survey results will help focus the subsurface sampling locations on areas of potential scour. Round 2 will include a limited number of subsurface cores to assess the potential presence of natural attenuation processes in the ISA.

Round 3 sediment sampling is intended to support the FS (see Section 8). However, data gaps related to uncertainties in the preliminary risk assessments and/or sources could be filled in Round 3 should this information be needed to make a risk management decision.

Surface Sediments Approach

In addition to the objectives presented in Section 6.4.3, a number of factors will be considered when selecting surface sampling locations:

- **Proximity to Sources.** Sediment sample locations will be placed near known and suspected historic and ongoing sources, including seeps, outfalls, utility crossings, and potential groundwater discharge areas. The intent of such sampling is to understand the effect of any such sources on sediments in the river.
- **Proximity to Overwater Structures.** Sediment sample locations will be placed near product transfer points (fuels and solid products) and docks to better understand these potential sources.
- **Previously Uncharacterized Areas.** Where there are exposure areas with little historic data, additional samples will be located to better understand the distribution of chemicals that may pose unacceptable risk or act as sources.
- **Nearshore Areas.** Sediment sample locations will be placed in previously uncharacterized nearshore areas because of the proximity of sources and the higher value of this habitat to biological resources. As evident from the maps provided and

discussed in Section 4, chemical concentrations tend to be highest in nearshore areas.

- **Sediment Transport.** Sediment sample locations will be placed in accreting areas rather than erosional areas. However, some sampling may occur in erosional areas to help understand the effects of erosion on chemical concentrations in these areas.

Sampling locations and methods will be presented in the FSP(s). The depth of sampling will be 1 foot, which is based on evaluation of bathymetric changes between December 2001 and August 2002 (DEA 2003) and potential ecological and human health exposure areas. Chemical analysis of surface sediments will follow the Round 2 QAPP until such time when a reduced list of COPCs may be available. Certain analyte groups will only be analyzed under specific conditions, including:

- VOCs will be analyzed where available groundwater data suggest that VOCs may be reaching the river.
- Butyltins will be analyzed offshore from ship repair/maintenance and storage facilities that were in operation after the introduction of TBT as an antifoulant.
- Dioxins and furans will be analyzed offshore from potential source areas and at a small number of stations distributed throughout the ISA.

Fish tissue analytical results may also be used to identify areas where these additional analyte groups will be analyzed.

Subsurface Sediments Approach

Subsurface sediment sampling will occur over two primary sampling events, with different objectives for each event. In Round 2, subsurface data will be generated to support the evaluation of potential sources and the presence of natural attenuation processes. The approach for and reasoning behind natural attenuation sampling is detailed in Section 8 and Appendix A. In Round 3, subsurface data will be generated to support the FS.

In a dynamic riverine system such as the LWR, sediments are eroding and accreting along variable spatial and temporal scales. It will be important in this system to evaluate subsurface sediment chemistry in areas that have the potential for erosion to cause buried sediments to become surface sediments and therefore potential sources.

The bathymetric surveys already completed by the LWG (DEA 2002a, 2003) demonstrate that typical erosional and depositional forces may result in changes to sediment elevations that can be on the order of a few feet in some places, although in most areas the river bed elevation changes were less than or equal to one foot. These surveys were conducted during a year that was characterized by relatively typical

flows for the last decade. In periods of higher flows and during flood events, there may exist a greater chance for sediment scour and re-deposition. Therefore, it is important to evaluate the chemistry of buried sediments in areas that may be scoured during extreme flow events.

Results from the hydrodynamic/sedimentation modeling that is being undertaken by the LWG will be available 120 days after EPA approval of the modeling approach technical memorandum. Based on modeling results, additional core locations may be identified as data gaps for Round 3 sampling (see Table 7-2).

Berthing areas are often associated with scour due to prop wash and are often dredged for navigation purposes. Review of either the 2001 or 2002 bathymetric maps (DEA 2002a, 2003) shows likely areas of prop-wash-induced sediment scour off several facilities. Again, it will be important to evaluate sediment chemistry in known or historic source areas that have the potential for erosion (e.g., from prop wash) and/or areas of potential navigational dredging that could cause buried sediments to become surface sediments.

Following the preliminary risk assessments, the LWG will identify SMAs that will contain areas that pose an unacceptable risk. If dredging is a reasonable remedial alternative for one or more of the SMAs, then additional subsurface chemical data may need to be collected during Round 3 and the RD/RA to refine the depth to which contamination extends and collect information on sediment engineering properties. Similarly, if natural attenuation is to be considered for an SMA, then appropriate subsurface sediment data will be collected in Round 3 to determine the efficacy of site-specific natural attenuation processes. SMA-specific information on sediments may also be needed for other alternatives such as capping or aquatic disposal, including additional surface/subsurface chemical and/or physical data.

7.2.2 Surface Water

Surface water samples will be collected to identify potential sources, to understand the distribution of chemicals resulting in potentially unacceptable ecological and human health risk (described in Sections 7.3 and 7.4), and to understand the potential for recontamination for the FS (described in Section 8).

The DQO process for understanding the distribution of chemicals in surface water is summarized in Table 7-4.

Problem Description

There is little existing water quality data for the ISA. Therefore, the objectives of the water sampling program are to assess water quality conditions in the ISA under different flow conditions, provide water quality data for use in the ecological and human health risk assessments, and provide water quality data for the assessment of recontamination potential during the FS.

Data Uses

Surface water data will be used to determine:

- If upland sources in the ISA are contributing to unacceptable risk from river water
- Support for the ecological and human health risk assessments
- If various river stages and flows and storm events have a measurable effect on the nature or concentration of surface water chemical constituents
- The impact to the ISA of potential upstream sources of surface water chemical constituents
- The potential presence of natural attenuation processes within the ISA
- The potential for recontamination of remedial alternatives (examined in the FS).

Data Needs

Sampling and analytical methods must be adequate to achieve detection limits that are below risk-based water quality screening levels. Sampling will be conducted during an early fall "first flush" stormwater runoff event and both low-flow and high-flow river conditions. Sample location and density must be adequate to assess variation in chemical concentrations in surface water immediately upstream, downstream, and within the ISA. Sample location and density must also be adequate to understand the potential for source effects to river water and sediments.

RI/FS Tasks

A tiered approach to the water quality investigation is proposed. Surface water sampling was proposed by the LWG but not approved by EPA in Round 1. In Round 2, surface water samples will be collected using high-volume sampling methods at three transects: one transect at RM 11 above the upstream boundary of the ISA, one transect at RM 6.3 within the ISA, and one transect at RM 4 at the lower boundary of the ISA. Upstream samples will be used to evaluate the upstream contribution of chemicals to the ISA. High-volume samples also will be collected at four locations (Rhone Poulenc, Willamette Cove, ATOFINA, and Portland Shipyard) during an optimum-flow sampling event to assess potential source effects. Grab samples will be collected to support the ERA. Grab samples will also be collected in potential swimming areas to support the HHRA.

Specific Round 2 water quality sample locations, analyses, collection methods, and required analytical detection limits will be provided in the Round 2 surface water sampling FSP. High-volume surface water sampling methods will achieve minimum reporting limits below chronic and acute Ambient Water Quality Criteria (AWQC) and Oak Ridge National Laboratory ecological screening values and below AWQC

for the protection of human health and EPA Region 9 PRGs. Grab sampling methods will achieve minimum reporting limits below chronic and acute AWQC and Oak Ridge National Laboratory ecological screening values and below EPA Region 9 PRGs for all COPCs except N-nitrosodimethylamine, toxaphene, and dioxins/furans. These criteria are used to identify analytical reporting limits and for screening purposes.

Additional surface water samples will be collected in Round 3 for analysis of persistent, bioaccumulative toxins (PBTs) using high-volume sampling methods if a data gaps analysis based on Round 2 sampling results, the ecological preliminary risk evaluation, food web modeling results, and groundwater impacts evaluation scoping determines that additional surface water data with very low minimum reporting limits are needed to develop PRGs or evaluate source effects. Similarly, if additional surface water sampling to determine chemical distributions, source effects, natural attenuation, or recontamination potential is necessary, the proposed approach will be presented in a Round 3 FSP.

7.2.3 Groundwater

Table 7-5 summarizes the DQO process for understanding the hydrogeologic physical system and the effects of groundwater discharges on ecological and human health risks and the distribution of chemicals in sediment.

Problem Description

In the physical conceptual site model (see Figure 5-1), groundwater flow is identified as a possible pathway between upland sites and the Willamette River. COIs are present in groundwater underlying a number of upland sites along the ISA. Because the river is a primary discharge point for the groundwater from the upland sites, it is important to determine whether these COIs can migrate to the Willamette River at concentrations that pose a potential human health or ecological risk. In addition, it is important to consider the total loadings of persistent, bioaccumulative toxins (PBTs) to the river.

Among the media investigated in the RI/FS, groundwater is unique because of the regulatory framework established by the memorandum of understanding (MOU) between EPA and DEQ (EPA et al. 2001). For purposes of the RI/FS, upland releases are assumed to be the source of contaminated groundwater. According to the MOU, DEQ has lead authority for investigating upland releases and, if necessary, requiring source control measures to protect sediment and water quality in the Willamette River against the threat of ongoing contamination from such releases. The purpose of DEQ investigation and source control measures is to identify and eliminate ongoing upland sources of contaminated groundwater that are contributing, or threaten to contribute, contaminants to the ISA.

Because of its focus on risk in the Willamette River, the groundwater component of the RI/FS will ultimately concentrate on evaluating the risks to human and ecological receptors from contact with groundwater contaminants that have been transported to the Transition Zone (including sediment and water) or surface water through seeps within the Site. The groundwater component of the RI/FS should consider the risk presented from the cumulative effects of PBTs entering the river and subsequent bioaccumulation in fish. To accomplish this, information on known groundwater sources impinging on the river is needed to identify chemical contaminants and potential exposure points in the river. In addition, information is needed to identify areas where groundwater contamination is possibly affecting the river, but cannot be confirmed with existing upland or in-water information. Under the Source Control Strategy, DEQ and EPA will implement a formal screening process to identify sites where groundwater COIs may result in unacceptable risks in the river. The combined upland investigations and Source Control Strategy processes provide a high degree of confidence that most of the sites where contaminated groundwater may adversely affect the Site are identified for consideration in the RI/FS.

As part of DEQ's ongoing Cleanup Program, DEQ has overseen or conducted extensive investigations of groundwater at upland sites adjacent to the ISA. The resulting data provides a basis for evaluating the effects of contaminated groundwater on risk in the river. However, additional information will be necessary to evaluate areas where data are insufficient to determine the need for further analysis. (Identification of such areas and the associated data needs are addressed in following sections.) Once groundwater contamination has reached the river, the receptors potentially most affected are benthic-dwelling fish and invertebrates. Human exposure may also occur through dermal contact with groundwater emerging as seeps in beach areas. In addition, contaminated groundwater discharging to areas of relatively isolated or quiescent waters may affect surface water quality and result in exposure to fish and/or amphibians. Humans and higher trophic-level ecological receptors could also be indirectly affected if groundwater COIs sorb to sediments, disperse in surface water to unacceptable levels, or bioaccumulate in prey items.

The potential for groundwater contaminants to affect ecological risk in sediments is highly dependent on the characteristics of the contaminants being introduced to the sediment. Groundwater contaminants with low water solubility and high soil/sediment adsorption coefficients will preferentially sorb to sediment particles, and only a small fraction will partition from sediment to the aqueous phase. Metals and hydrophobic organic contaminants typically have low mobility and high sediment sorption characteristics. For these chemicals, the aqueous concentration in the Transition Zone is controlled by the rate at which the chemical desorbs or dissociates from the solid phases and becomes available in Transition Zone water to benthic infauna. Toxicity and risk of such chemicals to ecological receptors can be assessed through chemical analysis or toxicity testing of bulk sediment samples from locations where the chemicals in groundwater are discharging to the Transition Zone.

Groundwater contaminants with high water solubility and low soil/sediment adsorption coefficients may not sorb to sediment, but may affect aqueous concentrations as contaminated groundwater moves into the Transition Zone. Other factors, such as organic carbon content of the sediment, volatility and degradation of the groundwater contaminant(s), and co-solvency mechanisms, will also affect the fate and transport of groundwater contaminants through the Transition Zone. Concentration of such chemicals in Transition Zone water is more likely to be dependent on the concentration in groundwater entering the Transition Zone and the extent to which it mixes with water from other sources. Such chemicals may not be identified in bulk sediment samples, and separate sampling methods may be necessary to estimate exposure where such contamination may occur and present a risk to identified ecological receptors, which are expected to be primarily benthic organisms.

Data Uses

The overall objective of the groundwater evaluation is to assess whether contaminated groundwater discharging to the ISA causes unacceptable risks to ecological and potential human receptors. Consequently, the groundwater evaluation process is integrated with the ERA and HHRA. Data collected to evaluate the impact of contaminated groundwater discharging to the ISA will be used to:

- Identify the locations and extent of contaminated groundwater impacts and the COI concentrations or measured toxicity of the potential impacts in the ERA
- Identify potential human exposures to COIs in groundwater seeps and to assess human health risks from that exposure in the HHRA
- Determine SMAs (see Section 6) within the Site
- Identify preliminary remedial actions.

The overall approach adopted by the LWG for evaluating effects of groundwater contaminants on sediments is consistent with the tiered approach for groundwater/surface water assessments recommended by EPA (2000b). The approach requires repeated integration of the site characterization and ERA tasks of the RI/FS.

Data Needs

Data needs for evaluating the potential impacts from groundwater contaminant discharge to the river are location-specific, and thus will be determined site-by-site based on the type of COIs present in groundwater as well as the existing understanding of groundwater flow and discharge. Data needs for the groundwater evaluation will be assessed by:

1. Compiling and evaluating existing data from DEQ files and published literature on the physical hydrogeologic system and upland contaminated groundwater distributions to identify where groundwater contamination is confirmed or has a reasonable potential to discharge to the ISA and identifying the COIs for these discharges
2. Developing an understanding of the physical relationship between groundwater and surface water within the ISA and the influence of the hydrogeological physical system on exposure pathways in the ISA
3. Refining and updating the hydrogeological CSM
4. Developing a process for assessing and focusing the areas for further evaluation and identifying the types of samples for addressing the data needs.

The updated CSM report will provide the results of the compilation and evaluation of groundwater physical system and groundwater quality data and a discussion of the influence of the hydrogeological physical system on exposure pathways in the ISA. The CSM will be augmented as additional information is gained through RI characterization tasks. The process for focusing the evaluation of potential impacts to sediment, the Transition Zone, seeps, and surface water from chemicals in groundwater discharging to the river, as described later in this section, will be negotiated with EPA prior to implementation.

If data needs are identified for characterizing potential impacts to receptors from groundwater discharging to the river, the LWG in cooperation with EPA will assess the need for additional data collection. The types of data needed to evaluate the potential for effects of exposure of receptors to groundwater discharges to the river or human use areas will vary on a site-by-site basis and may include one or more of the following:

- Chemistry of bulk sediment samples
- Chemistry of water samples obtained from the Transition Zone
- Chemistry of seep samples in human use areas
- Chemistry of surface water samples in quiescent areas
- Groundwater flow measurements
- Toxicity testing to support the ERA.

The activities and tasks for evaluating the potential impacts will be described in separate field sampling plans for individual sampling events.

RI/FS Tasks

As with other aspects of the RI/FS, the groundwater evaluation involves integrating data needs for characterizing chemical distributions in the river with those of the ERA

and HHRA, on which risk characterization decisions will be made. The proposed RI/FS tasks associated with groundwater are:

Task 1: Groundwater Data Review and CSM Update,

Task 2: Process for Assessing and Focusing Data Needs,

Task 3: Data Collection.

A description of each of these tasks is provided below.

Task 1. Groundwater Data Review and CSM Update

The objective of this initial task is to use the data compiled during the groundwater data review to update the hydrogeological CSM for the site. Specifically, the updated CSM will reflect the results of the groundwater data review and will include the following information:

- Description of the physical hydrogeologic framework, groundwater flow systems, and surface water/groundwater interactions
- Categorization of upland sites based on availability of groundwater chemistry data, presence of groundwater containing COIs, and presence of complete or likely complete exposure pathways to receptors in the river.

The existing hydrogeologic data compiled during the groundwater data review will be used to understand the following specific attributes of the physical hydrogeologic system:

- The nature and location of groundwater discharges
- Spatial relationship between hydrostratigraphic units and the river
- Spatial and temporal changes in groundwater flow and river stages.

The groundwater data will also be used to categorize the upland sites within the ISA based on available groundwater chemistry information, as follows: 1) sites where groundwater containing COIs are known or suspected to discharge to the river, 2) sites where COIs are present in groundwater but where upland data are insufficient to assess the potential for COIs to reach the river, and 3) sites where groundwater data are not available.

Upland sites where groundwater containing COIs are known or suspected to discharge to the river will be categorized based on the following factors:

- Known past or present releases of NAPL or aqueous-phase concentrations of COIs

- Frequent detections or high concentrations of COIs in groundwater samples collected adjacent to the riverbank
- High concentrations of COIs or NAPL in groundwater that intersects human-made or natural preferential pathways that potentially discharge to the river
- High concentrations of COIs or NAPL that are not adjacent to the river bank or do not intersect preferential pathways but COIs still have the potential to reach river sediments
- Presence of a complete exposure pathway between groundwater and receptors in the river.

Sites where COIs are present in groundwater but where available upland data are insufficient to assess the potential for COIs to reach the river will be referred to DEQ to address per the Source Control Strategy. Sites for which groundwater data are not available will be assessed using historical land use information, including historical aerial photographs and Sanborn maps, as available, to identify sites where there is a reasonable possibility for impacts to groundwater based on historical site uses. For these sites, available information will be summarized and recommendations made to DEQ for site assessment purposes. For sites where groundwater data gaps have been identified and where groundwater data are not available through the groundwater data review process and cannot be readily obtained for a particular site based on the RI/FS schedule, the LWG will evaluate the potential groundwater impacts to the river on a site-by-site basis and will implement a process for assessing data needs and potential data collection activities, as described under Tasks 2 and 3 below.

The physical hydrogeologic data and information on COIs in groundwater will be integrated with the information collected during the October 2002 seep reconnaissance survey (GSI 2003b) to refine the hydrogeologic CSM (Section 5.1). The CSM will continue to be updated following incorporation of data collected during subsequent RI/FS characterization activities.

Task 2. Process for Assessing and Focusing Data Needs

The objective of this task is to identify and focus areas where potential effects of chemicals in groundwater discharging to the river need further evaluation. The process for assessing and focusing these data needs will be developed in cooperation with EPA prior to implementation. It is anticipated that the areas requiring additional data and the types of data collection necessary to achieve this objective will vary between locations depending upon COIs and other site-specific data needs.

The process for assessing and focusing data needs will be based on the following information:

- Location(s) and geometry of upland groundwater COI plumes

- Horizontal and vertical groundwater gradients (groundwater flow direction) at the upland sites of interest
- Upland hydrostratigraphic information
- Locations where the groundwater pathways to receptors in the river have been identified as complete
- A survey to identify the locations of focused groundwater discharge
- A conservative contaminant screening step.

The first three sources of data information listed above will be evaluated and summarized as part of the updated CSM document. This information will be integrated with the groundwater discharge survey data and the contaminant screening to identify appropriate areas offshore of upland sites where groundwater COIs have a reasonable potential to reach the river. Also, the groundwater discharge survey data and the contaminant screening assessments, as described below, will be conducted iteratively to better focus the sampling effort on areas where there is a potential for impacts to receptors from groundwater discharging to the river.

Pilot studies may be conducted to evaluate the scope of RI groundwater sampling efforts and to evaluate sampling methodologies. If the pilot studies are deemed prudent, the details will be developed in cooperation with EPA in a technical memorandum prior to initiating any field work.

Groundwater Discharge Survey Assessment
The data needs assessment process will identify locations of groundwater discharge that should be further evaluated. The steps that will be used to identify these locations and the methodology for the assessment will include the following:

1. Evaluate the feasibility of utilizing survey tools (e.g., towed probes) to identify groundwater discharge areas on a site-specific basis.
2. Where feasible, use groundwater flow direction, plume location and geometry, and available stratigraphic information to guide a site-specific groundwater discharge survey at sites identified in Task 1 and through the contaminant screening assessment by using the appropriate techniques, such as forward-looking infra-red (FLIR) or towed probes.
3. Interpret the results in the context of the upland information.
4. Where use of survey techniques is not feasible, use groundwater flow direction, plume location and geometry, available stratigraphic information, the results of the contaminant screening,

and, if necessary based on consultations with EPA, other survey techniques such as an in-water stratigraphic survey to identify possible discharge areas.

5. Integrate information with the CSM and contaminant screening assessment to identify areas where groundwater discharge should be assessed using survey methods.

Contaminant Screening Assessment
The data needs process will also evaluate the potential for impacts to ecological and human receptors through a conservative screening level assessment. As stated above, the combined results of the screening step together with the information from the CSM and the groundwater discharge survey data will be used to focus the groundwater data collection task on areas where groundwater COIs have a reasonable potential to reach the river. The details of the screening approach to focus the evaluation of the exposure of ecological and human receptors to chemicals transported in groundwater discharging to the river will be proposed and negotiated with EPA prior to implementation. It is expected that sites where concentrations of COIs in groundwater do not or are not likely to reach the Transition Zone at concentrations that exceed conservative screening criteria (e.g., AWQCs) will not require additional sampling.

Ecological Screening Approach
Data needs for evaluating potential impacts to ecological receptors will be identified based on the results of prior tasks and an evaluation of COI characteristics. For locations where COI concentrations exceed screening criteria, chemical characteristics of the COIs will be evaluated for their preference to sorb to sediments. Criteria, including octanol-water partitioning coefficients (K_{ow}), organic carbon partitioning coefficients (K_{oc}), or soil/water partitioning coefficients (K_d), will be used in this analysis. In addition, physical characteristics of sediments and the types of contaminants that are present will also be considered to help determine appropriate media to be sampled.

Locations with COIs that preferentially sorb to sediments will be evaluated using bulk sediment samples and standard risk approaches for assessing effects to benthos. Locations with COIs that preferentially partition to the aqueous phase may be subjected to alternative sampling and analyses for characterizing exposure and risk, such as sampling of Transition Zone water and/or surface water sampling in quiescent areas. The type of sampling and analysis will include techniques that could be used for estimating exposure point concentrations. As noted previously, the types and quantity of sampling will be site-specific.

The details of the screening process, including the types of data to be screened and the screening-level values, will be discussed with EPA prior to implementation. Upon EPA approval, the proposed processes will be integrated into the ERA

approach and documented in a technical memorandum that will become part of the RI/FS Work Plan.

The results of this analysis and data collected during Round 2 and Round 3 of the RI will be incorporated into the ERA approach for benthic organisms and, if applicable, other receptors. The specific processes for risk analysis are detailed in the ERA approach (Appendix B).

Human Health Screening Approach
Data needs for assessing potential impacts to human receptors from COIs in groundwater discharging to the river will be evaluated using the results from the groundwater data review and seep reconnaissance survey through the following steps:

1. Compare upland sites identified in Task 1 (groundwater data review and conceptual model) that have a potential for COIs to discharge in groundwater with the identified seeps in potential human use areas. This comparison will assess whether any of the sites are located upgradient from the seeps where direct human contact could occur.
2. After the evaluation described above is completed, the LWG, in consultation with EPA and its partners, will determine which seeps will need further evaluation for human health risk assessment and the methods that will be used for this evaluation. This evaluation may include assessment of existing groundwater data or of new data collected by the LWG or other parties.

Seeps will be sampled to determine exposure point concentrations at human use areas where the exposure pathway for groundwater COIs is complete and may result in a risk to human receptors. Details of how risks from these pathways will be incorporated into the HHRA are described in the HHRA approach (Appendix C).

Task 3. Data Collection

Based on the results of the process for assessing and focusing data needs (Task 2), a sampling program will be designed to address data gaps where there is potential for groundwater impacts to human or ecological receptors. Details on the specific activities and sample locations will be described in separate FSPs submitted to EPA prior to implementation. It is expected that this data collection effort will occur during Round 2 and possibly in Round 3, if deemed necessary.

Based on current knowledge of the groundwater data, potential data collection efforts may include one or more of the following:

- Chemistry of bulk sediment samples for COIs that sorb to sediments at locations where concentrations exceed screening criteria, and where data gaps have been identified and

groundwater data adequate for assessing potential impacts to the river cannot be obtained in a timely fashion based on the schedule for the RI/FS

- Chemistry of samples of water in the Transition Zone for COIs that may not sorb to sediments at locations where concentrations exceed screening criteria, and where data gaps have been identified and groundwater data adequate for assessing potential impacts to the river cannot be obtained in a timely fashion based on the schedule for the RI/FS
- Chemistry of seep samples in human use areas.
- Chemistry of surface water samples in quiescent areas
- Groundwater flow measurements, where groundwater data adequate for assessing potential impacts to the river cannot be obtained in a timely fashion based on the schedule for the RI/FS
- Toxicity testing (as necessary for the ERA).

The potential effects of exposure of ecological receptors to groundwater discharging to the Transition Zone will be evaluated through sampling of sediment and water within the Transition Zone. Sediment and water sampling within the Transition Zone will be considered at potential groundwater discharge locations where groundwater COIs are confirmed to discharge or have a reasonable likelihood to reach the Transition Zone within the river. Sample density will be sufficient in the vicinity of these discharge areas to allow representative characterization of groundwater that poses a potential risk to biota.

The potential effects of exposure of humans to groundwater discharging in surface seeps will be assessed based on seep sample chemistry in defined human use areas. The effects of exposure of biota to groundwater discharges in quiescent areas will be evaluated through surface water sampling in such areas. Potential risks to human or ecological receptors associated with possible indirect exposure to COIs in groundwater will be evaluated using sediment, surface water, and tissue data.

Coordination of surface water and in-water groundwater data collection will be important at locations where groundwater COIs are assessed in order to understand potential relationships between chemicals detected in groundwater and surface water quality while reducing possible temporal variability.

Assessment of the potential effects on receptors and surface water of certain COIs transported in groundwater to the Transition Zone and surface water may require an integrated sampling approach involving both measurement of physical groundwater flow parameters and chemical sampling in the river. The types of data and techniques for obtaining the data are discussed in the following sections.

Physical Groundwater Data
Physical groundwater flow data may include measurement of groundwater flow direction and groundwater flux rates depending on the data needs for a particular location. The direction of groundwater flow adjacent to and in the river may be important for assessing the location and extent of the area where chemicals in groundwater may discharge to the Transition Zone and surface water. Groundwater flow information from individual sites will be used for assessing physical hydrogeological conditions in the Transition Zone where available and adequate. In areas where site-specific data are not available, groundwater flow proximate to the river is assumed to be directly towards the river or at perpendicular flow patterns to the river. Measurement of hydraulic head using nested mini-piezometers can be used, as necessary, where an understanding of vertical groundwater gradients is needed.

To assess risk and recontamination potential, knowledge of groundwater flux may be important for understanding local or overall contaminant flux and loading from a COI plume. The general rate of groundwater flux can be calculated from the hydraulic gradient and hydraulic conductivity measurements where these data are available from upland sites. When these data cannot be estimated from existing information, the groundwater flux rate in a localized area can be measured using seepage chambers.

Chemical Groundwater Data
The techniques used to collect water chemistry data from the Transition Zone or groundwater depend on the uses of the data and types of contaminants targeted. The sampling technologies typically used for assessing chemicals transported in groundwater to the river can be divided into two categories: passive and active. A brief description of proposed sampling techniques for each category is provided below. Specific sampling techniques for physical and chemical groundwater data will be described in FSPs for individual sampling events.

Passive Sampling Devices. Passive devices include semipermeable membrane devices (SPMDs), diffusion samplers, and peepers. Passive sampling techniques involve placing a sampling device in sediment or in the water column and allowing that device to reach chemical equilibrium with the surrounding media over time. The time required for equilibrium is dependent on the properties of the contaminants of interest. Passive devices provide quantitative or semi-quantitative results that may be used in a variety of RI/FS applications.

Active Sampling Devices. Active sampling devices are designed to obtain a representative concentration of a chemical in groundwater, including in the Transition Zone. Samples obtained using active sampling devices are concentrations representing a spatial and temporal point. Active sampling devices include mini-piezometers, temporary direct-push devices (e.g., Geoprobes®), and multi-level sampler devices.

7.3 ECOLOGICAL RISKS

Ecological receptors may be exposed to chemicals resulting from historical and ongoing releases and/or sources within Portland Harbor. Potential receptors in the ISA include species of aquatic plants, amphibians, reptiles, benthic and epibenthic invertebrates, fish, birds, and mammals. Exposure may occur through direct contact with sediment or water or through ingestion of sediment, surface water, and prey items. Tables 7-6 through 7-10 present the DQO process for assessing ecological risk. Appendix B describes the ERA approach.

7.3.1 Problem Description

Chemicals in sediment, water, or biota in the ISA may result in unacceptable risks to ecological receptors. The objective of the baseline ERA is to estimate potential risks to ecological receptors associated with exposure to chemicals resulting from historical and ongoing releases or sources within the ISA.

7.3.2 Data Uses

Data collected to support the ERA will be used to determine whether chemicals in sediment, water, or biota resulting from historic and ongoing releases or sources in the ISA cause unacceptable risks to ecological receptors and warrant consideration of further investigation or possible response action.

7.3.3 Data Needs

Chemicals in sediments (including solid and aqueous phases) and surface water may have adverse effects on ecological receptors through direct contact or ingestion of sediment and surface water. Therefore, areas where potential receptors could be exposed to sediments and surface water need to be identified. These exposure areas will be identified by evaluating the ecology, particularly the foraging habits, of all receptor species. Sediment and surface water data will be collected from those areas where exposure could occur.

Biota that have accumulated chemicals from surface water and sediment in the ISA could pose risks to ecological receptors that ingest those biota. Therefore, to evaluate potential risks to ecological receptors that prey on biota within the ISA, tissue data from representative prey items are needed.

Groundwater may be a source contributing to elevated chemical concentrations within the ISA. Therefore, to evaluate whether the discharge of contaminated groundwater to the ISA presents a risk, exposure points for groundwater will need to be identified. A review of historic data, physiochemical aspects of chemicals in groundwater, and the potential for ecological risks not already captured in the aquatic invertebrate risk evaluation needs to be completed.

7.3.4 RI/FS Tasks

As discussed in previous sections, the RI/FS will be an iterative process that includes multiple rounds of data collection. Data to support the ERA includes the following:

- Pre-AOC data
- Historic Category 1 data
- Round 1 data
- Round 2 data
- Round 3 data (if necessary to reduce uncertainties).

The following specific RI/FS tasks will address the data needs of the ERA:

1. All of the pre-AOC data collected under the stipulated agreement were used to develop the preliminary conceptual site model for the ERA.
2. The historic Category 1 data will be used in estimating risk to ecological receptors. Historic Category 1 and 2 data were used in scoping the ecological risk assessment (e.g., to better understand tissue concentrations from historic studies and to better understand the trends in sediment chemical distributions).
3. During Round 1, surface sediment samples were collected in areas that were identified, using existing data, as potential sources and provide ecological habitat for selected receptors. These data will be used in estimating risks.
4. Collocated with the sediment samples in Round 1, crayfish and sculpin tissue, benthic community, and, where possible, clam tissue samples were collected. The exact analyte list for each sample type is described in the Round 1 QAPP. These analytical results and benthic community characteristics will be used to refine the conceptual site model and as input into the preliminary risk evaluation. These data will also be used to assess the relationship between sediment and tissue concentrations.
5. In addition to these data, physical system and source information (e.g., bathymetry, seep reconnaissance) will be applied in the evaluation of the effect of groundwater on exposure pathways and its potential risk to infaunal invertebrates.
6. Data pertaining to the physical system (e.g., bathymetry) will be used to update the exposure scenarios for the ERA.

The following additional tasks will be performed to fill data needs for the baseline ERA:

1. Collection of surface water chemistry data in quiescent areas within the ISA for the purposes of determining exposure concentrations to aquatic invertebrates, fish, and amphibians from the surface water pathways.
2. Collection of bulk surface sediment samples for bioassay testing across the gradient of chemical concentrations observed in historic and 2002 data.
3. Collection of additional sediment chemistry samples, as needed, to fill any data gaps that remain after the 2002 sampling (e.g., assessment of the dietary pathways to fish and wildlife).
4. Collection of site-specific data, as needed, to parameterize the food web model that will be used to establish sediment preliminary remediation goals.

Data collected in Round 2 will be used to further refine the CSM and identify remaining data gaps. Additional data may be collected in Round 3 as needed to complete the risk assessment. The information collected in Rounds 1, 2, and 3 will be applied in the draft baseline ERA.

7.4 HUMAN HEALTH RISKS

Human receptors may be exposed to chemicals that are a result of historical and ongoing releases and/or sources within the ISA. Potential human uses in the ISA include occupational, recreational, transient, and fish consumption scenarios. Exposure may occur through direct contact with sediment or water or through ingestion of fish or shellfish. Appendix C contains the HHRA approach.

7.4.1 Problem Description

Chemicals in sediment, water, or biota in the ISA may result in unacceptable risks to some human receptors. However, these risks have not been estimated for human receptors. The objective of the HHRA is to estimate potential risks to human health associated with exposure to chemicals that are a result of historical and ongoing releases and/or sources within the ISA. Details of the DQO process used to develop data needs for the HHRA are included in Table 7-11.

7.4.2 Data Uses

Data collected to support the HHRA will be used to determine whether chemicals in sediment, water, or biota that are the result of historic and ongoing releases and/or

other sources to the ISA cause unacceptable risks to human health and warrant consideration of further investigation or possible response action.

7.4.3 Data Needs

Chemicals in sediments and surface water may have adverse effects on human receptors in areas where direct contact with those media occurs. These areas need to be identified, and human activities that could occur in those areas need to be evaluated to assess the potential for direct contact with sediment or surface water. Sediment and surface water data are then needed to evaluate risks from human activities that could result in direct contact.

Although groundwater is not anticipated to result in significant risks to human health, groundwater could result in potential risks to human receptors if direct contact with groundwater seeps occurs on a frequent basis and chemical concentrations in groundwater are high enough to pose a risk. Direct contact with groundwater may be a complete exposure pathway for human receptors at some beaches designated as human use areas, specifically at locations where groundwater seeps are found on the beach above the water line. Therefore, potential exposure points for seeps need to be identified. Results of a field reconnaissance survey conducted during low water to identify potential groundwater seep locations above the water line will be reviewed to determine if any of these seeps are located within potential human use beaches. Available upland groundwater data near any beaches identified in this review would also need to be reviewed to assess the potential for the presence of chemicals in these groundwater seeps at concentrations of concern. Additional data needs for the HHRA related to the groundwater pathway will be assessed as part of the groundwater evaluation, as described in Section 7.2.3.

Biota that have accumulated chemical constituents from surface water and sediment in the ISA could pose risks to human receptors who ingest those biota. Therefore, to evaluate risks to human health associated with consumption of biota, the fish and shellfish species that are caught in the ISA and consumed by humans need to be identified. If the HHRA indicates that consumption of biota from the ISA could result in unacceptable risks to human health, a model will be needed to estimate sediment and water chemical concentrations that could result in the chemical concentrations detected in biota tissue. Site-specific (and congener-specific, if needed) biota sediment accumulation factors (BSAFs) and bioconcentration factors (BCFs) will likely be required as inputs to the model. Data needed for the model will be collected during Rounds 2 and 3, as needed.

7.4.4 RI/FS Tasks

As discussed in previous sections, the RI will be an iterative process that includes multiple rounds of data collection. Data to support the HHRA include the following:

- Pre-AOC data
- Historic Category 1 data
- Round 1 data
- Round 2 data
- Round 3 data (if necessary for the food web model).

The draft baseline HHRA will be completed following Round 3.

RI/FS tasks that have been conducted to date to support the HHRA include the following:

1. The preliminary conceptual site model for the HHRA was developed based on pre-AOC data.
2. Historic data were compiled and categorized. Historic Category 1 data will be evaluated to identify data that could be used in the baseline HHRA. The results of this evaluation will be submitted to EPA as an interim deliverable. Historic Category 1 data will only be used in estimating risk to human receptors if appropriate for the receptors and exposure pathways that will be evaluated in the HHRA. Historic Category 1 and 2 data were used in scoping the HHRA (e.g., to better understand tissue concentrations, to begin evaluation of trends in sediment chemical distributions).
3. During Round 1, beach sediment samples were collected in human use areas where direct contact with sediment could occur. The basis for selecting human use areas is described in Appendix C. Because potential contact with beach sediment would be ongoing and would occur throughout a beach area, composite surface sediment samples were collected to be representative of the type of exposure that could occur. Beach sediment samples were collected during low tide and at low water when the maximum beach area was exposed. These data will be used in estimating risks to human health.
4. A limited qualitative survey was conducted to identify target fish and shellfish species for human consumption. The survey included interviews with two local fishers, as well as a review of the investigation by the Oregonian and the limited surveys of other portions of the Willamette River (ATSDR 2002). Based on the results of the survey and to support the HHRA, four resident fish species and shellfish (crayfish) tissue samples were collected in the ISA during Round 1. Fish and shellfish tissue data collected in the ISA during the Round 1 field studies will be used

in the baseline HHRA to estimate potential risks to human health from fish consumption.

5. A reconnaissance survey of groundwater seeps, conducted in October 2002, found seeps at or near 12 beaches identified as potential human use areas. A methodology for evaluating seeps for potential human health risks will be discussed with EPA and its partners and incorporated into the HHRA Approach (Appendix C), when approved.

The following additional tasks will be performed to fill data needs for the baseline HHRA:

1. Composite surface sediment samples were collected at human use beaches to be representative of potential human exposures, but these samples may not be appropriate for evaluation of response actions. Therefore, the results of beach sediment samples from Round 1 will be compared to appropriate Region 9 PRGs for soil to evaluate whether discrete beach sediment samples are needed. If the composite sample for a beach exceeds risk-based screening levels, that beach will be identified and the need for further data collection will be evaluated. Results of the evaluation of the beach sediment samples will be submitted to EPA as an interim deliverable. If needed, additional beach sediment samples will be collected during Round 2.
2. Upland groundwater data will be compiled for the RI/FS. The upland groundwater data for sites adjacent to beaches where groundwater seeps were identified will be reviewed during Round 2. The data review will evaluate whether chemicals might be present in groundwater at the point of discharge in human use areas.
3. Surface water samples will be collected in Round 2 within quiescent river areas near selected recreational beaches and unsecured riverfront areas where transient encampments have been observed. These are areas where swimming and other direct contact could occur. These data will be used to evaluate potential risks to human health associated with ingestion of, or dermal contact with, surface water. To address site characterization data needs, surface water samples will also be collected during Round 2 from three river transect locations. These samples should be representative of surface water conditions in non-quiescent areas within the ISA. Samples collected from these locations could also be used to evaluate potential direct human contact with surface water (e.g., during windsurfing) in non-quiescent areas of the ISA.

4. Finally, if the risk assessment finds that fish consumption may result in unacceptable risks to human health, a food web model will be needed to evaluate the relationship between sediment, surface water, and tissue. Site-specific data (sediment, surface water, and prey items) will be collected, as needed, to support the food web model that will be used to establish sediment preliminary remediation goals based on detected concentrations of chemicals in fish tissue.

The data collected from the RI/FS tasks above will be used to complete the baseline HHRA.

Sturgeon, adult spring Chinook, and adult Pacific lamprey were collected in the summer of 2003 through a cooperative effort of the ODHS, ATSDR, Oregon Department of Fish and Wildlife (ODFW), the City of Portland and EPA, Region 10. Although these data were not collected as part of the RI, they will be evaluated by the LWG and used in the HHRA. EPA and LWG will use a collaborative process for identifying data needs, data gaps, data uses and evaluations for salmonids, lamprey and sturgeon.

8.0 FEASIBILITY STUDY APPROACH

Though the primary goal of the RI and baseline risk assessment is to determine the areas that may require cleanup, the goal of the FS is to identify the appropriate remedy consistent with the nine CERCLA criteria. The RI and risk assessment are primarily information-gathering and evaluation tasks to understand existing conditions at the Site, while the FS is concerned primarily with identifying reasonable future actions that could be used to conduct a remedial action consistent with CERCLA requirements. Consequently, the FS relies greatly on the data collection and existing conditions description provided by the RI and risk assessment. However, some information gathering must also occur specifically for the FS so that various proposed actions can be evaluated for their potential to succeed (i.e., feasibility) in cleaning up the Site.

Because certain FS tasks are primarily concerned with collecting FS-specific information, they are described using an organization similar to that found in Section 7 for risk and chemical distribution/source information (a DQO style presentation). However, the portions of the FS that are concerned primarily with evaluating the outputs of the RI and risk assessment, as well as developing proposed actions, are described more generally as a series of data analysis and deliverable steps.

In the following sections, the overall FS process and major tasks are briefly described (Appendix A contains the detailed FS process). Key tasks are then described in more detail and, where appropriate, are presented in the DQO style of the previous section. Wherever possible, the information flow that will occur between RI, risk assessment, and major FS tasks is illustrated. However, because the FS essentially relies on all of the information generated by the previous studies, there may be specific pieces of information that will be used but are not specifically identified for a particular FS task. For example, bathymetry is essential to almost every FS task, but use of this information is not repeatedly identified throughout the text.

8.1 FS PROCESS AND MAJOR STEPS

The FS process can be understood in two basic ways that are illustrated in Figure 8-1:

- The sequence of evaluation tasks that will lead to a selected remedial alternative
- The information that will flow from the RI/risk assessment/FS data collection to major FS tasks.

The major tasks for performing the FS are described below.

Preliminary Planning Tasks. As a part of this Work Plan, several memoranda have been prepared to describe specific processes that are proposed to evaluate existing information or to help in planning of the FS (Appendix A, Attachments A1-A4):

- Development of preliminary RAOs
- Description of a proposed disposal facility siting process
- Identification of potential sources of capping materials
- Analysis of natural attenuation data gaps.

These memoranda generally lay out processes or information that will be of later use in the FS. How these proposed processes fit into the overall project are further described below and detailed in the Appendix A attachments.

RAOs. The FS must start with a description of the objectives of the remediation. These form the basis from which the success and effectiveness of proposed actions can be evaluated. This task determines the goals of the entire FS process. The RAO memorandum describes the Applicable or Relevant and Appropriate Requirements (ARARs) and To Be Considered (TBC) initiatives that will be used in determining an appropriate RAOs and a Site remedy. Compliance with ARARs is one of the CERCLA "threshold" criteria (the other being overall protection of human health and the environment) for evaluation of alternatives.

Treatability Studies. Treatment is one potential remedial alternative. In some cases, laboratory- or pilot-scale studies must be conducted to understand the feasibility of treatment technologies. This task involves determining the need for such studies and conducting these studies when and if they are needed.

Facility Siting Studies. Many remedial options include the removal of sediments and disposal or treatment at some other location. This task will identify potential disposal site and treatment locations that may need to be evaluated for the FS.

Natural Attenuation Studies. Natural attenuation is one type of remedial alternative that will require data collection on the physical and chemical systems of the river to understand its potential feasibility. This task includes both the data collection and data evaluations that will be conducted to determine the feasibility of this particular option.

Development, Screening, and Evaluation of Remedial Alternatives. This task involves the first step in identifying potential remedial alternatives for the Site. It will proceed in a series of remedial alternative development and evaluation steps that will rely on various types of data analysis including:

- Determination of SMAs and, for SMAs in which dredging is considered a potential remedial action, volumes of sediment requiring remediation

- Evaluation of remediation and disposal site engineering properties
- Analysis of the recontamination potential at remediated sites.

This step in the FS process follows EPA (1988) guidance on conducting FSs and includes evaluation of alternatives against the three screening criteria of effectiveness, cost, and feasibility as well as detailed evaluation of alternatives against the nine CERCLA evaluation criteria.

A preliminary list of remedial technologies that will be considered in the development of remedial alternatives has been developed and is presented in Appendix A, Attachment A1. In summary, the remedial technologies for sediments that will be considered in the development of remedial alternatives are:

- No Action
- Institutional Controls
- Natural Attenuation
- *In-situ* Containment (e.g., capping)
- *In-situ* Treatment
- Removal and Disposal (e.g., aquatic, nearshore, or upland confined disposal)
- Removal and Treatment

In addition, other remedial technologies that may apply to chemicals in fish tissue and/or water are discussed in Appendix A, Attachment A1.

FS Report. This report describes all of the above data collections, data evaluations, and remedial alternative development and evaluation steps. The purpose of this task is to present the recommended remedial alternatives to EPA and its partners for review and eventual agreement, and, finally, to assist in development of the ROD.

The following sections describe the methods and approach to each of these tasks in more detail.

8.2 REMEDIAL ACTION OBJECTIVES

Preliminary RAOs were developed for the project and are described in the Preliminary Draft Remedial Action Objectives Technical Memorandum (see Appendix A, Attachment A1). This section summarizes the preliminary RAOs defined in that technical memorandum. It should be noted that the technical memorandum also describes the process of how these preliminary RAOs were

determined. In general, the process closely followed CERCLA guidance (EPA 1988). RAOs provide a context for the FS and, when established early in preliminary form, help focus the FS toward effective remedial alternatives.

It is important to note the following specific definitions of terms used in the preliminary RAOs.

Reduce Risks. Lessening the unacceptable risks from chemicals by lowering their concentrations, mobility, bioavailability, toxicity, or exposure to receptors. The assessment endpoints used to define unacceptable risks are presented in detail in the ERA and HHRA approaches (Appendices C and D). In summary, the ERA endpoints are the survival, growth, and reproduction of relevant ecological receptors. For human health, the endpoints are carcinogenic and non-carcinogenic effects to people (using EPA's typical risk range for cancer risks of 1×10^{-4} to 1×10^{-6}). Use of the word "reduce" is not intended to imply that the risk reduction must occur through a decrease in chemical concentration in the matrix of interest.

Acceptable Levels. Risks posed by chemicals that are below unacceptable adverse risk or harm to either the ecological or human health receptors identified above using the assessment endpoints defined in the ERA and HHRA approaches (Appendices C and D, respectively). These risk levels will be eventually quantified through the baseline risk assessment.

The five preliminary RAOs listed in Section 6.1 all follow the specific requirements of RAOs in EPA (1988) guidance. The FS will consider "background" following EPA guidance (EPA 2002b) on the use of background in RI/FS evaluations and other relevant EPA Superfund guidance. The intent is that RAOs will not result in remedial action (or cleanup) levels that are below background levels, including anthropogenically caused background levels. This is consistent with EPA (2002b) guidance on consideration of background in risk management. Site-specific background levels will be identified in a future technical memorandum (see Secton 6.3.2).

In addition to the RAOs the following general objectives (which are not RAOs) for the remedial action are considered important by the LWG.

- Promote remedial actions that do not limit current or planned waterway, municipal, commercial, industrial, recreational, or Tribal ceremonial uses.
- Promote remedial actions that are feasible for the physical system of the Willamette River.
- Integrate remedial actions with NRDA findings and restoration plans, where appropriate.

As detailed in the technical memorandum, RAOs will be developed and refined at the start of the formal FS (after Round 3 sampling) in coordination with EPA. An integral part of developing RAOs is considering ARARs. Appendix A, Attachment A1, reviews ARARs and TBCs that may be appropriate for use in this FS.

8.3 TREATABILITY STUDIES FOR SEDIMENTS

Treatability study tasks are described in detail in Appendix A. A summary is provided below.

8.3.1 Problem Description

Treatability studies provide information on the suitability of site-specific sediments or other matrices for treatment technologies and help to understand how various treatment technologies may or may not be viable for this specific site. Consistent with the SOW, if existing information is sufficient to determine suitable technologies and/or judge their appropriateness without treatability studies, treatability studies do not need to be conducted.

8.3.2 Decisions and Data Uses

Sufficient information must be available to compare, in a consistent manner, treatment technologies with all other technologies. If literature information is insufficient, treatability studies for specific technologies may be necessary. Two basic preliminary decisions must be made:

- Which treatment technologies are effective and cost-competitive (potentially suitable) as compared with other general response actions?
- For those potentially suitable technologies, would treatability studies be needed to determine the appropriateness of the technologies for this specific site?

8.3.3 Data Needs

To make the preliminary decisions, a literature survey of existing treatment technologies is needed. If this information is insufficient to compare, in a consistent manner, treatment technologies with other remedial alternatives, then treatability tests should be conducted.

8.3.4 Treatability Study Tasks

Per Section 8.1.1 of the SOW, the LWG will conduct a literature survey on existing sediment treatment methods. Information on performance, relative costs, applicability, removal efficiencies, operation and maintenance requirements, and implementability of candidate technologies will be compiled and evaluated.

Based on this review and data evaluation, the LWG will recommend to EPA in a technical memorandum (Treatability Study Literature Survey Technical Memorandum) whether treatment is a feasible and cost-effective general response action for sediments. If so, the specific types of treatment technologies likely to be feasible and cost-effective (and why) will be presented and discussed in a technical memorandum. Finally, the memorandum will indicate whether site-specific treatability studies are needed to further evaluate any of these technologies.

If a decision is made to perform treatability studies, the LWG will select in conjunction with EPA the type of treatability testing to use (e.g., bench vs. pilot). A brief technical memorandum (called a statement of work in the AOC and defined as the Evaluation of Treatability Studies Technical Memorandum) will be prepared by the LWG that lists the candidate technologies, identifies the scale at which they will be tested (pilot vs. bench), and lists available facilities/sites at which the testing can occur. Testing will occur on the basis of this memorandum.

As shown in Figure 8-1, the Literature Survey Technical Memorandum will be provided in time to refine general response actions (immediately after Round 3 sampling). If treatability tests are conducted, they will be completed in time for the refinement of alternatives step in the FS process.

8.4 FACILITY SITING STUDIES

This FS task is described in detail in Appendix A, Attachment A2, and is summarized here.

8.4.1 Problem Description

Sufficient information must be available on potential sites for sediment disposal to reasonably evaluate dredging or other removal remedial options. The actual availability, distance, and configuration of facility sites affect many aspects of the remedial alternative, including the major FS selection criteria of effectiveness, cost, and feasibility.

8.4.2 Decisions and Data Uses

Sufficient information must be available on disposal sites such that the removal option can be reasonably evaluated in the FS consistent with other alternatives. All

types of disposal sites are to be considered, such as aquatic, nearshore, upland, and currently operating landfills.

8.4.3 Data Needs

The locations, limitations, and general configurations of potential sites must be known. Where these are currently operating landfills, this would include tipping and other commercial fees as well as taxes.

8.4.4 Facility Siting Tasks

The following major steps to facility siting and disposal site identification are presented in Appendix A, Attachment A2:

1. Define the geographic limits of the study area to be considered for facility siting.
2. Estimate the volume of sediments that might be disposed based on Round 2 information available.
3. Evaluate the study area for sites of appropriate size (given Step 2 volume assumptions) and use preliminary screening criteria to create a preliminary inventory of sites.
4. Determine the specific volume and the chemical, physical, and geotechnical characteristics of the sediments to be disposed (information available after Round 3 sampling).
5. (Optional) Rescreen sites from Step 3 to create a refined site list, based on the information from Step 4 and any additional useful criteria that become evident from the information gathered in Step 4. (If Step 4 information is insufficient to further refine the site list, then this step will be skipped.)
6. Conduct a brief evaluation of each site on the refined list (or preliminary list of Step 5 is skipped) using CERCLA-based criteria to arrive at a final ranked list of potential sites.

This process will create a “menu” of options that can be used in remedial alternative development described below. In addition, Round 3 sampling may also include collection of engineering samples from prime candidate disposal locations prior to Step 4. This would allow further refinement of remedial alternatives involving disposal sites.

The facility siting process invokes some of the substantive requirements of certain ARARs, such as for consideration of in-water disposal, Section 404(b)(1) criteria should be considered during the selection and screening of the alternatives evaluation. For example, an in-water disposal option may not pass the 404(b)(1) alternatives

analysis if the only upland disposal site is a commercial landfill. Information and consideration of one or more on-site upland disposal sites in addition to a landfill may be required to fulfill 404 requirements. It is anticipated that early outreach on the proposed disposal site list for FS evaluation may be conducted to help understand the range of potential public opinion on the sites.

8.5 NATURAL ATTENUATION STUDIES

Appendix A, Attachment A4, describes natural attenuation studies in detail. This section summarizes those studies. The DQO process for natural attenuation is summarized in Table 8-1.

8.5.1 Problem Description

For natural attenuation to be evaluated as a potential remedial alternative for portions of the Site, it must be predicted whether the processes present at the Site are likely to cause natural attenuation to occur, and if so, how quickly that attenuation will progress. Because natural attenuation occurs through numerous physical, chemical, and biological processes, the most common method of predicting the potential for natural attenuation is through the use of computer models that require specific data inputs. Consequently, considerable information on natural systems at the Site must be collected and evaluated in time for the evaluation of this alternative in the FS.

8.5.2 Decisions and Data Uses

It must be determined whether there is a reasonable probability that natural attenuation is a feasible alternative for any portions of the Site. Data must be collected on the physical/chemical system to allow adequate modeling of the Site.

8.5.3 Data Needs

Data needs are determined by the specific computer models proposed to predict the potential for natural attenuation. The selection of models is described in Appendix A, Attachment A4. Table 8-2 summarizes those data needs based on the models selected in Appendix A. The steps referred to in Table 8-2 are outlined below.

8.5.4 Data Collection and Evaluation Tasks

A tiered approach to natural attenuation studies will be followed to focus resources on the areas of the site where natural attenuation may be a plausible alternative. The following three-step process is proposed:

- **Step 1.** Identify areas that have basic processes that are potentially suitable for natural attenuation based on information already available for the river system.
- **Step 2.** Conduct select sampling (in Round 2) within a few areas that appear characteristic of the range of potential natural attenuation processes at the Site and simple probabilistic modeling. Eliminate from future evaluations the types of areas that have a low probability of having processes that support natural attenuation.
- **Step 3.** Conduct detailed sampling (in Round 3) and modeling in SMAs that appear to have suitable processes for natural attenuation (based on Step 2 results) to determine viability and rate of natural attenuation.

Step 1 identifies areas of the river that potentially have natural attenuation processes that are characteristic of types or river conditions (e.g., embayments, backwaters, eddies, slips, otherwise protected areas). These areas will be reviewed, and particular sites will be selected for sampling in Step 2 that are representative of the range of overall site characteristics that may be conducive to natural attenuation. These characteristic areas do not represent proposals for natural attenuation, but will help focus future natural attenuation sampling in Round 3. Based on Round 3 information, modeling will be conducted that will identify specific areas where natural attenuation may be a viable remedial alternative. The data collection proposed to support these steps is summarized in Table 8-3. Information for some parameters will be obtained from either literature values and/or other studies conducted for this RI/FS, including STA® results and hydrodynamic modeling results. Information on groundwater conditions will be obtained through LWG lead groundwater studies proposed elsewhere in this Work Plan, as well as groundwater data collected by individual parties as a part of DEQ-directed upland cleanup efforts.

The information from Round 3 natural attenuation sampling and subsequent modeling will be used to define areas that may be suitable for natural attenuation as a remedial alternative.

8.6 SEDIMENT MANAGEMENT AREAS AND VOLUMES

The first step in the FS is defining areas and volumes of sediments where remediation will be necessary. This includes both area-specific risks and sediments that cause risks through site-wide processes such as bioaccumulation of chemicals.

8.6.1 Problem Description

At the conclusion of the RI and baseline risk assessment process, the nature and extent of sediment contamination and risks (including site-wide risks) will be understood in sufficient detail to define SMAs and volumes of sediments potentially posing risks. SMAs are a tool for defining sediment regions within the Site that can be discretely considered for development of remedial alternatives. The development of SMAs does not preclude the evaluation and inclusion of site-wide risks in the definition of sediments requiring cleanup or development of remedial technologies for those site-wide risks. The FS will develop comprehensive alternatives that evaluate natural attenuation, capping, dredging and other options for these areas. Therefore, the sampling completed at the end of Round 2 should provide sufficient types and amounts of information to preliminarily define these areas. Additional data will likely be collected in Round 3 to further refine some SMAs and sediment volumes, and generate data needed to evaluate remedial alternatives in the FS. In other cases, refinement of SMAs can be conducted after the ROD in the RD/RA phase of the project.

8.6.2 Decisions and Data Uses

The primary objective of the FS is to identify a menu of remedial options for SMAs within the Site. These remedial options could apply to SMAs singly, in combination, or to the entire site. Because for many types of risks, the level of risk will vary between regions of the Site, the Site will be broken down into a "mosaic" of discrete areas (i.e., SMAs) where remedial options can be evaluated and applied, leading to the development of remedial alternatives. The definition of this mosaic of SMAs is the primary decision required.

The decision requires input from a wide variety of data types (discussed in the next section). These data will be used define the mosaic of SMAs that will be used in the FS.

8.6.3 Data Needs

To delineate SMAs, the following types of evaluations based on site data are needed:

- A delineation of areas posing unacceptable risks for ecological and human health receptors both within regions of the site and site-wide
- A categorization of risks within areas that pose unacceptable risks (e.g., areas that pose a principal threat and/or "high" risk versus relatively "low" risk areas)
- A categorization of site-wide risks and the areas that contribute to those site-wide risks

- Delineation of sediment volumes (vertical and horizontal extent) that pose unacceptable risks, where deeper sediments may pose potential future risks
- Delineation of sediment volumes sufficient for evaluation of remedial alternatives in the FS (particularly for areas where dredging is likely due to navigation, water dependent, or other similar uses)
- Identification of physical environments (e.g., erosive areas, deposition areas, nearshore benches, navigation channels, depressions)
- Identification of habitat types and areas of special habitat significance
- Identification of river and shoreline land uses that affect remedial alternatives (e.g., navigation channels, current and future marine facilities, proposed shoreline developments)
- Identification of areas that may be impacted by ongoing sources (upstream and/or upland).

The information that will support these evaluations includes the following:

- **Ecological Risk Areas**: based on the results of the ERA, which will also provide information on relative risk to determine principal threat areas as well as areas of relatively "high" vs. "low" risk. Site-wide ecological risks will also be included.
- **Human Health Risk Areas:** based on the results of the HHRA, which will also provide information on relative risk to determine principal threat areas as well as areas of relatively "high" vs. "low" risk. Site-wide human health risks will also be included
- **Volumes**: surface and subsurface sediment chemistry
- **Physical Environment**: SPI, STA®, grain size, low- and high-flow bathymetry, radioisotope cores, sediment trap data, preliminary natural attenuation modeling results, hydrodynamic/sediment transport modeling results, and site geography
- **Habitat Types:** based on the results of the ERA
- **River Uses**: navigation channel limits, aerial photographs, property maps, and information from property owners, land use and marine master planning documents.

- **Ongoing Sources**: in-river surface sediment, Transition Zone water (if collected), and surface water chemistry, data collected by DEQ through upland cleanup actions, sediment trap data, and subsurface sediment chemistry.

8.6.4 SMA and Volume Tasks

The FS tasks needed to define SMAs and volumes are described below.

Review Round 2 Data Collection for Preliminary SMAs

The preliminary risk assessment results (based on data for tissue chemistry, surface sediment chemistry, subsurface sediment chemistry, beach sediment chemistry, bioassays, and water chemistry), bathymetry, SPI, STA®, and grain size, as well as hydrodynamic modeling, have been or will be collected in Rounds 1 and 2. These tasks are described in detail in Section 7. How those tasks will be adapted to fulfill the SMA data needs is described below.

The biased surface and subsurface sediment sampling approaches proposed for site characterization and risk tasks for Round 2 include samples that target locations where specific information is desired, such as filling potential spatial data gaps, determining areas where risk pathways or receptors exist, and understanding source effects from potential upland sources. Altogether, these samples cover a wide range of general site conditions within the ISA, including nearshore areas, deeper areas, the navigation channels, maintenance dredge areas, depressions, benches, potential deposition and scour areas, and in and around slips and features like Swan Island. Because of this wide coverage, this information can be used to define preliminary SMAs at the end of Round 2 sampling that account for unacceptable risks including site-wide risks and physical components of the Site.

As described in the natural attenuation task above, preliminary information will also be available for radioisotope cores at the end of Round 2. This information will help to define potential deposition areas of the Site. However, it will not be essential to the development of preliminary SMAs after Round 2. As described above, preliminary hydrodynamic/sediment transport and natural attenuation modeling tasks will be completed by the end of Round 2 data collection. This information will be useful in describing the range of physical environments present at the Site, and will be input directly into a preliminary definition of SMAs that account for sediment depositional, dynamic equilibrium, and erosive areas.

Information has been gathered on the general existing conditions of the Site, including site geography, navigation channel limits, aerial photographs, and property maps that can be input directly into SMA definition. Information has also been gathered on the status of DEQ investigations of potential sources within the ISA. Finally, the nature and extent of contaminants in water and sediment (including upland groundwater and Transition Zone information) will provide additional

information that will also be factored into SMA definition relative to potential ongoing sources and potential background levels of chemicals.

The primary additional tasks that are not part of other efforts and have been identified to help define SMAs are:

- Obtain periodic updates of DEQ-gathered information on sources through the course of Round 2 so that these can be input into the preliminary SMAs
- Obtain information from land owners about potential future uses of shorelines and waterways.

This second task will be conducted by interviewing major landowners along the shoreline, reviewing both dredging records and existing maintenance dredging permits, reviewing the City of Portland Comprehensive Plan and Port of Portland marine master plan, to determine areas that are or will be routinely maintained for navigation. It must be realized that in many cases landowners may either be uncertain about potential future uses and/or unwilling to provide this information for commercial reasons. Consequently, where information gaps exist, it will be assumed for SMA definition that existing uses would be maintained at shoreline sites.

Define Preliminary SMAs and Volumes

There is no well-defined guidance or process for defining SMAs that applies to all situations. SMA development will be an iterative process that considers how areas of risks (including site-wide risks), volumes of sediments, physical environments, biological environments, and site uses overlap. It will primarily be a mapping exercise. Sediment areas that define unacceptable ecological risks, unacceptable human health risks, physical environments (e.g., erosive, depositional, benches, depressions, and landforms), and site uses will be separately mapped. This includes mapping areas of discreet risk as well as sediment or sources that contribute to site-wide ecological or human health risks. Where possible, the individual locations (such as surface sediment stations) that are used to define the areas will also be shown on the maps. These separate layers and sampling locations will be overlaid to see how they interact and group. Generally, SMAs will be defined to minimize the number of risk, physical, and site use boundaries that are crossed by each SMA while keeping the SMAs at sizes that are reasonable to evaluate from an engineering perspective. Areas of relatively high risk (i.e., principal threat areas or “hot spots”) will also be considered in developing SMAs. Principal threat areas may either be parts of SMAs or uniquely separate SMAs. The general magnitude of risks as described in the ERA and HHRA documents will also be considered using information such as hazard quotients, risk probabilities, and other risk estimates. The identification of principal threat areas will assist in the evaluation of remedial alternatives that may better address areas of particularly concentrated or toxic chemicals that differ in character from other SMAs or the Site in general.

It should be noted that risks may be defined either on an area basis either regionally or over the entire site or an extrapolation of areas from one or more point samples. Where risks are based on point samples that are extrapolated to areas, spatial or statistical procedures may be used to define the areas of risks. Where risks are available on an area-weighted average basis (e.g., over a home range or a swimming beach or the entire site, where appropritate for the risk pathway involved), these areas will be used to define the risk area component of the overlay. In some cases, such as risks involving bioaccumulation pathways, the area posing risk may be a large portion or even the entire site. This situation will also be mapped for the appropriate chemicals and pathways.

Once a preliminary SMA map is defined, it will be examined to determine where SMA boundaries are based on relatively limited data sets. If it appears that further definition of these boundaries is needed in order to develop a reasonable set of remedial alternatives for evaluation in the FS, then these areas may be targeted for additional sampling in Round 3. If this information is not critical to the FS, refinement of SMA boundaries may be left to the RD/RA phase after the ROD.

Refine SMAs After Round 3 Data Collection

It is anticipated that after Round 3 data collection, the SMAs will be refined. The following information will likely be available at that time:

- Additional natural attenuation sampling (water samples, sediment traps, radioisotope cores) and modeling results
- Additional subsurface sediment cores intended to define volumes of sediment posing risks.

These data will be used to refine SMAs relative to physical system types (e.g., erosion or deposition areas), as well as areas that may be specifically suited for one or more remedial types (e.g., natural attenuation).

Subsurface coring in Round 3 will be conducted to specifically determine the depth of contamination in SMAs that appear to be potential candidates for dredging (either through remedial design or for navigational purposes) or in areas that have a potential to erode over time or during major flood events. This information may also be gathered for principal threat areas. Chemical levels in subsurface sediments would be compared to risk-based levels established in the baseline risk assessments to determine volumes of impacted sediments.

8.7 RECONTAMINATION POTENTIAL

8.7.1 Problem Description

To the extent practicable, ongoing sources should be controlled before remedial actions are implemented so that recently cleaned areas are not re-impacted by the same or other ongoing sources. This will be accomplished by performing the following tasks:

1. Developing and understanding of source processes through existing information (as reviewed in Section 3)
2. Developing a conceptual site model of ongoing sources that could affect the river (as reviewed in Section 5.1.1)
3. Collecting data to understand ongoing sources (as reviewed in Section 7.2)
4. Obtaining and reviewing data from DEQ on upland sources that are gathered as a part of various upland site investigations
5. Referring to DEQ-identified ongoing sources that appear to be impacting the river for new or further source control implementation at those sites
6. Identifying in-river sediment sources that may be adversely affecting downstream areas for cleanup under the FS alternatives.

This approach will include evaluating all types of potential sources discussed in Section 3, such as outfall discharges, groundwater discharges, spills, bank erosion, chemical leaching from surfaces, atmospheric deposition, and water and sediment transport within the river.

The above tasks will be undertaken by the LWG and/or referred to DEQ for additional action (as noted above) and will be the primary methods for identifying and controlling sources early in the cleanup process. It is important to note that the recontamination evaluation discussed in this section is not the main method of source control, which is regulated by DEQ for upland sites. Rather, the recontamination evaluation serves as a later verification that sources are suitably controlled for remediation to proceed. If this evaluation indicates sources may not be suitably controlled, then this information will be referred to DEQ for additional investigation of upland sources before actual construction of in-water remediation could commence.

Once sources are controlled to the extent practicable, a method is needed to assess whether recontamination may occur after construction of in-water cleanup actions. This recontamination evaluation will be undertaken after identifiable sources have been controlled or are being controlled, but before completion of the FS.

The evaluation of potential recontamination after primary source controls depends on whether concentrations from various sources stay at post-source control levels

established through the above efforts and the effect of these concentrations on future cleanup actions, and if the cleaned up areas stay clean. If either of these conditions are not expected to be met, further source controls should be implemented prior to construction of the cleanup actions. Implementation of additional source controls is expected to be carried out by upland property owners with direction by DEQ. In-water sources will be controlled through the remedial actions identified in the FS process.

8.7.2 Decisions and Data Uses

As noted above, a decision must be made whether it is acceptable to proceed with remedial actions given the number, type, and concentration of sources present at the completion of the FS. Data needed are described below, and would be used in predictive modeling inputs to determine the potential for recontamination under various remedial alternatives. The RI will collect information on potential effects of ongoing sources to the river waters and sediments. This information will be referred to DEQ for further source investigations and controls as appropriate.

It is important to note that comparison of source levels to criteria or risk-based levels may be uninformative to understand the potential for recontamination and is probably an unacceptably simple approach. For example, it may be known that an outfall periodically exceeds water quality criteria, but this knowledge, by itself, does not indicate whether such discharges might cause settling of chemical constituents to the riverbed at concentrations that pose sediment-related risks.

8.7.3 Data Needs

Assuming that some type of predictive modeling is needed, data needs are determined by the model input requirements. In addition to these specific inputs, it is necessary to understand the general presence and location of potential upland sources along the riverbanks. Further, it is necessary to have a general understanding of the levels of chemicals and sediments that move into the ISA from upstream and downstream. This information will be useful to determine the location to run the model and at what spatial density.

The same natural attenuation model discussed above for Round 3 is also proposed for use to assess the potential for recontamination. Natural attenuation models predict changes in surface sediment chemistry given present understanding of water column, subsurface sediment, and groundwater sources. These models can also be used to predict changes in sediment chemistry that will occur after, for example, dredging or capping.

The data needs are the same as those described for natural attenuation. Given information on incoming sediment concentrations (see Natural Attenuation Studies section above), these models can be used to predict how the post-remediation cap

surface or dredged surface chemical concentrations will change over time. If the post-remediation sediment surface reaches unacceptably high concentrations in the modeling, this provides valuable information that additional source controls need to be considered before such a remedial action should be undertaken. In addition, sufficient data must be available on the known or suspected sources so that where and at what density to model can be determined.

8.7.4 Recontamination Evaluation Tasks

The data collected for natural attenuation (as detailed in Appendix A, Attachment A4) in Round 3 will provide the basic inputs for the recontamination model, including:

- Grain size
- Surface chemical concentrations, water content, specific gravity
- Hydrodynamic modeling
- Sedimentation rates from radioisotope cores and/or sediment traps
- Settling sediment chemical concentrations from water column samples or sediment traps
- Mixed layer depth and mixing rate.

The modeling approach will use a one-dimensional fate and transport model that focuses on the sediment bed. As described in Appendix A, Attachment 4, the Boudreau model is currently proposed, but will described in greater detail in a modeling technical memorandum for EPA review and approval. The model predicts changes in chemical concentrations in the sediment bed given various chemical inputs (such as settling sediment) and outputs (such as diffusion and biodegradation). The data needs described above would be the primary information used to estimate these inputs and outputs. Thus, a future condition can be assumed (such as clean sediment surface after remediation) and existing and/or predictions of future chemical conditions of sources and the water column can be used to determine whether that clean sediment bed will recontaminate to unacceptable levels. Because the model is one-dimensional, it can be applied discreetly to various locations throughout the site to understand how recontamination potential might vary spatially.

Also, where groundwater is a known or suspected source (and/or flow of clean groundwater through impacted subsurface sediments is suspected), information on these sources and subsurface concentrations would be needed. This information may be available through LWG efforts, DEQ-directed efforts at individual upland sites, or a combination of both.

If the appropriate data are not available for any of these parameters, then the LWG will work with EPA to identify a process and method for obtaining the data, which may include: LWG data collection, data collection by individual upland site property owners, and/or data collection directed by DEQ on or near upland properties. However, Round 2 data collection described in Sections 6, 7.2, and 8.5 is intended to provide the vast majority of these data.

Where to model and at what density will be determined by available source effect information, which by Round 3 will likely include:

- LWG efforts to understand source effects to river waters and sediments (see Section 7.2)
- DEQ efforts to identify and control sources at individual sites
- EPA efforts regarding control of upstream sources.

It is difficult to predict the state of knowledge on all these sources at the time that Round 3 starts. Consequently, an exact program of sampling and analysis cannot be described at this time. However, the concept is to review the status and amount of source effect information and fill in data gaps, as needed, to provide sufficient information for recontamination modeling. This may include further sampling of sources that appear to be substantially contributing to in-water concentrations of chemicals of concern. While sampling of particular sources may be important to fill data gaps, direct measurements of in-water concentrations of chemicals is critical to making evaluations of recontamination potential. This might also include such studies as sediment traps near outfalls, water column samples near suspected sources, subsurface chemistry near sources, and sampling water quality in the Transition Zone near known or suspected groundwater sources. Again, any such data gaps will be filled in Round 3.

Although modeling summarized here and described more in Appendix A, Attachment 4, is intended to be the primary method of predicting potential future recontamination, other methods of data collection will be considered that might help directly verify recontamination potential. These may include characterization of potential areas that may erode and allow transport of chemicals downstream. This could also include examination of historical chemical concentration profiles in downstream areas with comparison to information on existing water column inputs. These and other data collection methods could be used to understand variations in potential long-term inputs in the model so that conditions sampled during Round 3 are not erroneously assumed to apply to all future conditions.

8.8 DEVELOPMENT, SCREENING, EVALUATION, AND SELECTION OF REMEDIAL ALTERNATIVES

The overall steps to the evaluation and selection of remedial alternatives is shown in Figure 8-1. As noted in Section 8.1, a range of remedial alternatives will be evaluated, including no action, institutional controls, *in-situ* containment, *in-situ* treatment, removal and disposal, removal and treatment. The steps of the FS process are generally prescribed by the SOW, and, to a lesser extent, by CERCLA guidance (EPA 1988) (see Appendix A). As outlined in Appendix A, the FS process results in series of alternative development reports that will be submitted to EPA (Figure 8-1). Appendix A currently describes this approach consistent with the linear process outlined in the SOW.

Wherever possible, some of the deliverables will be submitted simultaneously rather than in sequence. The most likely place to expedite the schedule is by simultaneous submittal of the following documents:

- Identify and Screen Remedial Technologies, Assemble and Document Alternatives, Screening Evaluation of Alternatives, and Alternatives Development and Screening summary reports
- Detailed Comparison of Alternatives Report and the Feasibility Study Report.

The process will be streamlined wherever possible, and the LWG is open to alternate ways of accelerating the above reports. Once agreement has been reached with EPA on how to schedule the FS deliverables, Appendix A will be revised to reflect this process.

In addition to the data needs identified by the previous tasks, some additional data on engineering properties of sediments and/or disposal sites in various areas may be needed in Round 3. These will generally include analyses like grain size, Atterberg limits, consolidation tests, and sheer tests. This information will be directly input into the evaluation of alternatives.

It should also be noted that this is the step in the FS process where remedial alternatives are screened and evaluated in detail per EPA (1998) guidance. This includes screening alternatives against the three primary criteria of effectiveness, cost, and feasibility, as well as detailed evaluation of alternatives against the nine CERLCA evaluation criteria of:

Threshold Factors:

- Overall protection of human health and the environment
- Compliance with ARARs

Primary Balancing Factors:

- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, and volume through treatment
- Short-term effectiveness
- Implementability
- Cost

Modifying Considerations:

- State acceptance
- Community acceptance.

For compliance of ARARs, a list of potential ARARs for the project have been compiled in Appendix A, Attachment 1. This includes regulations that address such potentially important issues as flooding and the affects of in-water work on aquatic resources. Thus, the remedial alternatives will need to have some early assessment of the magnitude of mitigation and its cost to run through the nine criteria evaluation.

8.9 FS REPORT

The FS report is the final deliverable under the AOC and describes the recommendation of the alternatives evaluation process and documents all the FS data collection, data evaluation, modeling, and engineering tasks. Appendix A describes the FS report in more detail. The purpose of this task is to present the recommended remedial alternatives to EPA and partners for review and approval, and finally, to assist in development of the proposed plan and ROD.

9.0 PROJECT MANAGEMENT PLAN

This project management plan describes the roles and qualifications of key personnel conducting the RI/FS for the Site. This plan also describes how the LWG will communicate and coordinate, both with EPA and among the LWG members (including the consultant team), the decision-making process and key decision points, project reporting requirements, schedule and schedule control, and cost control. A separate data management plan is provided in Appendix G.

9.1 PROJECT ROLES AND RESPONSIBILITIES

The overall project organization and major task responsibilities are illustrated in Figure 9-1. The RI/FS is being conducted by the LWG under the oversight of EPA, Region 10. Members of the LWG who are signatories on the AOC include:

- ATOFINA Chemicals, Inc.
- Chevron USA Inc.
- City of Portland
- Gunderson, Inc.
- Northwest Natural
- Oregon Steel Mills, Inc.
- Port of Portland
- Time Oil Co.
- ConocoPhillips Company (successor to Tosco Corporation)
- Union Pacific Railroad.

9.1.1 Agency Roles and Responsibilities

As described in the AOC and associated SOW, EPA is the lead agency for all in-water RI/FS activities and will oversee LWG activities associated with implementing the RI/FS. EPA will coordinate all Trustee, Tribe, and State of Oregon input with respect to development of technical and decision documents. At the completion of the RI/FS, EPA will select the remedy to be implemented at the Site. EPA will also oversee a public involvement process with input from the LWG. As stated in the SOW, EPA is the supporting agency for upland cleanup and source control activities. The site managers for EPA are currently Mr. Chip Humphrey and Ms. Tara Martich. A formal replacement for the EPA project manager designated in the AOC has not been made. All correspondence with EPA shall be sent to these individuals at the addresses listed in Table 9-1.

DEQ is the lead agency responsible for all upland cleanups and source control activities associated with the Site. In addition, DEQ is the support agency for the in-water RI/FS and will coordinate upland cleanup activities and decision-making with EPA. The lead contact for DEQ is Mr. Jim Anderson; his contact information is found in Table 9-1.

Trustee agencies and Tribes will review technical documents prepared under this AOC and will participate in technical meetings. Contact information for trustee and Tribal organizations is also presented in Table 9-1.

9.1.2 LWG Roles and Responsibilities

The LWG will conduct an RI/FS and report the results in documents according to the AOC and referenced EPA guidance. EPA has directed that negotiations on implementation of Early Actions be conducted outside the process covered by this Work Plan. Early Actions will be conducted under DEQ or EPA authority separate from work being performed under the AOC.

The LWG is co-chaired by Mr. Jim McKenna of the Port of Portland and Mr. Bob Wyatt of Northwest Natural. All official contact with the LWG should be through these co-chairs (see Table 9-1).

9.1.3 Consultant Team Roles and Responsibilities

The LWG consultant team is responsible for implementation of the RI/FS tasks at the direction and oversight of the LWG. Each team member is responsible for major RI/FS tasks reflecting their firm's areas of expertise. In turn, each firm will support other consultant team members where appropriate. Mr. Keith Pine of Integral Consulting, Inc. [formerly Striplin Environmental Associates (SEA)] will coordinate the RI/FS consultant activities and develop and implement the RI with support from Mr. Gene Revelas. Dr. Bill Williams and Ms. Laura Kennedy of Kennedy/Jenks Consultants are responsible for conducting the human health risk evaluation. Dr. Mike Johns and Ms. Lisa Saban of Windward Environmental will conduct the evaluation of ecological risks. Mr. Walt Burt of Groundwater Solutions will coordinate the groundwater tasks. Mr. Tom Schadt and Mr. Carl Stivers of Anchor Environmental will be responsible for the FS. Ms. Barbara Smith of Harris and Smith Public Affairs will provide public participation support for the project. Dr. David Ellis of Archeological Investigations Northwest will be responsible for coordinating the cultural resources work.

The consultant team effort will be augmented by use of experts in specific aspects of the RI/FS. These experts will be identified in work plans for specific sampling and analysis tasks.

Qualifications of the project managers for the consultant team are summarized below.

Mr. Keith Pine, a managing scientist with Integral Consulting, will manage the RI and coordinate the overall RI/FS efforts. In this role, he will oversee the RI technical work, participate in LWG strategic planning and agency negotiations, and coordinate RI/FS activities with the LWG consultant team and other technical consultants. Mr. Pine has 18 years experience in managing and providing oversight of sediment, soil, and groundwater investigations and cleanups at dozens of CERCLA, RCRA, and brownfields sites in the Pacific Northwest. An Oregon-registered geologist, he has managed multimedia RI/FS and RCRA facility investigations at several large facilities including an aerospace industrial site along the Lower Duwamish Waterway (Seattle), Frontier Hard Chrome (Vancouver), and Northwest Pipe and Casing (Clackamas).

Mr. Gene Revelas, a managing scientist at Integral Consulting, will provide assistance to Keith Pine in overall coordination of the RI/FS efforts and will also be the project's sampling and analysis coordinator. In these roles, he will assist in the coordination of RI/FS activities among the LWG consultant team and will oversee the efforts of Integral's field, laboratory coordination, and data analysis and evaluation project staff. Mr. Revelas has 18 years of technical and project management experience in the interpretation and regulatory use of aquatic environmental data with an emphasis on contaminated sediment site evaluations, dredged material characterizations, and open-water disposal site monitoring. He is an expert in the use of sediment-profile imaging for benthic habitat quality mapping and assessment. Mr. Revelas has directed sediment collection and data evaluation programs at complex contaminated sediment sites such as Hylebos Waterway in Commencement Bay (Tacoma) and the East Waterway in Seattle.

Dr. Bill Williams, a senior toxicologist and project manager at Kennedy/Jenks Consultants, will have primary responsibility for the human health risk assessment. Dr. Williams has over 19 years of experience conducting human health and ecological risk assessments. He has been instrumental in the development of new concepts to define cleanup strategies at contaminated sites, especially the conception and development of site-specific protective concentration levels. Protection concentration levels extend the results of risk assessments to bridge the gap between risk estimates and engineering cleanup strategies.

Ms. Laura Kennedy is a toxicologist and risk assessor at Kennedy/Jenks. Her experience in environmental consulting includes human health, ecological, and predictive risk assessments. She has conducted numerous risk assessments of industrial and residential sites and freshwater and riverine areas for both public and private sector clients. Recently, Ms. Kennedy conducted a series of human health and ecological risk assessments as components of voluntary cleanup actions. The risk assessments evaluated potential exposure to chemicals, including metals, PAHs, and PCBs in soil, water, and sediments.

Dr. Michael Johns, a principal of Windward Environmental, LLC, will serve as the ecological risk assessment manager. Dr. Johns is an aquatic scientist specializing in aquatic ecological risk assessments, particularly those associated with contaminated sediment. The emphasis of his 25 years of professional experience has been on the effects of toxic pollutants on aquatic organisms. Dr. Johns has managed RI/FS, NRDA, and other large multitask, multidisciplinary environmental investigations. His recent responsibilities include the Lower Duwamish Waterway RI/FS (Seattle), the East Waterway RI/FS (Seattle), the Grand Calumet River NRDA (Indiana), the Calcasieu Estuary Combined RI/FS and NRDA (Louisiana), and two Supplementary RIs at the Harbor Island Superfund Site in Seattle. Dr. Johns is a recognized expert on the use of bioassessment techniques to evaluate sediment contamination.

Ms. Lisa Saban, a senior scientist at Windward Environmental, LLC, will serve as Dr. John's ecological risk assessment project manager. Ms. Saban has served as a project manager or lead ecological risk assessor for numerous complex ERAs and sediment investigations over the last 12 years. She has managed and conducted environmental studies on the local, national, and international level, for both private and public sector clients. She has extensive experience negotiating in client-stakeholder interactions, managing complex ERAs, NRDA and injury evaluations, and directing oversight and review of sediment and water quality studies. She has been involved in numerous stakeholder groups as a lead sediment specialist and ecological risk assessor.

Mr. Walter Burt, a principal hydrogeologist at Groundwater Solutions, Inc., will serve as the technical lead for groundwater-related issues. Mr. Burt is a hydrogeologist with over 13 years of experience in conducting hydrogeologic studies in the Pacific Northwest. Much of his focus has been on groundwater characterization, groundwater supply, and contaminant fate- and transport-related projects in the lower Willamette Valley and Portland areas. Recent projects include site and regional hydrogeologic investigations involving assessment of groundwater/surface water interactions along the lower Willamette and Columbia rivers for construction, water supply, and contaminant transport and remediation purposes. He recently served as technical lead for the environmental oversight consultant team for the Willamette River West Side CSO project, project manager for the Phase 2 Deep Aquifer Yield Numerical Flow Model of the Portland Basin, and senior consultant to the Portland Water Bureau for groundwater technical services on the Columbia South Shore Wellfield.

Mr. Tom Schadt, a senior aquatic scientist and principal at Anchor Environmental, has 20 years experience in environmental consulting, including nationwide experience with sediment remediation. Mr. Schadt's major area of focus is shoreline redevelopment and cleanup projects, and investigation of water and sediment quality and biological effects. His sediment project experience includes CERCLA, state-led, and voluntary action sites. Much of his project management experience is with sediment management issues, including sediment characterization, FS development,

cleanup design, long-term monitoring, and NRDAs. Tom has participated in sediment cleanup projects in both freshwater and marine environments, including rivers, lakes, bayous, estuaries, and bays.

Mr. Carl Stivers, a senior aquatic scientist at Anchor Environmental, has 15 years of consulting experience in sediment and water quality investigations. Past projects have included water quality impact evaluation, contaminated sediment investigation and remediation, and dredge sediment investigations. Mr. Stivers specializes in the management of complex environmental investigations particularly for sediment-related projects. Mr. Stivers has managed large-scale sediment remediation, water quality, and dredge disposal projects covering a wide range of sediment and water quality issues, including dredge and disposal impacts, sediment chemistry and toxicology, oceanographic studies, sediment risk assessments, benthic ecology, habitat restoration, NRDAs, chemical fate and transport modeling, sediment disposal site evaluation, and disposal suitability testing.

Ms. Barbara Smith is vice president and partner at Harris and Smith Public Affairs. She has more than 22 years of experience in journalism, government, and public affairs. Her work in environmental communications involves dozens of National Priorities List (NPL), Model Toxics Control Act (MTCA), Resource Conservation & Recovery Act (RCRA), Temporary Storage Depot, and Voluntary Cleanup Program sites, specializing in working with multi-PRP groups. She has facilitated several community advisory groups, participated in organizing local communities on behalf of site-specific communications, and has spoken on risk communication and environmental public involvement at many Pacific Northwest and national symposia. Harris and Smith Public Affairs has represented public and private sector clients throughout the Northwest from its Seattle-based office for more than 15 years.

Mr. David Ellis, M.P.A., a senior archaeologist at Archeological Investigations Northwest (AINW), will coordinate the cultural resources analysis. Mr. Ellis has directed cultural resource studies in the Portland area since 1976. He has been with AINW since 1990, serving as project manager for most AINW projects in the Portland area. Mr. Ellis has also served since 1992 as project manager for AINW's ethnographic and traditional cultural property studies. The latter experience included regular and frequent consultations and meetings with Tribal representatives. Mr. Ellis will supervise records search and data-gathering efforts, and represent AINW in team meetings and meetings with agencies and Tribes as needed. He will also be available for assistance and advice on Tribal coordination and consultation efforts.

9.2 COMMUNICATION AND COORDINATION

The complexity and duration of this project require a high level of organization and options for communications between EPA, EPA's partners, and the LWG, and among

the members of each of those parties. In recognition of this complexity, several communications tools have been developed.

9.2.1 Shared Server

A collaborative web site has been established that allows selective access to project information, documents, and data. This web site is available to EPA, supporting agencies, members of the LWG and their respective consultants, and the RI/FS consultant team. Access requires a current web browser and an Internet connection, and access to the site is controlled via password.

Once users log in, the web site is organized into a series of tabular pages that provide viewable and downloadable announcements, the current calendar for project meetings, a user directory and contact list, and copies of the draft and final technical or decision documents. Validated data, maps, photos, and other information will also be made available on the web site. Tips for site use and information about changes to the site are posted on the home page. A search function is available to facilitate use of the site. Links to EPA and DEQ project web sites are also provided.

9.2.2 Meetings

In addition to electronic communications via the project web site, EPA and LWG technical and project management representatives meet on a regular basis, with the frequency of meetings depending on current project activities. Agenda are discussed and agreed upon in advance of each meeting. Either party can request a meeting or conference call to resolve specific issues in advance of scheduled meetings. Additional technical subgroup meetings between agency technical experts and managers and members of the consultant team and LWG are also used to foster additional discussion or develop details for an aspect of the RI/FS. As an example, the consultant team members in charge of the risk assessments met with EPA's toxicologists and risk assessors to discuss the risk assessment approach during preparation of the June 2002 RI/FS Work Plan. Similarly, technical subgroup meetings for groundwater, nature and extent, Early Actions, HHRA, and ERA have been conducted between agency technical experts and managers and members of the consultant team and LWG to facilitate resolution of issues and development of this Work Plan. Decisions on documents to be submitted to EPA or on how such documents should be drafted will only be made at meetings attended by LWG and EPA project managers.

9.3 DECISION-MAKING PROCESS

9.3.1 LWG Decision-making Process

The LWG will review data and information generated through implementation of this Work Plan consistent with the DQOs identified or refined throughout the RI/FS. The LWG consultant team will assist the LWG in interpretation of the data and information, and will make recommendations to the LWG for future RI/FS tasks or work products. The LWG will submit to EPA written recommendations regarding future RI/FS efforts.

9.3.2 EPA/DEQ/LWG Decision-making Process

Project decision-making is a cooperative process involving key technical and management staff from EPA, DEQ, and the LWG. Through frequent technical and management meetings, technical issues are discussed and evaluated, with the objective of reaching consensus on decisions.

EPA, DEQ, and the LWG hold regular project management meetings to discuss the agencies' technical and policy issues. These informal meetings provide an opportunity for the agencies and the LWG to raise issues pertaining to any aspect of the RI/FS and to strategize how best to address the issues. Agency project managers and members of the LWG project management team attend the project management meetings.

EPA and the LWG also have periodic formal technical meetings to discuss specific technical issues. The objective of these meetings varies. Some meetings are informational with the LWG providing data or recommended project approaches to EPA. In other meetings, EPA has the opportunity to provide the LWG with comments on technical approaches and documents.

Lastly, EPA, EPA's partners, and the LWG periodically hold informal *ad hoc* meetings and technical subgroup meetings during which technical experts have wide-ranging discussions of certain topics. The goal of these sessions is for both EPA and LWG technical experts to voice their opinions on technical issues. Principals from EPA and the LWG will attend *ad hoc* and technical subgroup meetings, although final resolution of technical issues is generally not a goal of these meetings.

9.3.3 Key Decisions

There are a number of key decisions that need to be made during the RI/FS, as well as any number of smaller decisions, that will focus the overall project.

Data Quality Objectives

EPA's (2000a) DQO process will be relied upon throughout the RI/FS to formulate the technical questions that will be addressed through field and/or literature studies.

EPA's 7-step DQO process will be applied prior to and following each data-gathering effort, including the compilation of historical data and field sampling programs, to identify outstanding data gaps and to make recommendations on any additional data-gathering activities that may be needed.

Risk Assessment Parameters

Numerous decisions must be made prior to submittal of the HHRA, ERA, and baseline risk assessment deliverables. For the ERA, decisions regarding assessment endpoints, receptors, exposure, models, and toxicological data and other issues will be made. For the HHRA, key issues include exposure scenarios, consumption rates, and toxicological data. These decisions are being made through a combination of informal *ad hoc*, subgroup, and formal technical meetings.

Preliminary Remedial Action Objectives

The development of preliminary RAOs is discussed in this Work Plan and Appendix A, Attachment A1. The preliminary RAOs are relatively broad statements of work that will be developed as additional information is gathered during the RI/FS. It is anticipated that the preliminary RAOs will developed at the start of the FS and final RAOs will be developed by the end of the FS process. The final RAOs will continue to be broadly defined statements of goals for the overall selected remedial alternative or combination of alternatives.

Field Sampling Plans

Decisions on field sampling plans will be made following application of the DQO process and identification of risk assessment parameters. The LWG will develop its proposed approach, including the types, numbers, and locations of samples, types of analyses, analytical requirements, and data reporting, for consideration by EPA. The LWG will revise these plans following receipt of comments from EPA.

Treatability Testing

As a step in the FS, a decision will need to be made regarding the need for treatability testing to develop further information regarding candidate treatment technologies, if any are identified. Treatability testing is complex and can involve a significant amount of time. The determination that treatability testing will be necessary should be made early in the overall RI/FS to allow time for such testing.

Identification of Potential Sediment Management Areas

A key decision will be the determination of potential sediment management areas (SMAs). Based on results of the baseline risk assessment, areas associated with unacceptable ecological or human health risk will be identified. These areas will be compared to other physical and site use areas to define SMAs. The FS will evaluate remedial alternatives for each SMA. EPA will decide on the cleanup action(s) that will be required for each SMA in its ROD.

Identification of Source Impacts to Site

Elements of sampling and analysis plans and data evaluations will be designed to understand how sources impact river sediments and waters. These include issues of upland sources, including groundwater, and sources entering the Site from upstream and downstream. Where this information indicates that sources are causing unacceptable risks to the Site, they will be referred to the appropriate agency for further investigation and, where appropriate, source controls. It is the LWG's understanding that DEQ is primarily responsible for investigating sources related to upland sites along the river, while EPA will be primarily responsible for investigating sources that are originating from upstream (or downstream) in the watershed. Further, the LWG understands that the RI/FS must include sampling and evaluations to understand source risks within the Site, but that the appropriate agencies are primarily responsible for identifying PRPs for those sources and enforcing appropriate actions by those parties.

9.4 REPORTING REQUIREMENTS

Required reporting includes monthly progress reports due to EPA on the 10th of each month, and the RI/FS technical reports provided in Table 9-2. Draft documents are to be provided to EPA according to the schedule presented in the AOC. Following receipt of draft documents, EPA will prepare written comments and provide them to the LWG. EPA has indicated that written comments will be provided no more than 30 days following receipt of a document.

Data, GIS products, maps, and/or photos will also be delivered to EPA, per the approved schedule and following the AOC requirements.

All draft and final technical documents will be posted to the project web site for agency review and comment, according to the deliverable dates outlined in the next section. Document content will follow EPA guidance for major deliverables such as the RI, baseline risk assessment, and FS.

As required by the AOC, deliverables will be sent by certified mail, return receipt requested, to the individuals listed in Table 9-1, the LWG co-chairs, and to any other addressees that EPA may designate in writing.

Monthly progress reports will describe activities conducted during the prior month; the preliminary results of any sampling, testing, or other data analysis performed during that period; the schedule for the next two months; and any problems or issues encountered, along with proposed resolutions.

9.5 SCHEDULE

The schedule for the RI/FS deliverables and tasks is provided in Table 9-2. Schedule control will be a very important task throughout the RI/FS. The goal of the EPA and the LWG continues to be conducting the RI/FS in an expedited manner. As such, the LWG frequently reviews work progress and associated schedules with the LWG consultants to ensure that the project is being completed as efficiently as possible. Schedule deviations may be requested to increase the overall efficiency of the program. For example, the schedule for this Work Plan was extended to allow for additional time for meetings with EPA and its project team to ensure that the work elements in the Work Plan met with EPA approval, thus reducing both EPA review time and the time needed for the LWG to revise and finalize the document.

There may be other instances when EPA and the LWG agree that a schedule revision is needed to resolve issues. If this occurs, the LWG will work with EPA to resolve the issues in a reasonable timeframe.

9.6 COST CONTROL

EPA and the LWG acknowledge that the RI/FS will be a complex and costly effort. However, EPA and the LWG also believe that the project can be completed cost-effectively. Elements of cost control include adhering to EPA's DQO process (EPA 2000a) to ensure that field studies focus on the collection of data that are necessary for the decision-making process, generating data that allow EPA and the LWG to focus on the most critical issues (e.g., sediment profile imaging to better understand physical transport), and the use of electronic deliverables whenever possible. These and other approaches will be used to control costs to the extent practical.

10.0 REFERENCES

Adolfson Associates, Walker Macy, Esther Lev Environmental Consulting, Winterowd Planning Services, and Ecotrust. 2000. Willamette River Inventory: Natural Resources. Public review draft. Prepared for City of Portland Bureau of Planning, Portland, OR. Adolfson Associates Inc., Portland, OR.

AGI Technologies. 1995. Sediment Sampling and Analysis Report Rose Festival Fleet Moorage Front Avenue Seawall: Hawthorne to Steel Bridges, City of Portland. Prepared for Rose Festival Association and City of Portland. AGI Technologies, Portland, OR.

AMEC. 2001. Draft Groundwater Transport Evaluation Data Needs Report, RPAC – Portland Site. Prepared for Aventis CropScience. AMEC Earth & Environmental, Inc., Portland, OR.

Anchor Environmental. 2001. NW Natural "Gasco" Site Draft Screening Level Nearshore Source Control Evaluation Results Report. Prepared for Oregon Department of Environmental Quality on behalf of NW Natural, Seattle, WA. Anchor Environmental, L.L.C., Seattle, WA.

Anderson, C.W., T.M. Wood, and J.L. Morace. 1996. Distribution of Dissolved Pesticides and Other Water Quality Constituents in Small Streams, and their Relation to Land Use, in the Willamette River Basin, Oregon. Water-Resources Investigations Report 97-4268. U.S Department of the Interior, U.S. Geological Survey, Portland, OR. 87 pp.

ASCE. 1975. Sedimentation Engineering. V. Vanoni, ed., American Society of Civil Engineers, New York.

ATSDR. 2002. Public Health Assessment, Portland Harbor, Portland, Multnomah County, Oregon. EPA Facility ID OR0001297969. Draft Report. U.S. Department of Health and Human Services, Agency for Toxic Substances and Disease Registry, Atlanta, GA.

Barrett, P. 2002. Personal Communication (phone conversation on May 29, 2002 with Karl Krcma, Parsons Brinckerhoff, Portland, OR). Oregon Graduate Institute (OGI), Portland, OR.

Beeson, M.H., K.R. Fecht, S.P. Reidel, and T.L. Tolan. 1985. Regional Correlations within the Frenchman Springs Member of the Columbia River Basalt Group: New Insights into the Middle Miocene Tectonics of Northwestern Oregon. *Oregon Geology* 47:87-96.

Beeson, M.H., T.L. Tolan and I.P. Madin. 1991. Geologic Map of the Portland Quadrangle, Multnomah and Washington Counties, Oregon and Clark County, Washington. Geological Map Series GMS-75. Oregon Department of Geology and Mineral Industries, Portland, OR.

Beeson. M.H. 2003. Personal Communication (internal review meeting on February 12, 2003 with Jason Melady, Groundwater Solutions, Inc.).

Bonn, B.A. 1998. Polychlorinated Dibenzo-p-dioxin and Dibenzofuran Concentration Profiles in Sediment and Fish Tissue of the Willamette Basin, Oregon. *Environ. Sci. & Tech.* 32(6):729-735.

Burch, W.M. 1987. Personal Communication (memo of September 1, 1987 to R. Krizenbeck, U.S. EPA). U.S. Environmental Protection Agency, Office of Toxic Substances, Washington, DC.

CAS. 1994. T-2 Berth 203 Project (K941554). Prepared for the Port of Portland. Columbia Analytical Services, Inc., Kelso, WA.

CH2M Hill. 2000a. Expanded Preliminary Assessment for the Linnton Site. Agency Review Draft. Prepared for Georgia-Pacific West, Inc. CH2M Hill, Portland, OR.

CH2M Hill. 2000b. Preliminary Evaluation of City Outfalls, Portland Harbor Study Area. Notebook 1, Eastshore Stormwater and CSO Outfalls. Prepared for City of Portland Bureau of Environmental Services, Portland, OR. CH2M Hill, Portland, OR.

CH2M Hill. 2000c. Preliminary Evaluation of City Outfalls, Portland Harbor Study Area. Notebook 2, Westshore Stormwater and CSO Outfalls. Prepared for City of Portland Bureau of Environmental Services, Portland, OR. CH2M Hill, Portland, OR.

CH2M Hill. 2001. Preliminary Assessment and Dredging Sampling Results, Goldendale Alumina Unloading Facility. Prepared for Goldendale Aluminum Company. CH2M Hill, Portland, OR.

CH2M Hill, Brown and Caldwell, and Associated Firms. 1994. Final Facilities Plan, Combined Sewer Overflow Management Plan. OPW35083.RE.93. Prepared for City of Portland Bureau of Environmental Services, Portland, OR. CH2M Hill, Portland, OR.

City of Portland. 2001a. Guild Lake Industrial Sanctuary Plan. City of Portland Bureau of Planning. December 21, 2001 (effective). Ordinance No. 176092. Resolution No. 36041. Portland, Oregon. http://www.planning.ci.portland.or.us/pdf/gl_adopted_0102.pdf

City of Portland. 2001b. Portland's Willamette River Atlas. City of Portland Bureau of Planning. August 2001. Portland, OR. http://www.planning.ci.portland.or.us/pdf/rr_atlas.pdf

City of Portland. 2002. Lab Data for Phase 1 Data Evaluation and Phase 2 Work Planning for City of Portland Outfall 18 and Lab Data for City of Portland Outfall M-1. City of Portland, Portland, OR.

City of Portland Bureau of Environmental Services. 1998. Portland's CSO Characteristics from 1990 to 2000. City of Portland, OR. 20 pp.

Columbia Analytical Services. 1994. T-2 Berth 203 Project (K941554). Submitted to Port of Portland. Columbia Analytical Services, Inc., Kelso, WA.

Crecilius, E.A., D.L. Woodruff, and M.S. Myers. 1989. 1988 Reconnaissance Survey of Environmental Conditions in 13 Puget Sound Locations. Prepared for U.S. Environmental Protection Agency, Region 10. Battelle Ocean Sciences, Sequim, WA.

CRITFC. 1994. A Fish Consumption Survey of the Umatilla, Nez Perce, Yakama, and Warm Springs Tribes of the Columbia River Basin. Technical Report 94-3. Prepared by Columbia River Inter-Tribal Fish Commission, Portland, OR.

Csuti B., A.J. Kimerling, T.A. O'Neil, M.M. Shaughnessy, E.P. Gaines, and M.M.P. Huso. 1997. Atlas of Oregon Wildlife. Oregon State University Press, Corvallis, OR.

Curtis, L.R., H.M. Carpenter, R.M. Donohoe, D.E. Williams, O.R. Hedstrom, M.L. Deinzer, M.A. Bellstein, E. Foster, and R. Gates. 1993. Sensitivity of Cytochrome P450-1A1 Induction in Fish as a Biomarker for Distribution of TCDD and TCDF in the Willamette River, Oregon. *Environ. Sci. & Tech.* 27:2149-2157.

Dames & Moore. 1998. Environmental Audit Report. Prepared for Cascade General, Beaverton, OR. Dames & Moore, Portland, OR.

DEA. 2001. Multibeam Bathymetric Survey of the Lower Willamette River Work Plan. Prepared for Striplin Environmental Services, Inc., Olympia, WA. David Evans and Associates, Inc., Portland, OR

DEA. 2002a. Lower Willamette River Multibeam Bathymetric Survey Report. Prepared for Striplin Environmental Associates, Inc., Olympia, WA. David Evans and Associates, Inc., Portland, OR.

DEA. 2002b. Willamette Acoustic Doppler Current Profiler Survey Results, June 2002. Prepared for Striplin Environmental Services, Inc., Olympia, WA. David Evans and Associates, Inc., Portland, OR.

DEA. 2003. Lower Willamette River Summer 2002 Multibeam Bathymetric Survey Report. Prepared for Striplin Environmental Services, Inc., Olympia, WA. David Evans and Associates, Inc., Portland, OR.

Dempster, G.R., and G.A. Lutz. 1968. Water Discharge Determinations for the Tidal Reach of the Willamette River from Ross Island Bridge to Mile 10.3 Portland, Oregon. U.S. Geological Survey, in cooperation with the U.S. Atomic Energy Commission, Washington, DC.

DEQ. 1994. Willamette River Toxics Study 1988/1991. Oregon Department of Environmental Quality, Portland, OR.

DEQ. 1998. Oregon's Final 1998 Water Quality Limited Streams-303(d) List. Oregon Department of Environmental Quality, Portland, OR. 286 pp.

DEQ. 2000a. Annual Accomplishments Reports, 1995 - 2000. Oregon Department of Environmental Quality, Office of Compliance and Enforcement, Portland, OR. 21 pp.

DEQ. 2000b. Fish Tissue Data Tables for Mercury in the Willamette River. Oregon Department of Environmental Quality, Water Quality Division, Portland, OR.

DEQ. 2000c. Guidance for Conduct of Deterministic Human Health Risk Assessments. Oregon Department of Environmental Quality, Waste Management and Cleanup Division, Portland, OR.

DEQ. 2000d. Oregon's 2000 Water Quality Assessment Report: Section 305(b) Report. Oregon Department of Environmental Quality, Portland, OR. 168 pp.

DEQ. 2001a. Willamette Basin TMDLs: Work Plan for Development of Models to Address Willamette River Temperature, Bacteria, Algae, Dissolved Oxygen, and pH Concerns. Draft Report. Oregon Department of Environmental Quality, Watershed Management Section, Portland, OR.

DEQ. 2001b. Work Plan for Middle Willamette Subbasin Total Maximum Daily Load (TMDL). Oregon Department of Environmental Quality, Portland, OR.

DEQ. 2002. Wastewater Permits Database, DEQ Source Information System. http://www.deq.state.or.us/wq/sisdata/facilityhomenew.asp. Oregon Department of Environmental Quality, Portland, OR.

Ecology & Environment. 2001. Sediment Remedial Design, Field Sampling Data Summary Report, McCormick & Baxter Creosoting Company, Portland, OR. Prepared for Oregon Department of Environmental Quality, Portland, OR. Ecology & Environment Inc., Portland, OR.

Ecology & Environment. 2003. Surface Water, Sediment, and Groundwater Sampling Report, September 2002, McCormick & Baxter Creosoting Company Site, Portland, Oregon. Prepared for Oregon Department of Environmental Quality. Ecology & Environment, Inc., Portland, OR.

Elf Atochem. 1999. Sediment Riverbank Data, Portland, OR. Elf Atochem North America, Inc, Portland, OR.Ellis Ecological Services. 2000. A Review and Compilation of Available Information on Fish Use of the Portland Harbor, Portland, Oregon. Prepared for Port of Portland. Ellis Ecological Services, Inc., Estacada, OR.

Ellis Ecological Services. 2002. Portland Harbor Superfund Site Technical Memorandum: Juvenile Salmonid Residence Time in Portland Harbor. Draft Report. Ellis Ecological Services, Inc., Estacada, OR. 31 pp.

EMCON. 1996. Supplemental Environmental Site Assessment St. Johns Riverfront Property Portland, Oregon. Prepared for Trust for Public Land. EMCON, Portland, OR.

EPA. 1983. Results of the Nationwide Urban Runoff Program (NURP). Final Report. U.S. Environmental Protection Agency, Water Planning Division, Washington, DC. 186 pp.

EPA. 1988. Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA, Interim Final. (OWSER Directive 9355.3-01). EPA/540/G-89/004. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Washington, DC.

EPA. 1989. Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual (Part A), Interim Final. EPA/540/1-89/002. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, DC.

EPA. 1992. National Study of Chemical Residues in Fish. Volumes I and II. U.S. Environmental Protection Agency, Washington DC.

EPA. 1996. Columbia River Basin Contaminant Aquatic Biota and Sediment Data. Online database: www.epa.gov/r10earth/data/crbdata.html. U.S. Environmental Protection Agency, Region10, Seattle, WA.

EPA. 1997. Exposure Factors Handbook. EPA/600/P-95/002Fa. U.S. Environmental Protection Agency, Office of Research and Development, Washington, DC.

EPA. 1998. Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual (Part D), Interim Final. Publication 9285.7-01D. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Washington, DC.

EPA. 2000a. Guidance for the Data Quality Objectives Process, EPA QA/G-4. EPA/600/R-96/055. U.S. Environmental Protection Agency, Office of Environmental Information, Washington DC. 100 pp.

EPA. 2000b. Proceedings of the Ground-Water/Surface-Water Interactions Workshop, July 2000. EPA/542/R-00/007. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, DC.

EPA. 2001a. Adminstrative Order on Consent for Remedial Investigation/Feasibility Study for Portland Harbor Superfund Site. U.S Environmental Protection Agency, Portland, OR. 92 pp.

EPA. 2001b. Stipulation and Agreement, Portland Harbor Superfund Site. U.S. Environmental Protection Agency, Region 10, Seattle, WA. (September 28, 2001).

EPA. 2002a. Personal Communication (letter dated November 4, 2002 from Wallace Reid to Robert Wyatt and Trey Harbert, Lower Willamette Group regarding approval of Round 1 Quality Assurance Project Plan). U.S. Environmental Protection Agency, Region 10, Seattle, WA.

EPA. 2002b. Principles for Managing Contaminated Sediment Risks at Hazardous Waste Site. Memorandum from Marianne Lamont Horinko, EPA Assistant Administrator, to EPA Policy Managers. OSWER Directive 9285.6-08. U.S. Environmental Protection Agency, Washington, DC. (February 12, 2002).

EPA. 2002c. Transmittal of Policy Statement: "Role of Background in the CERCLA Cleanup Program." OSWER 9285.6-07P. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Washington, DC.

EPA and DEQ. 2002. Community Involvement Plan - Portland Harbor Superfund Site, February 2002. http://yosemite1.epa.gov/r10/cleanup.nsf/5c8919bc41f032578825685f006fd670/e46ae970d06761ce882567ac007316b9?OpenDocument#docs (Accessed June 6, 2002).

EPA, DEQ, Confederated Tribes and Bands of the Yakima Nation, Confederated Tribes of the Grande Ronde Community of Oregon, Confederated Tribes of the Siletz Indians, Confederated Tribes of the Umatilla Indian Reservation, Confederated Tribes of the Warm Springs Reservation of Oregon, Nez Perce Tribe, National Oceanic and Atmospheric Administration, Oregon Department of Fish and Wildlife, U.S. Department of the Interior. 2001. Memorandum of Understanding for Portland Harbor Superfund Site. February 8, 2001.

EVS Environment Consultants. 2000. Characterization of Skeletal Deformities in Three Species of Juvenile Fish from the Willamette River Basin. Prepared for Oregon Department of Environmental Quality, Water Quality Division, Portland, OR. EVS Project No. 2/839-02. EVS Environment Consultants, Inc., Seattle, WA. 42 pp. (Willamette River Basin Studies: Ecological Health Technical Study).

Exponent. 1999. January 1999 Sediment Sampling Results for Tosco Terminal. Prepared for Tosco. Exponent, Bellevue, WA.

Exponent. 2001. Pre-Remedial Investigation Field Activities Data Report Oregon Steel Mills, Inc., Portland Oregon Mill. Prepared for Stoel Rives LLP. Exponent, Lake Oswego, OR.

Fuhrer, G.J. 1989. Quality of Bottom Material and Elutriates in the Lower Willamette River, Portland Harbor, Oregon. Prepared in Cooperation with the U.S. Army Corps of Engineers, Portland, OR. U.S. Department of the Interior, U.S. Geological Survey, Denver, CO.

Fuhrer, G.J., D.Q.Tanner, J.L. Morace, S.W. McKenzie, and K.A. Skach. 1996. Water Quality of the Lower Columbia River Basin: Analysis of Current and Historical Water-Quality Data through 1994. Lower Columbia River Bi-State Water Quality Programs. Water-Resources Investigations Report 95-4294. U.S. Geological Survey in cooperation with Roy F. Weston, Portland, OR. 157 pp.

GeoEngineers. 2000. Remedial Investigation, Former Pope & Talbot Wood Treatment Site, St Helens, Oregon. Completed for Pope & Talbot, Inc. and the Port of St Helens. GeoEngineers, Inc., Portland, OR.

GeoSea Consulting. 2001. A Sediment Trend Analysis (STA®) of the Lower Willamette River. Draft Report. GeoSea Consulting Ltd., Brentwood Bay, B.C.

Geraghty & Miller. 1991. Hydrogeological Investigation of the Doane Lake Area, Portland, Oregon, February 22, 1991. Geraghty & Miller, Seattle, WA.

Gleeson, G.W. 1972. Return of a River: The Willamette River, Oregon. Oregon State University, Water Resources Research Institute, Corvallis, OR. 103 pp.

GSI. 2003a. Upland Groundwater Data Review Report, River Mile 2-11, Lower Willamette River. Groundwater Solutions, Inc., Portland, OR.

GSI. 2003b. Technical Memorandum: Results of Seep Reconnaissance Survey, River Mile 2-10.5, Lower Willamette River. Groundwater Solutions, Inc., Portland, OR.

Hahn and Associates and Decision Management Associates. 1998. Phase I Remedial Investigation Summary Report and Preliminary Analysis of Soil Data (as Appendix 1). Prepared for N.W. Natural - Gasco Facility. Hahn and Associates, Inc., Portland, OR.

Harding ESE. 2001. Results of Bioassay Analyses-Cargill Irving Elevator Terminal. Prepared for Cargill, Inc. Harding ESE, Inc., Novato, CA.

Hart Crowser. 1988. Remedial Action Plan, Station "L" Site, Willamette River Sediments. Prepared for Portland General Electric Company. Hart Crowser, Inc., Lake Oswego, OR.

Hart Crowser. 1997. Sediment Characterization Study River Terminals 1, 2, and 5 Willamette River. Prepared for Port of Portland, Portland, OR. Hart Crowser, Inc., Lake Oswego, OR.

Hart Crowser. 1998. Sediment Characterization Study Terminal 4, Berth 416, Willamette River. Prepared for Port of Portland, Portland, OR. Hart Crowser, Inc., Lake Oswego, OR.

Hart Crowser. 1999a. Remedial Investigation Report Terminal 4, Slip 3 Sediments. Prepared for Port of Portland, OR. Hart Crowser, Inc. Lake Oswego, OR.

Hart Crowser. 1999b. Sediment Characterization Study of Local Sponsor's Berths; Columbia and Willamette River Navigation Channel Deepening; Longview and Kalama, Washington and Portland, Oregon. Hart Crowser, Inc., Lake Oswego, OR.

Hart Crowser. 1999c. Sediment Characterization Study, Marine Terminal 2, Berths 203-206, Portland, Oregon. Prepared for Port of Portland. Hart Crowser, Inc., Lake Oswego, OR.

Hart Crowser. 1999d. Sediment Characterization Study Marine Terminal 4, Berth 416 Portland, Oregon. Prepared for Port of Portland, OR. Hart Crowser, Inc. Lake Oswego, OR.

Hart Crowser. 2000. Final Site Investigation Report Port of Portland Confined Dredged Material Disposal Ross Island Facility. Prepared for Port of Portland, OR. Hart Crowser, Inc. Lake Oswego, OR.

Hart Crowser. 2001a. Dredge Material Characterization Study Marine Terminal 2, Berths 203-206 and Marine Terminal 5, Berth 501. Prepared for Port of Portland. Hart Crowser, Inc., Lake Oswego, OR

Hart Crowser. 2001b. Willamette River Reference Area Study - Phase I Results and Recommendations for Phase II Sampling Locations. Prepared for U.S. Army Corps of Engineers, Portland District. Hart Crowser, Inc., Lake Oswego, OR.

Hart Crowser. 2002. Lower Willamette River Reference Area Study. Prepared for U.S. Army Corps of Engineers, Portland District. Hart Crowser, Inc., Lake Oswego, OR.

Hartman Associates. 1995. Summary of Sediment Quality Information for Portland Ship Yard. Prepared for Port of Portland, Portland, OR. Hartman Associates, Inc., Seattle, WA.

Hartman Associates and Fishman Environmental Services. 1995. Chemical Characterization of Sediments Adjacent to Storm Water Discharge in the Willamette River Near Portland. Prepared for Port of Portland, Portland, OR. Hartman Associates, Inc., Seattle, WA.

Henny, C., R. Grove, and O. Hedstrom. 1996. A Field Evalution of Mink and River Otter on the Lower Columbia River and the Influence of Environmental Contaminants. Final Report. Contract Numbers ODEQ 143-94. WDE C9500038. Prepared for the Lower Columbia River Bi-State Water Quality Program. National Biological Service, Forest and Rangeland Ecosystem Science Center, N.W. Research Station, Corvallis, OR.

Hjort R.C., P.L. Hulet, L.D. LaBolle, and H.W. Li. 1984. Fish and Invertebrates of Revetments and other Habitats, the Willamette River, Oregon. Technical Report E-84-9. U.S. Army Corps of Engineers, Vicksburg, MS.

Jacobs Engineering. 2000a. Expanded Preliminary Assessment Data Report Marine Finance Site. Revised Final. Prepared for Oregon Department of Environmental Quality. Jacobs Engineering, Golden, CO.

Jacobs Engineering. 2000b. Expanded Preliminary Assessment Data Report Union Pacific Railroad Albina Yard. Final. Prepared for Oregon Department of Environmental Quality. Jacobs Engineering, Golden, CO.

KHM Environmental Management. 1999. Environmental Site Assessment of GATX Terminals Corporation. Prepared for GATX Terminals Corporation. KHM Environmental Management, Tigard, OR.

KHM Environmental Management. 2000. Remedial Investigation Report, Willbridge Facility, Portland, Oregon. Prepared for Oregon Department of Environmental Quality. KHM Environmental Management, Inc., Portland, OR.

KHM Environmental Management. 2001. Revised 60-Inch Storm Sewer Interim Remedial Actions, Tosco Willbridge Terminal. KHM Environmental Management, Tigard, OR.

Kittelson, R. 2003. Personal Communication (phone conversation on February 5, 2003 with Jason Creech, DEA). U.S. Geological Survey, Portland, OR.

Landau Associates. 2000a. Baseline Sediment Characterization, In-Water Clear Zone Sampling Results, Ross Island Lagoon. Landau Associates, Inc., Edmonds, WA.

Landau Associates. 2000b. Ecological Survey: Fall 1999 & Spring 2000 Ross Island Sand & Gravel Co. Portland, Oregon. Final Report. Prepared for Perkins Coie, LLP, Lake Oswego, OR. Landau Associates, Inc., Lake Oswego, OR.

Landau Associates. 2000c. Phase I Remedial Investigation Ross Island Sand & Gravel Co. Final Report. Prepared for Perkins Coie, LLP. Landau Associates, Inc., Edmonds, WA.

Landau Associates. 2001. Phase II Remedial Investigation, Time Oil Northwest Terminal, Portland, Oregon. Prepared for Time Oil Co. Landau Associates, Inc., Lake Oswego, OR.

Landau Associates. 2002. Fourth Quarter 2001 Groundwater Report, Time Oil Northwest Terminal, Portland, Oregon, April 8, 2002. Landau Associates, Inc., Lake Oswego, OR.

Lee, K. 2002. Personal Communication (phone conversation on May 29, 2002 with Karl Kcrma, Parsons Brinckerhoff). U.S. Geological Survey, Portland, OR.

Maul, Foster & Alongi. 1996. Willamette Western Property. Maul Foster & Associates, Inc., Vancouver, WA.

McKenzie, S.W. 1977. Analyses of Bottom Material from the Willamette River, Portland Harbor, Oregon: U.S. Geological Survey Open-File Report 77-740. U.S. Geological Survey, Portland, OR. 8 pp.

Michelsen, T.C., T.C. Shaw, and S. Stirling. 1996. Testing, Reporting, and Evaluation of Tributyltin Data in the Puget Sound Dredged Disposal Analysis and Sediment Management Standards Programs. SMS Technical Information Memorandum. Washington Department of Ecology, Olympia, WA.

NRC. 2002. National Response Center Database, 1995 – 2001. www.nrc.uscg.mil/foia.htm

ODHS. 2001. Agencies Issue Consolidated Advisory for Consumers of Willamette River Fish. Oregon Department of Human Services, Portland, OR.

Oregonian. 2000. The Oregonian's "River of Risk" series - December 17-20, 2000. The *Oregonian* Newspaper, Portland, OR. 32 pp.

Osborn, J. 1945. A Story of a Shipyard - Its Beginning and Development from the Years 1941 through 1945. Oregon Shipbuilding Corporation, Portland, OR.

OSU. Undated. Analytical Report. Food Safety & Environmental Stewardship Laboratory. Environmental and Molecular Toxicology Department, Oregon State University, Corvallis, OR.

Parametrix. 2002. MarCom Expanded Preliminary Assessment. Prepared for MarCom. Parametrix, Bellevue, WA.

Pastorok, R.A., D.C. Peek, J.R. Sampson, and M.A. Jacobson. 1994. Ecological Risk Assessment for River Sediments Contaminated by Creosote. *Environ. Toxicol. and Chem.* 13(12):1929-1941.

PNG Environmental. 2001. Chevron Willbridge Terminal Dock Sediment Sampling. Prepared for Chevron Products Company. PNG Environmental, Portland, OR.

Port of Portland. 1992. Laboratory Report for Port of Portland PSRY Berth 311 Sediment Characterizations. Danil Hancock, Port of Portland, Portland, OR.

Port of Portland. 1994a. Summary Terminal 4 Berth 408 Dredging Sediment Quality. Port of Portland, Portland, OR.

Port of Portland. 1994b. Terminal 2, Berth 203 Sediment Characterization. Port of Portland, Portland, OR.

Port of Portland. 1997. Terminal 2 Preliminary Assessment Appendix II. Port of Portland, Portland, OR.

Port of Portland. 2000a. Terminal 1 Preliminary Assessment Appendix. Port of Portland, Portland, OR.

Port of Portland. 2000b. Terminal 4 - Slip 1 Preliminary Assessment Appendix. Port of Portland, Portland, OR.

Port of Portland. 2002. Terminal 5 Preliminary Assessment with Appendix II. Port of Portland, Portland, OR.

Poston, T. 2001. Treated Wood Issues Associated with Overwater Structures in Marine and Freshwater Environments. Draft Report. Prepared for Washington Department of Fish and Wildlife, Washington Department of Ecology and Washington Department of Transportation. Battelle Marine Sciences Laboratory, Sequim, WA.

PSEP. 1986. Puget Sound Estuary Program: Recommended Protocols for Measuring Conventional Sediment Variables in Puget Sound. Final Report. Prepared for U.S. EPA, Region 10, Office of Puget Sound, Seattle, WA and the U.S. Army Corps of Engineers, Seattle District, Seattle, WA. Tetra Tech, Inc., Bellevue, WA.

PSEP. 1997a. Puget Sound Estuary Program: Recommended Guidelines for Measuring Organic Compounds in Puget Sound Sediment and Tissue Samples. Final Report. Prepared for U.S. EPA, Region 10, Seattle WA and Puget Sound Water Quality Action Team, Olympia, WA. King County Water Pollution Control Division Environmental Laboratory, Seattle, WA.

PSEP. 1997b. Puget Sound Estuary Program: Recommended Protocols for Measuring Metals in Puget Sound Sediment and Tissue Samples. Final Report. Prepared for U.S. EPA, Region 10, Seattle WA and Puget Sound Water Quality Action Team, Olympia, WA. King County Water Pollution Control Division Environmental Laboratory, Seattle, WA.

PSEP. 1997c. Puget Sound Estuary Program: Recommended Protocols for Quality Assurance and Quality Control Guidelines for the Collection of Environmental Samples in Puget Sound. Final Report. Prepared for U.S. EPA, Region 10, Seattle WA and Puget Sound Water Quality Action Team, Olympia, WA. King County Water Pollution Control Division Environmental Laboratory, Seattle, WA.

PTI. 1989. Data Validation Guidance Manual for Selected Sediment Variables Draft Report. Prepared for Washington Department of Ecology. PTI Environmental Services, Inc., Bellevue, WA. 154 pp.

PTI. 1992. McCormick & Baxter Creosoting Company Remedial Investigation Report. PTI Environmental Services, Inc., Bellevue, WA. (Volume 4, Appendices G-R).

Puchy, C.A., and D.B. Marshall. 1993. Oregon Wildlife Diversity Plan 1993-1998. Oregon Department of Fish and Wildlife, Portland, OR.

PWB and CH2M Hill. 2001. Deep Aquifer Yield Groundwater Flow Model. Portland Bureau of Water Works, Portland, OR.

Rickert, D.A., V.C. Vance, S.W. McKenzie, and W. Hines. 1977. A Synoptic Survey of Trace Metals in Bottom Sediments of the Willamette River, Oregon. River - Quality Assessment of the Willamette River Basin, Oregon. U.S. Geological Survey Circular 715-F. U.S. Geological Survey, Western Region, Menlo Park, CA. 27 pp.

Rinella, J.F., and S.W. McKenzie. 1977. Elutriation Study of Willamette River Bottom Material and Willamette-Columbia River Water. U.S. Geological Survey Open-File Report 78-28. U.S. Geological Survey, Portland, OR in cooperation with U.S. Army Corps of Engineers, Portland District, Portland, OR.

Sanders, D., D. Livesay, and D. Shelton. 2003. Personal Communication (memo of March 14, 2003 to SEA, Olympia, WA). City of Portland Bureau of Environmental Services and CH2M Hill, Portland, OR.

Schmitt, C.J., and W.G. Brumbaugh. 1990. National Contaminant Biomonitoring Program: Concentrations of Arsenic, Cadmium, Copper, Lead, Mercury, Selenium, and Zinc in U.S. Freshwater Fish, 1976-1984. *Arch. Environ. Contam. Toxicol*. 19:731-747.

Schmitt, C.J., J.L. Zajicek, and P.H. Peterman. 1990. National Contaminant Biomonitoring Program: Residues of Organochlorine Chemicals in U.S. Freshwater Fish, 1976-1984. *Arch. Environ. Contam. Toxicol*. 19:748-781.

SEA. 1998. Portland Shipyard Sediment Investigation Data Report. Final Report. Prepared for Port of Portland. Striplin Environmental Associates, Olympia, WA.

SEA. 2000. Marine Terminal 1 Baseline Investigation. Final Report. Prepared for the Port of Portland. Striplin Environmental Associates, Inc., Olympia, WA.

SEA. 2001a. Draft Combined SAP/QAPP for the Lower Willamette River Sediment Profile Image Survey. Prepared for Lower Willamette Group, Portland, OR. Striplin Environmental Associates, Inc., Olympia, WA.

SEA. 2001b. Portland Harbor Superfund Site Technical Memorandum: Data Quality Objectives For Historical Data. Striplin Environmental Associates, Inc., Olympia, WA. 8 pp. (file folder).

SEA. 2001c. Portland Harbor Superfund Site Technical Memorandum: Proposed Database Approach. Striplin Environmental Associates, Inc., Olympia, WA.

SEA. 2002a. Fish Tissue Homogenization and Shipping Standard Operating Procedure, Round 1 Portland Harbor RI/FS. Prepared for Lower Willamette Group, Portland, OR. Striplin Environmental Associates, Inc., Olympia, WA. (August 28, 2002).

SEA. 2002b. Integration of Sediment Trend Analysis (STA) Survey Results with Historic Bathymetry in the Lower Willamette River. Prepared for Lower Willamette Group, Portland, OR. Striplin Environmental Associates, Inc., Olympia, WA.

SEA. 2002c. Preliminary Analytical Concentration Goals. Written communication to Wallace Reid, U.S. Environmental Protection Agency, Region 10, Seattle, WA. Striplin Environmental Associates, Inc., Olympia, WA. (Revised February 22, 2002).

SEA. 2002d. Round 1 Health and Safety Plan. Prepared for Lower Willamette Group, Portland, OR. Striplin Environmental Associates, Inc., Olympia, WA.

SEA. 2002e. Round 1 Quality Assurance Project Plan, Final Report. Prepared for Lower Willamette Group. Striplin Environmental Associates, Inc., Olympia, WA.

SEA. 2002f. Sediment Profile Image Survey of Lower Willamette River. Prepared for Lower Willamette Group, Portland, OR. Striplin Environmental Associates, Inc., Olympia, WA.

SEA. 2003. Historical Chemistry Data Category Reclassification. Prepared for the Lower Willamette Group, Portland, OR. Striplin Environmental Associates, Olympia, WA.

SEA and DEA. 2003. Lower Willamette River May 2003 Multibeam Bathymetric Survey Report, Draft. Prepared for the Lower Willamette Group. Prepared by Striplin Environmental Services, Inc., Olympia, WA and David Evans and Associates, Inc., Portland, OR.

SEA, Windward, Anchor Environmental, and Kennedy/Jenks. 2002a. Preliminary Planning, Scoping, and Problem Formulation Document. Prepared for Lower Willamette Group, Portland, OR. Striplin Environmental Associates, Olympia, WA. (June 14, 2002).

SEA, Windward, Anchor Environmental, and Kennedy/Jenks. 2002b. Round 1A Field Sampling Plan, Portland Harbor RI/FS. Draft Report. Prepared for Lower Willamette Group, Portland, OR. Striplin Environmental Associates, Olympia, WA. (April 22, 2002).

SEA, Windward, Anchor Environmental, and Kennedy/Jenks. 2002c. Round 1 Field Sampling Plan, Portland Harbor RI/FS. Draft Report. Prepared for Lower Willamette Group, Portland, OR. Striplin Environmental Associates, Olympia, WA. (June 14, 2002).

SEA, Windward, and Kennedy/Jenks. 2002a. Fish Tissue Composting and Shipping Standard Operating Procedure, Portland Harbor RI/FS. Prepared for Lower Willamette Group, Portland, OR. Striplin Environmental Associates, Olympia, WA.

SEA, Windward, and Kennedy/Jenks. 2002b. Fish Tissue Sampling Standard Operating Procedure, Round 1A Portland Harbor RI/FS. Prepared for Lower Willamette Group, Portland, OR. Striplin Environmental Associates, Olympia, WA.

SEA, Fishman, Ellis Ecological Services, Windward, Anchor Environmental, and Kennedy/Jenks. 2003. Summary of Round 1 Field Sampling Activities. Prepared for Lower Willamette Group, Portland, OR. Striplin Environmental Associates, Olympia, WA.

SECOR. 2002. Forensic Geochemical Assessment of Nearshore Sediments, Remedial Investigation Work Plan, Atlantic Richfield/BP Terminal 22T. SECOR, Tualatin, OR.

Strait, S.R., and R.B. Mercer. 1986. Hydraulic Property Data from Selected Test Zones on the Hanford Site. Document No. BWI-DP-051. Prepared for the U.S. Department of Energy. Rockwell Hanford Operations, Richland, WA.

Swanson, R.D., W.D. McFarland, J.B. Gonthier and, J.M. Wilkinson. 1993. A Description of Hydrogeologic Units in the Portland Basin, Oregon and Washington. Water-Resources Investigations Report 90-4196. U.S. Department of the Interior, U.S. Geological Survey, Portland, OR.

Tetra Tech. 1992. Willamette River Basin Water Quality Study. Component 2: Review and Summary of Toxic Pollutants in the Willamette River and Major Tributaries. Final Report. Prepared for Oregon Department of Environmental Quality, Portland, OR. Tetra Tech, Inc., Redmond, WA.

Tetra Tech. 1993. Willamette River Basin Water Quality Study. Willamette River Basin Biological Responses to Stressors Component Report. Final Report TC 8983-06. Prepared for Oregon Department of Environmental Quality, Portland, OR. Tetra Tech, Inc., Redmond, WA.

Tetra Tech. 1995. Willamette River Basin Water Quality Study. Summary and Synthesis of Study Findings. Final Report 97-094. Prepared for Oregon Department of Environmental Quality, Portland, OR. Tetra Tech, Inc., Redmond, WA. 119 pp.

Tetra Tech and E&S Environmental Chemistry. 1993. Willamette River Basin Water Quality Study. Component 8: Willamette River Basin Nonpoint Source Pollution Component Report. Final Report TC 8983-08. Prepared for Oregon Department of Environmental Quality, Portland, OR. Tetra Tech, Inc., Redmond, WA. 33 pp.

Tetra Tech and Taxon Aquatic Monitoring Company. 1994. Willamette River Basin Water Quality Study, Phase II. Biological Sampling Data Report. Final Report TC 9719-02. Prepared for Oregon Department of Environmental Quality, Portland, OR. Tetra Tech, Inc., Redmond, WA. 136 pp.

Tetra Tech, E&S Environmental Chemistry, Limno-Tech, and Taxon Aquatic Monitoring Company. 1993. Summary Report, Willamette River Basin Water Quality Study. Final Report TC 8983-10. Prepared for Oregon Department of Environmental Quality. Tetra Tech, Inc., Redmond, WA.

Thomas, C.M., and R.G. Anthony. 1997. Environmental Contaminants and Breeding Biology of Great Blue Herons in the Columbia River Basin. M.S. Thesis. Oregon State University, Corvallis, OR. 137 pp.

Trimble, D.E. 1963. Geology of Portland, Oregon and Adjacent Areas. A Study of Tertiary and Quaternary Deposits, Lateritic Weathering Profiles, and Quaternary History of Part of the Pacific Northwest. USGS Bulletin 1119. U.S. Department of the Interior, U.S. Geological Survey. U.S. Government Printing Office, Washington, DC. 119 pp.

Uhrich, M.A., and D.A. Wentz. 1999. Environmental Setting of the Willamette Basin, Oregon. Water-Resources Investigations Report 97-4082-A. U.S. Department of the Interior, U.S. Geological Survey, Portland, OR. 26 pp.

URS. 2001. Northwest CSO Force Main River Crossing Study. Prepared by URS for the City of Portland Bureau of Environmental Service, Portland, OR. URS Corporation, Portland, OR.

USACE. 1966. Vertical Datum Planes in Oregon. U.S. Army Corps of Engineers, Portland District, Portland, OR.

USACE. 1987. Polychlorinated Biphenyl and Trace-Metal Concentrations in Columbia River and Willamette Harbor Bottom Sediment. OR-88F. U.S. Army Corps of Engineers, Portland District, Portland, OR.

USACE. 1988. Lower Willamette River Sediment Samples. U.S. Army Corps of Engineers, Portland District, Portland, OR.

USACE. 1989. Sediment Data Moorings 1989 – 1995. U.S. Army Corps of Engineers, Portland District, Portland, OR.

USACE. 1990. Columbia & Willamette River 1990. U.S. Army Corps of Engineers, Portland District, Portland, OR.

USACE. 1991. Portland – Vancouver Harbor Information Package, Reservoir Regulation and Water Quality Section. U.S. Army Corps of Engineers, Portland District, Portland, OR.

USACE. 1997. Willamette River Sediment Data 1997 CRCD Project. U.S. Army Corps of Engineers, Portland District, Portland, OR.

USACE. 1998. Willamette River Raw Data 1986 - 1998. U.S. Army Corps of Engineers, Portland District, Portland, OR.

USACE. 1999. Willamette River Sediment Sampling Evaluation. U.S. Army Corps of Engineers, Portland District, Portland, OR.

USACE. 2000. Willamette River Sediment Sampling Evaluation. U.S. Army Corps of Engineers, Portland District, Portland, OR.

USACE, EPA, Ecology, DEQ, and WDNR. 1998. Dredged Material Evaluation Framework Guidance for the Lower Columbia River Management Area. Draft. Cooperatively published by U.S. Army Corps of Engineers, Seattle District, Portland District, Northwestern Division; U.S. Environmental Protection Agency, Region 10; Washington State Department of Ecology; Oregon Department of Environmental Quality; and Washington State Department of Natural Resources, Seattle, WA.

USGS. 1998. Dioxins and Furans in Bed Sediment and Fish Tissue of the Willamette Basin, Oregon, 1992-95. Water-Resources Investigations Report 97-4082-D. National Water-Quality Assessment Program, U.S. Department of the Interior, U.S. Geological Survey, Portland, OR.

Ward D.L., P.J. Connolly, R.A. Farr, and A.A. Nigro. 1988. Feasibility of Evaluating the Impacts of Waterway Development on Anadromous and Resident Fish in Portland Harbor. Annual Progress Report. Fish Research Project. Oregon Department of Fish and Wildlife, Portland, OR.

Wentz, D., I. Waite, and F. Rinella. 1998. Comparison of Streambead Sediment and Aquatic Biota as Media for Characterizing Trace Elements and Organochlorine Compounds in the Willamette Basin, Oregon. Kluwer Academic Publishers, Netherlands. p. 673-693.

Weston. 1998. Portland Harbor Sediment Investigation Report, Multnomah County, Oregon. Report No. 04000-019-036-AACE. Prepared for U.S. Environmental Protection Agency and Oregon Department of Environmental Quality, Portland, OR. Roy F. Weston, Inc., Seattle, WA.

West Consultants, Inc. 2004. Hydrodynamic/Sedimentation Modeling for the Lower Willamette River, Development of Modeling Approach, Draft. Prepared for the Lower Willamette Group. Prepared by West Consultants, Inc., Bellevue, WA.

Willingham, W.F. 1983. Army Engineers and the Development of Oregon: A History of the Portland District, U.S. Army Corps of Engineers. U.S. Army Corps of Engineers, Portland, OR.

Windward, Kennedy/Jenks, and SEA. 2002. Portland Harbor Superfund Site: Analytical Concentration Goals for Target Analytes in Sediment, Tissue, and Water Samples. Prepared for Lower Willamette Group, Portland, OR. Windward Environment L.L.C., Seattle, WA.

Wong, et al. 2001. The Portland Hills Fault: An Earthquake Generator or Just Another Old Fault? In: *Oregon Geology*, Volume 63, No. 2. Oregon Department of Geology and Mineral Industries, Portland, OR.

Wood, T. 2002. Personal Communication (phone conversation May 29, 2002 with Karl Kcrma, Parsons Brinckerhoff). U.S. Geological Survey, Portland, OR.

Woodward-Clyde Consultants. 1995. Rhône-Poulenc St Helens Road Facility, 1st Quarter 1995: Surface Water and Sediment.

Yelen, T.S., and H.J. Patton. 1991. Seismotectonics of the Portland, Oregon Region. *Seism. Soc. Am. Bull*. 81:109-130.

Young, D.R., G.V. Alexander, and D. McDermott-Ehrlich. 1979. Vessel-related Contamination of Southern California Harbors by Copper and other Metals. *Mar. Poll. Bull*. 10:50-56.

11.0 GLOSSARY OF TERMS

A

Absorption: The uptake of water, other fluids, or dissolved chemicals by a cell or an organism (as tree roots absorb dissolved nutrients in soil).

Acceptable Levels: Levels of chemicals in media that do not cause unacceptable adverse risk to either ecological or human health receptors.

Adsorption: The process of adhering a chemical on the surface of a solid material as a chemical transport mechanism.

Alluvial: Relating to sediment deposited by flowing water.

Anthropogenic: Natural and human-made substances present in the environment as a result of human activities.

Aqueous: Composed of liquid water medium.

Aquifer: An underground geological formation, or group of formations, containing usable and practicably extractible quantities of water. Aquifers are sources of groundwater for wells and springs.

Assessment Endpoint: In ecological risk assessments, an explicit expression of the environmental value to be protected. It includes both an ecological entity and specific attribute thereof. For example, osprey are a valued ecological entity; reproduction and population maintenance of osprey, the attribute, form an assessment endpoint.

Attenuation: The process by which a compound is reduced in concentration over time, through absorption, adsorption, degradation, dilution, or transformation.

B

Background: Constituents or locations that are not influenced by the releases from a site, either naturally occurring or anthropogenic.

Bed Load: Sediment particles resting on or near the channel bottom that are pushed or rolled along by the flow of water.

Benthic Invertebrates: Organisms without vertebrae dwelling either in the sediment or on the sediment in streams and rivers.

Bioavailability: Degree of ability to be absorbed and ready to interact in organism metabolism.

Biota: The animal and plant life of a given region.

C

Carcinogen: Any substance that can cause or aggravate cancer.

Characterization of Ecological Effects: A step in the ecological risk assessment process that evaluates the ability of a stressor to cause adverse effects under given circumstances.

Characterization of Exposure: A step in the ecological risk assessment process that evaluates the interaction of a stressor with one or more receptors.

Cleanup: Actions taken to deal with a release or threat of release of a hazardous substance that could affect humans or the environment. The term "cleanup" is sometimes used interchangeably with the terms remedial action, removal action, response action, natural attenuation, or corrective action.

Columbia River Datum (CRD): A vertical datum established for the Columbia River from the lower river to the Bonneville Dam and on the Willamette from the Columbia up to Willamette Falls. At the Morrison Street bridge gauge, the CRD is 1.85 feet above NVGD29/47.

Combined Sewer Overflow: Discharge of a mixture of stormwater and domestic waste when the flow capacity of a sewer system is exceeded during rainstorms.

Community: In ecology, an assemblage of populations of different species within a specified location in space and time. Sometimes, a particular subgrouping may be specified, such as the benthic community in a river.

Confined Aquifer: An aquifer in which groundwater is confined under pressure that is significantly greater than atmospheric pressure.

Chemical(s) of Concern (COC): Chemicals identified through the baseline risk assessment that are judged to cause unacceptable adverse effects to human health and/or ecological receptors.

Chemical(s) of Interest (COI): Chemicals that have been detected at a site but have not been screened in the risk assessment process.

Chemical(s) of Potential Concern (COPC): Chemicals of interest that have been screened-in for evaluation in the risk assessment process.

D

Data Quality Objectives (DQOs): Qualitative and quantitative statements of the overall level of uncertainty that a decision-maker will accept in results or decisions based on environmental data. They provide the framework for planning and managing environmental data operations consistent with user's needs.

Dermal Absorption: Process by which a chemical penetrates the skin and enters the body as an internal dose.

Dermal Contact: Contact between a chemical and the skin.

Detection Limit: The lowest concentration of a chemical that can reliably be distinguished, with a stated level of confidence, from a zero concentration.

Dredging: Removal of mud and sediment from the bottom of water bodies.

E

Early Action: A non-time critical removal action pursuant to 40 CFR 300.415(b)(4).

Ecological Exposure: Exposure of a non-human organism to a stressor.

Ecological Risk Assessment: The application of a formal framework, analytical process, or model to estimate the effects of human actions(s) on a natural resource and to interpret the significance of those effects in light of the uncertainties identified in each component of the assessment process. Such analysis includes initial problem formulation, exposure and effects assessments, and risk characterization.

Ecosystem: The interacting system of a biological community and its non-living environmental surroundings.

Effluent: Wastewater--treated or untreated--that flows out of a treatment plant or industrial outfall. Generally refers to wastes discharged into surface waters.

Environmental Exposure: The interaction of a stressor with a human or ecological receptor.

Erosion: The removal of soil or sediment by wind or water.

Exposure Assessment: Identifying the pathways by which chemicals may reach receptors and estimating how much of a chemical an individual is likely to be exposed to.

Exposure Concentration: The concentration of a chemical interacting with the receptor.

Exposure Pathway: The path from sources of chemicals through environmental media to human or ecological receptors.

Exposure Route: The way a chemical enters an organism after contact (e.g., ingestion).

Exposure: The interaction of a stressor with a human or ecological receptor.

F

Flood Stage: A river stage established by the National Weather Service (NWS) above which flood damage may occur. The NWS defines flood stage for the Willamette River at Portland as 18.0 feet (datum unspecified).

G

Groundwater: Fresh water found beneath the earth's surface, usually in aquifers, that supplies wells and springs.

Groundwater Discharge: Groundwater entering surface water or exiting to the ground surface.

H

Habitat: The place where a population or community (e.g., human, animal, plant, microorganism) lives and its surroundings, both living and non-living.

Hazardous Substance: Any substance defined as a "hazardous substance" under CERCLA or ORS Chapter 465.

Hydraulic Gradient: In general, the direction of groundwater flow due to changes in the depth of the water table.

Hydrogeology: The geology of groundwater, with particular emphasis on the chemistry and movement of water.

I

Initial Study Area (ISA): The 5.7-mile stretch of the Willamette River from approximately the southern tip of Sauvie Island at river mile 3.5 to the southern end of Swan Island at river mile 9.2, and adjacent areas logically associated with an evaluation of the in-water portion of this stretch of the river. The ISA does not include upland sources of contamination being investigated or cleaned up pursuant to ORS 465 as implemented by the Oregon Department of Environmental Quality.

L

Light Non-Aqueous Phase Liquid (LNAPL): A non-aqueous phase liquid with a specific gravity less than 1.0. Because the specific gravity of water is 1.0, most LNAPLs float on top of the water table. Most common petroleum hydrocarbon fuels and lubricating oils are LNAPLs.

Lipid Solubility: The maximum concentration of a chemical that will dissolve in fatty substances. Lipid soluble substances are insoluble in water. They will very selectively disperse through the environment via uptake in living tissue.

Lowest Observed Adverse Effect Level (LOAEL): The lowest level of a stressor that causes statistically and biologically significant differences in test samples as compared to other samples subjected to no stressor.

M

Matrix: The sample material in which the chemicals of interest are found (e.g., water, sediment, tissue).

Mean High River Stage: The arithmetic mean of the maximum (e.g., highest daily measurement) observed river stage data in a given period (e.g., monthly mean high river stage).

Mean Sea Level (MSL): MSL is a tidal datum determined over a 19-year National Tidal Datum Epoch. It pertains to local mean sea level and should not be confused with the fixed datums of North American Vertical Datum of 1988 (NAVD88) or the National Geodetic Vertical Datum of 1929 (NGVD29). Data referencing MSL as the vertical datum in the Portland Harbor is technically on NGVD29/47.

Media: Specific environments such as air, water, soil that are the subject of regulatory concern and activities.

Mean High Water (MHW): A tidal datum. The average of all the high water heights observed over the National Tidal Datum Epoch (19-year period).

Mean Low Water (MLW): A tidal datum. The average of all the low water heights observed over the National Tidal Datum Epoch (19-year period).

Method Detection Limit (MDL): See *Detection Limit.*

Municipal Discharge: Discharge of effluent from wastewater treatment plants that receive wastewater from households, commercial establishments, and industries in the coastal drainage basin. Combined sewer/separate storm overflows are included in this category.

N

North American Vertical Datum of 1988 (NAVD88): This vertical datum is the national standard geodetic reference for heights. NAVD88 is a fixed datum derived from local mean sea level observations at Father Point/Rimouski, Quebec, Canada. NAVD88 replaced NGVD29/47 as the national standard geodetic reference for heights.

National Geodetic Vertical Datum of 1929 and Supplemental Adjustment of 1947 (NGVD29/47): NGVD29/47 is a fixed datum adopted and adjusted in 1947 as a national standard geodetic reference for heights prior to June 24, 1993 and is now considered superseded by NAVD88. NGVD29 is sometimes referred to as Sea Level Datum of 1929 or as **Mean Sea Level (MSL)** on some early issues of U.S Geological Survey topographic quads. NGVD 29 was originally derived from a general adjustment of the first-order leveling networks of the U.S. and Canada after holding mean sea level observed at 26 long-term tide stations as fixed. Historical data referencing MSL as the vertical datum in Portland Harbor is technically on NGVD29/47.

Naturally Occurring: Substances present in the environment in forms that have not been influenced by human activity.

Nature and Extent: Characterization of chemical distribution within a site.

No Observable Adverse Effect Level (NOAEL): An exposure level at which there are no statistically or biologically significant increases in the frequency or severity of adverse effects between the exposed population and its appropriate control. Some effects may be produced at this level, but they are not considered adverse or precursors to adverse effects.

No Observed Effect Concentration (NOEC): Exposure concentrations at which there are no statistically or biological significant differences in the frequency or severity of any effect in the exposed or control populations.

Non-Point Sources: Diffuse pollution sources (i.e. without a single point of origin or not introduced into a receiving stream from a specific outlet). The pollutants are generally carried off the land by stormwater.

O

Operable Unit: A discrete action that comprises an incremental step toward comprehensively addressing site problems. This discrete portion of a remedial response manages migration or eliminates or mitigates a release, threat of release, or pathway of exposure.

Ordinary High Water or High Water: Defined as the vegetation line or the line the water impresses on the soil by covering it for sufficient periods to deprive it of vegetation. It is established by field observation of seasonally high river levels by the U.S. Army Corps of Engineers and designates the jurisdictional limits of the Corps regulatory program. From Willamette RM 0 to 16, the ordinary high-water level ranges from 14.7 to 15.2 feet CRD (USACE 1991). The Oregon Division of State Lands defines the ordinary high water line (OHWL) as a line on the bank or shore to which high water ordinarily rises annually in season. The OHWL excludes exceptionally high-water levels caused by large floods (e.g., 100-year events).

P

Pathway: The physical course a chemical or pollutant takes from its source to the exposed organism.

Perched Water: Zone of unpressurized water held above the water table by impermeable rock or sediment.

Permeability: The rate at which liquids pass through soil or other materials in a specified direction.

Plume: A visible or measurable discharge of a contaminant from a given point of origin.

Point Source: A stationary location or fixed facility from which pollutants are discharged.

Population: A group of interbreeding organisms (i.e. members of the species) occupying a particular space; the number of humans or other living creatures in a designated area.

Porewater: Water extracted from the interstices of a sediment sample for water quality analysis or toxicity testing purposes.

Portland River Datum (PRD): Datum of reference plane from which river stage is measured on the Willamette River at Portland at the Morrison Bridge gauge. PRD equals 1.55 feet above NGVD29/47 or MSL, and the PRD gauge reports water levels 0.30 foot above CRD levels at this location.

Pre-AOC: Events including sampling and other studies that occurred prior to signing of the AOC for the Site.

Principal Threat: Those source materials considered highly toxic or highly mobile that generally cannot be reliably contained or would present a significant risk to human health or the environment should exposure occur.

Q

Quality Assurance/Quality Control (QA/QC): A system of procedures, checks, audits, and corrective actions to ensure that all EPA research design and performance, environmental monitoring and sampling, and other technical and reporting activities are of the highest achievable quality.

R

Receptor: Human or ecological entity to be evaluated in a risk assessment.

Recharge Area: A land area in which water reaches the zone of saturation from surface infiltration (e.g., where rainwater soaks through the earth to reach an aquifer).

Recharge: The process by which groundwater is added to a zone of saturation, usually by percolation from the soil surface (e.g., the recharge of an aquifer).

Remedial Action (RA): The actual construction or implementation phase of a Superfund site cleanup that follows remedial design.

Risk: A measure of the probability that an adverse effect to human health or ecological receptors will occur as a result of a release of a hazardous substance.

Risk Assessment: Qualitative and quantitative evaluation of the risk posed to human health or the environment by the actual or threatened release of specific chemical(s).

Risk Characterization: The last phase of the risk assessment process that estimates the potential for adverse human or ecological effects to occur from exposure to a stressor and evaluates the uncertainty associated with the estimate.

Risk Estimate: A description of the probability that organisms exposed to a specific dose of a chemical will develop an adverse effect (e.g., cancer).

Risk Management: The process of evaluating and selecting alternative regulatory and non-regulatory responses to risk. The selection process necessarily requires the consideration of legal, economic, and behavioral factors.

Risk Reduction: Lessening the unacceptable risks from chemicals by lowering their concentrations, mobility, bioavailability, toxicity, or exposure to receptors.

River Stage: Height of a river measured relative to a datum or specific elevation.

Round 1: RI/FS field work performed during 2002. Initially termed Round 1A and Round 1 to denote separation of several months between sampling events.

Round 2: RI/FS field work proposed for after Round 1.

Round 3: RI/FS field work proposed for after the preliminary risk assessment is completed.

S

Saturated Zone: The area below the water table where all open spaces are filled with water under pressure equal to or greater than that of the atmosphere.

Silt: Sedimentary materials composed of fine or intermediate-sized mineral particles.

Solubility: The amount of mass of a compound that will dissolve in a unit volume of solution. Aqueous solubility is the maximum concentration of a chemical that will dissolve in pure water at a reference temperature.

Sorption: The action of soaking up or attracting substances.

Storm Sewer: A system of pipes (separate from sanitary sewers) that carries water runoff from buildings and land surfaces.

Stressors: Physical, chemical, or biological entities that can induce adverse effects on ecosystems or human health.

Surface Runoff: Precipitation, snowmelt, or irrigation water in excess of what can infiltrate the soil surface and be stored in surface depressions.

Surface Water: All water naturally open to the atmosphere (e.g., rivers, lakes, reservoirs, ponds, streams, impoundments, seas, estuaries).

T

Threshold: The lowest dose or concentration of a chemical at which a specified measurable effect is observed and below which it is not observed.

Transition Zone: The interval where both groundwater and surface water comprise some percentage of the water occupying pore space in sediments.

Trophic Levels: A functional classification of species that is based on feeding relationships.

Toxicity Testing: Biological testing (usually with an invertebrate, fish, or small mammal) to determine the adverse effects of a compound or effluent.

Toxicity: The concentration at which a substance or mixture of substances can cause adverse effects in humans or animals.

U

Unconfined Aquifer: An aquifer containing water that is not under pressure; and where the water level in a well is the same as the water table outside the well.

Unsaturated Zone: The area above the water table where soil pores are not fully saturated, although some water may be present.

Urban Runoff: Stormwater from urban environments including industrial, residential, commercial, vacant, and transportation land uses.

V

Vadose Zone: The zone between land surface and the water table within which the moisture content is less than saturation (except in the capillary fringe) and pressure is less than atmospheric. Soil pore space also typically contains air or other gases. The capillary fringe is included in the vadose zone.

Volatile: Any substance that evaporates readily.

W

Water Quality Criteria: Standards of water quality not to be exceeded under the Clean Water Act.

Weight of Scientific Evidence: Considerations in assessing the interpretation of published information about toxicity—such as quality of testing methods, size, and power of study design; consistency of results across studies; and biological plausibility of exposure-response relationships and statistical associations.

Willamette River Flood Stage: Defined as +18 feet CRD on the lower Willamette River.

integral consulting inc

LWG Lower Willamette Group

Figure 1-1
Portland Harbor RI/FS
Vicinity Map

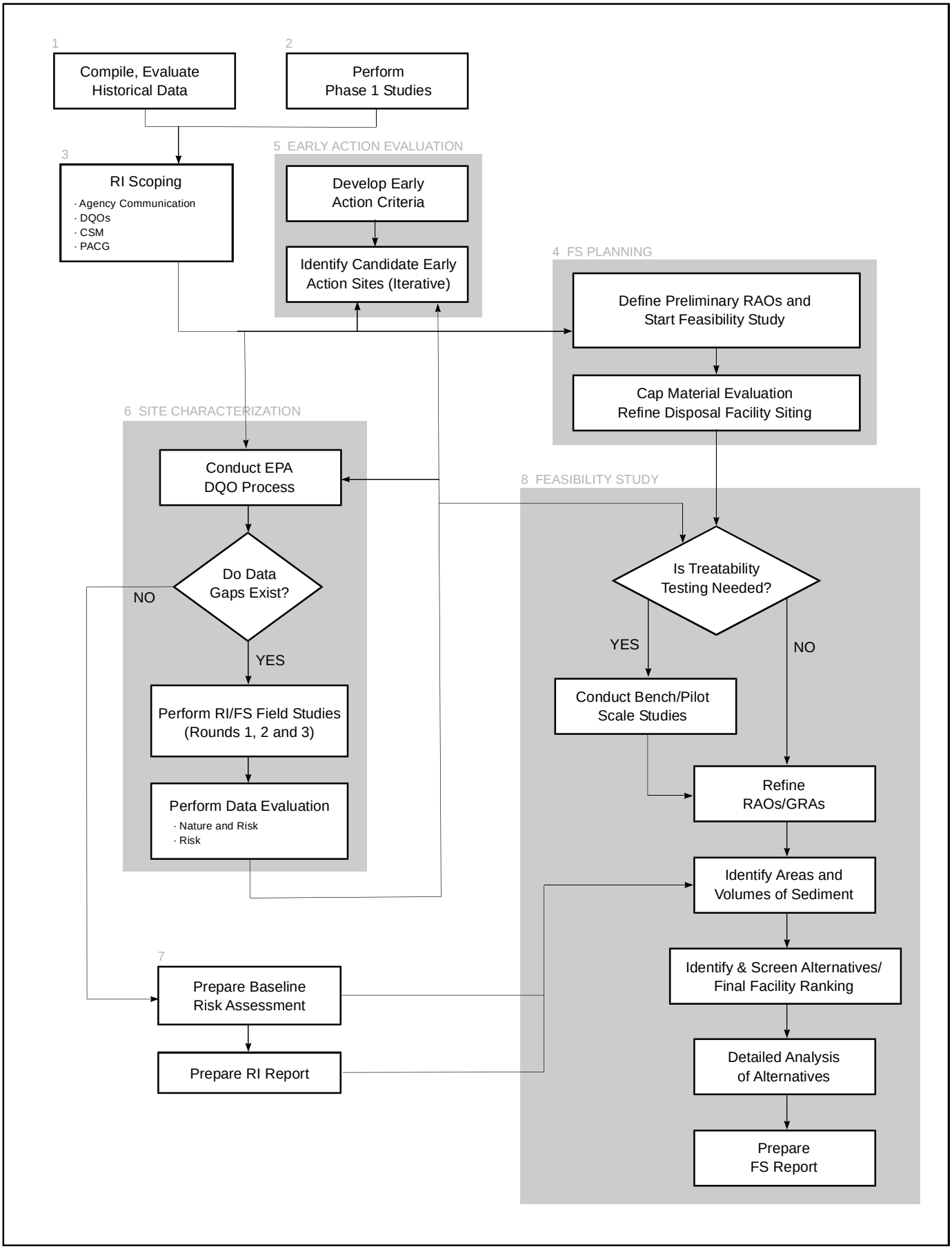
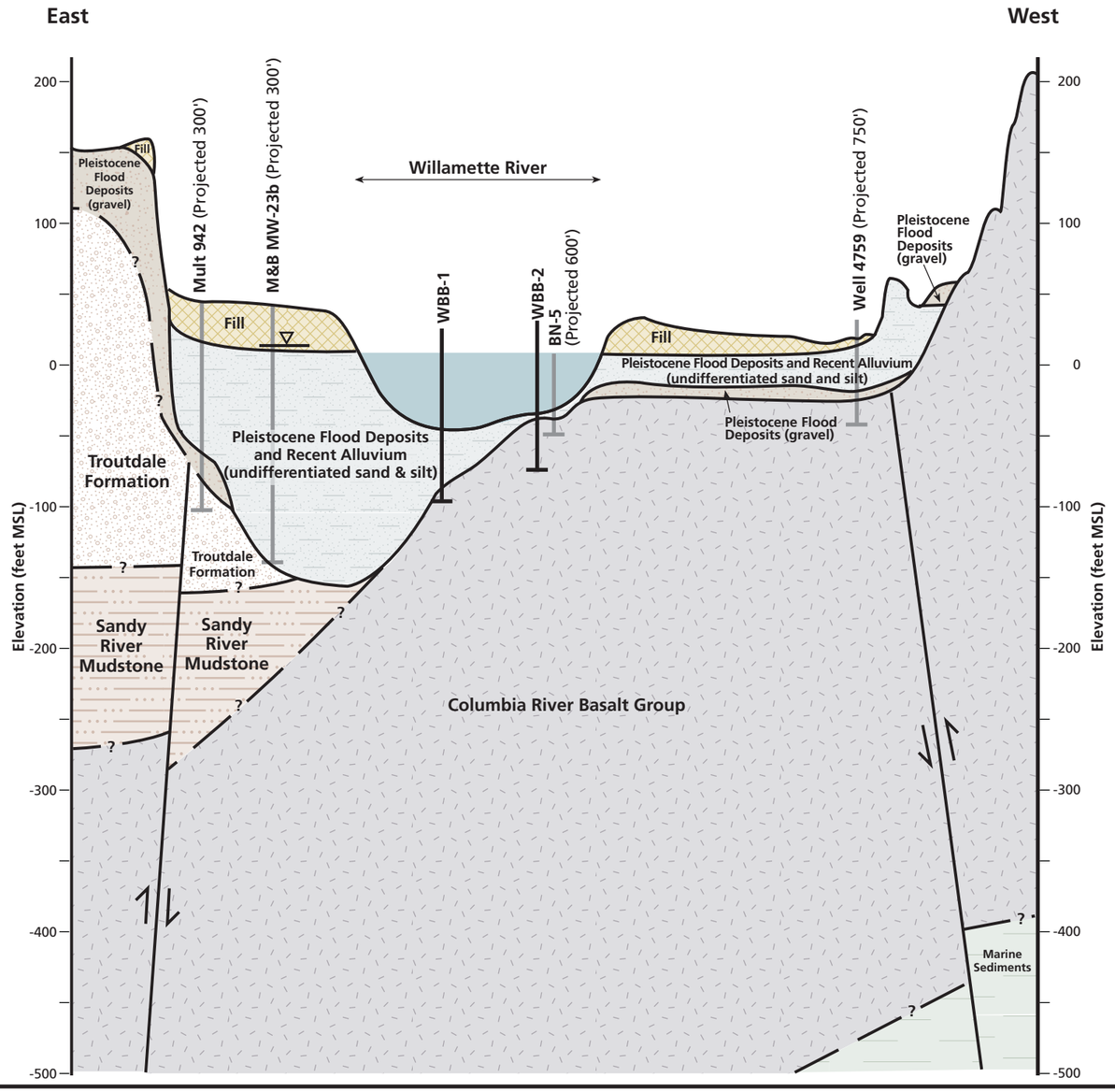


Figure 1-2. Portland Harbor RI/FS Project Flowchart. (Box numbers are referenced in Section 1.3.2.)

10/22/03 Generalized Geologic Section



LEGEND

0 1,000 2,000

HORIZONTAL SCALE IN FEET
VERTICAL EXAGGERATION = 10X

Mult 53996 — Boring/Well ID (WRD ID where available)

Surface elevation along profile

Boring/Well, Projected

Bottom of boring/well

- Fill
- Pleistocene Flood Deposits and Recent Alluvium (Sand and Silt)
- Pleistocene Flood Deposits (Gravel)
- Troutdale Formation
- Sandy River Mudstone
- Columbia River Basalt
- Marine Sediments

Notes: Scale and elevations are approximate.
Geologic information from City of Portland Force Main Project (URS 2000) (Beeson, et al. 1991)

Reference: Fault locations and orientation based on Wong (2001)

LWG Lower Willamette Group

Groundwater Solutions Inc.

Figure 2-1
Portland Harbor RI/FS
Generalized Geologic Section

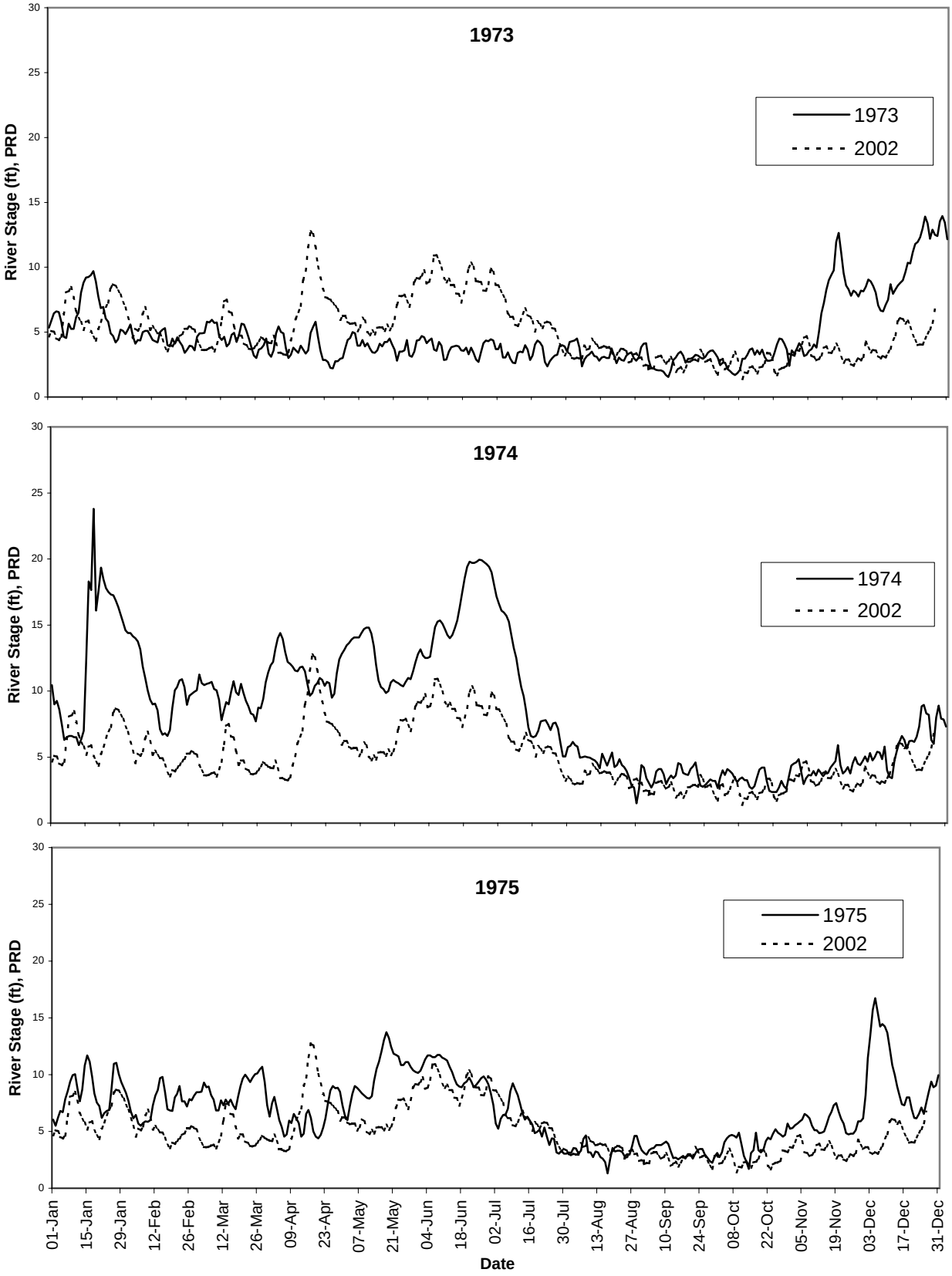


Figure 2-2a. Portland Harbor RI/FS. Daily Mean Willamette River Stage Height (ft, PRD) at Portland (RM 12.8) for 1973-75.

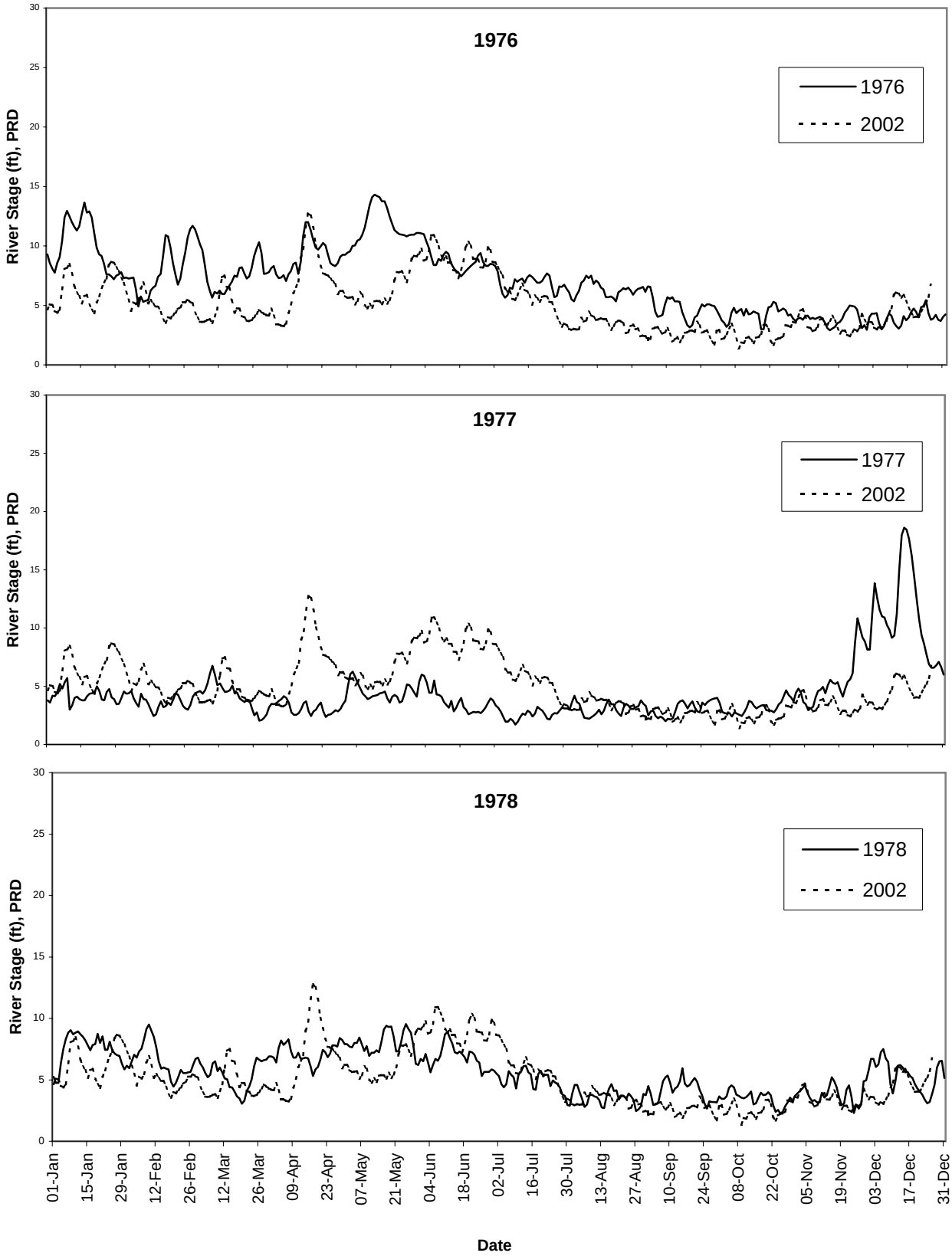


Figure 2-2b. Portland Harbor RI/FS. Daily Mean Willamette River Stage Height (ft, PRD) at Portland (RM 12.8) for 1976-78.

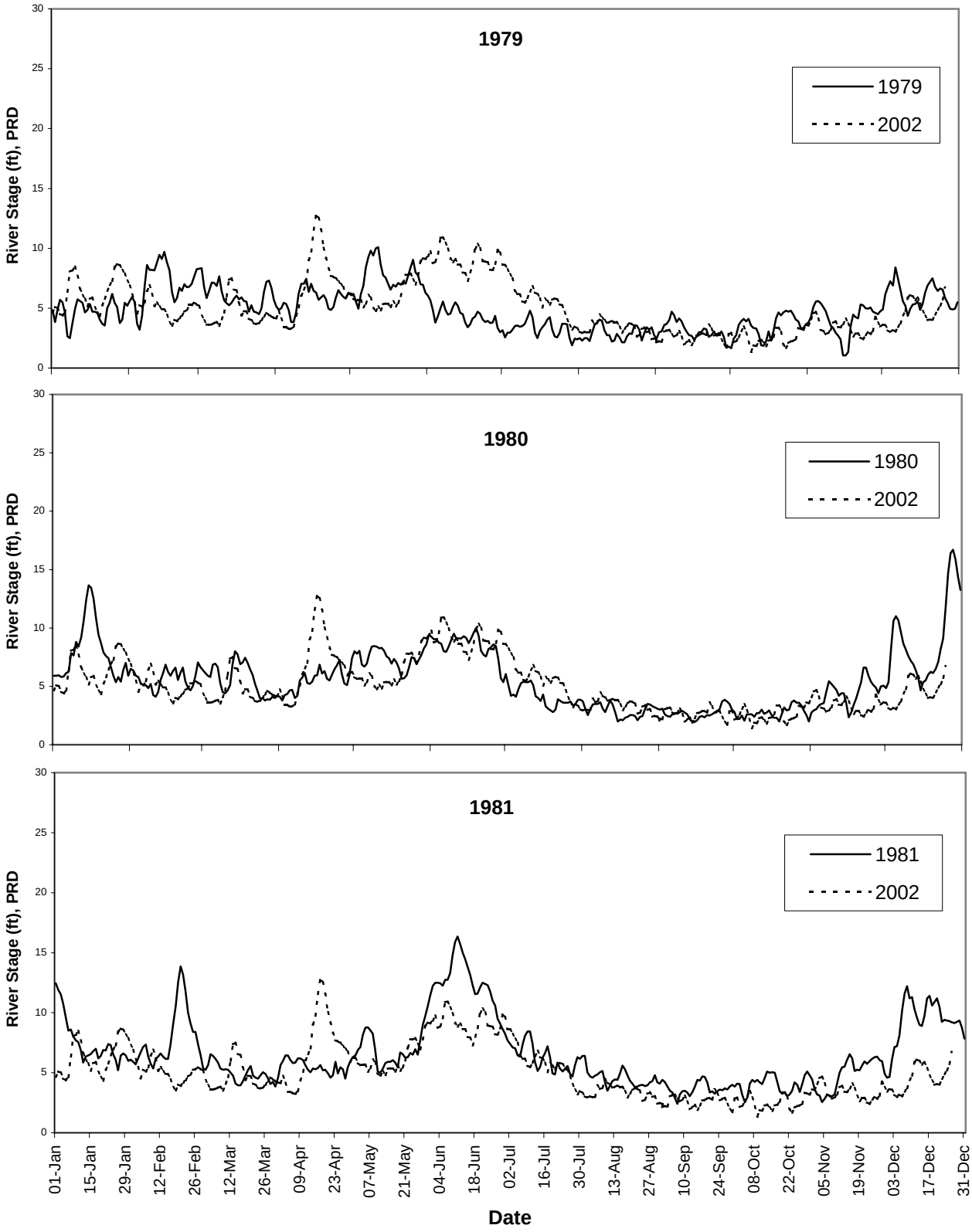


Figure 2-2c. Portland Harbor RI/FS. Daily Mean Willamette River Stage Height (ft, PRD) at Portland (RM 12.8) for 1979-81.

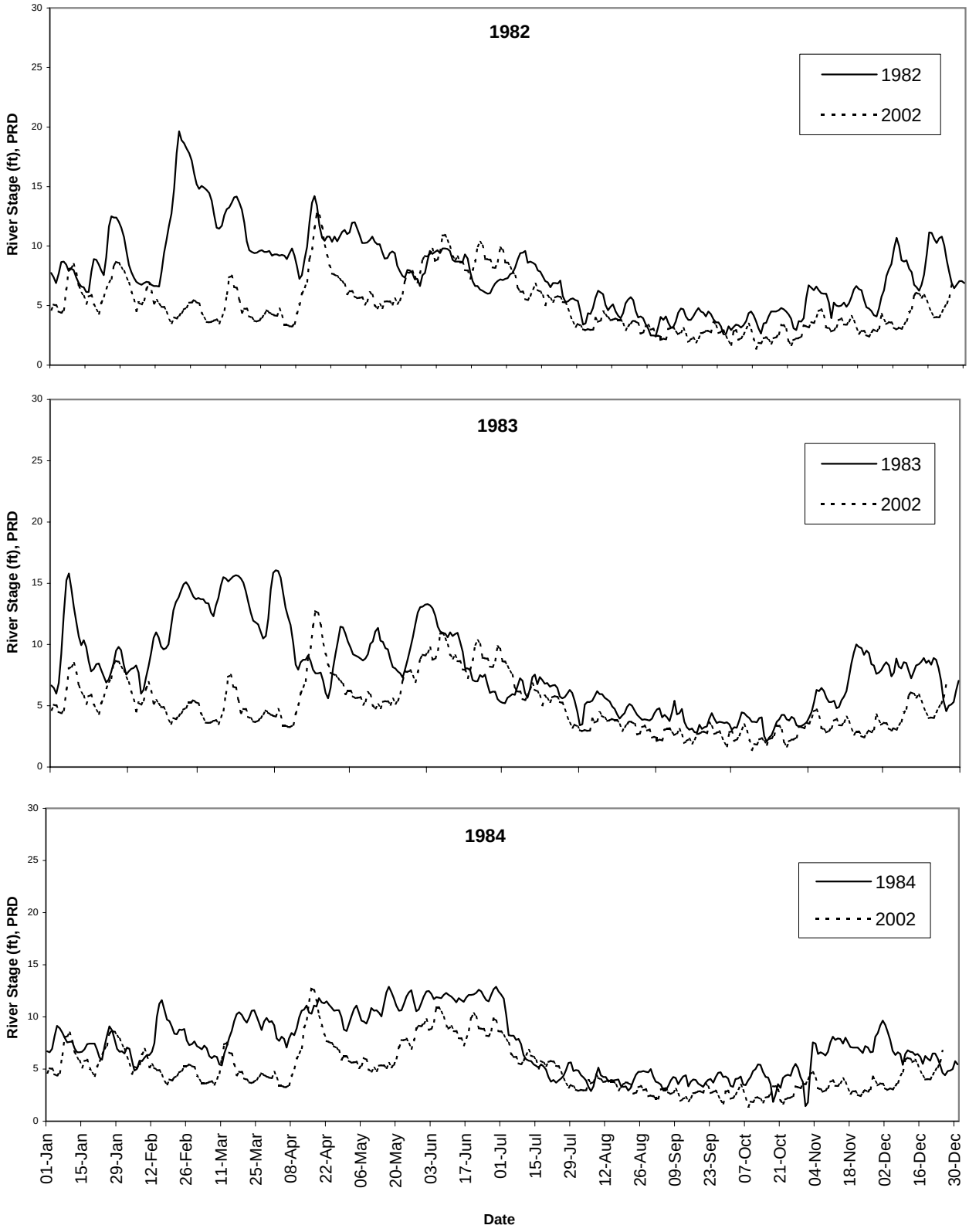


Figure 2-2d. Portland Harbor RI/FS. Daily Mean Willamette River Stage Height (ft, PRD) at Portland (RM 12.8) for 1982-84.

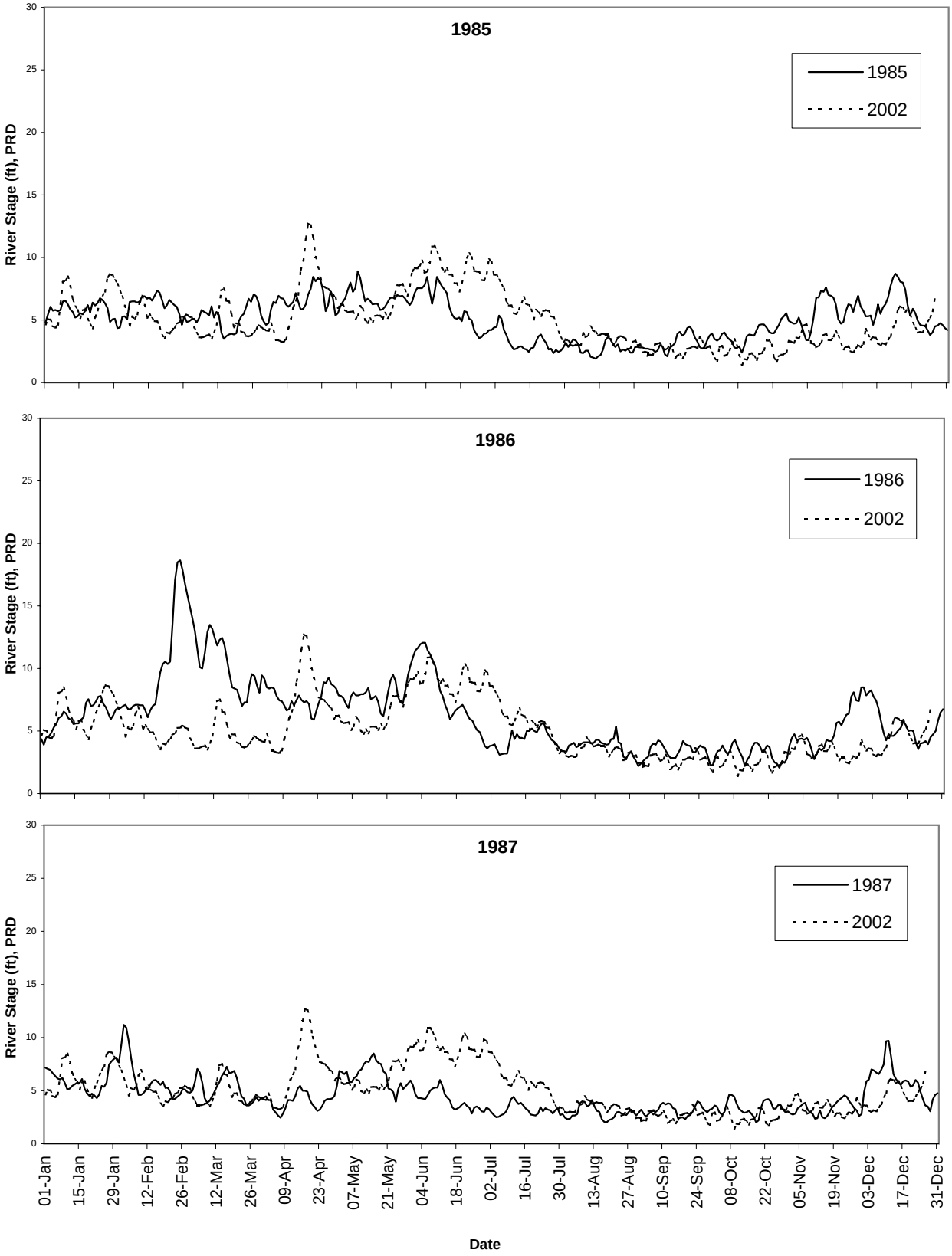


Figure 2-2e. Portland Harbor RI/FS. Daily Mean Willamette River Stage Height (ft, PRD) at Portland (RM 12.8) for 1985-87.

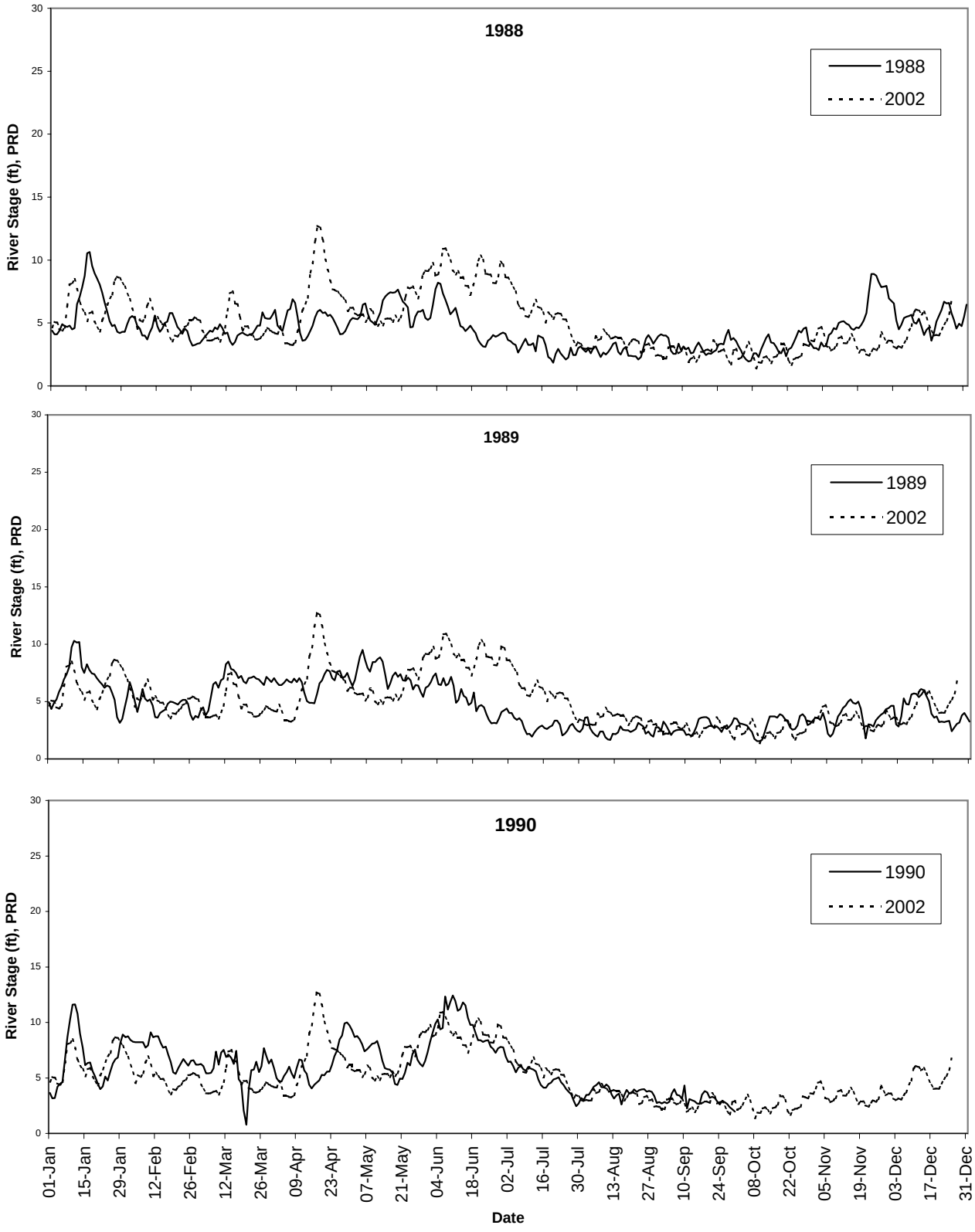


Figure 2-2f. Portland Harbor RI/FS. Daily Mean Willamette River Stage Height (ft, PRD) at Portland (RM 12.8) for 1988-90.

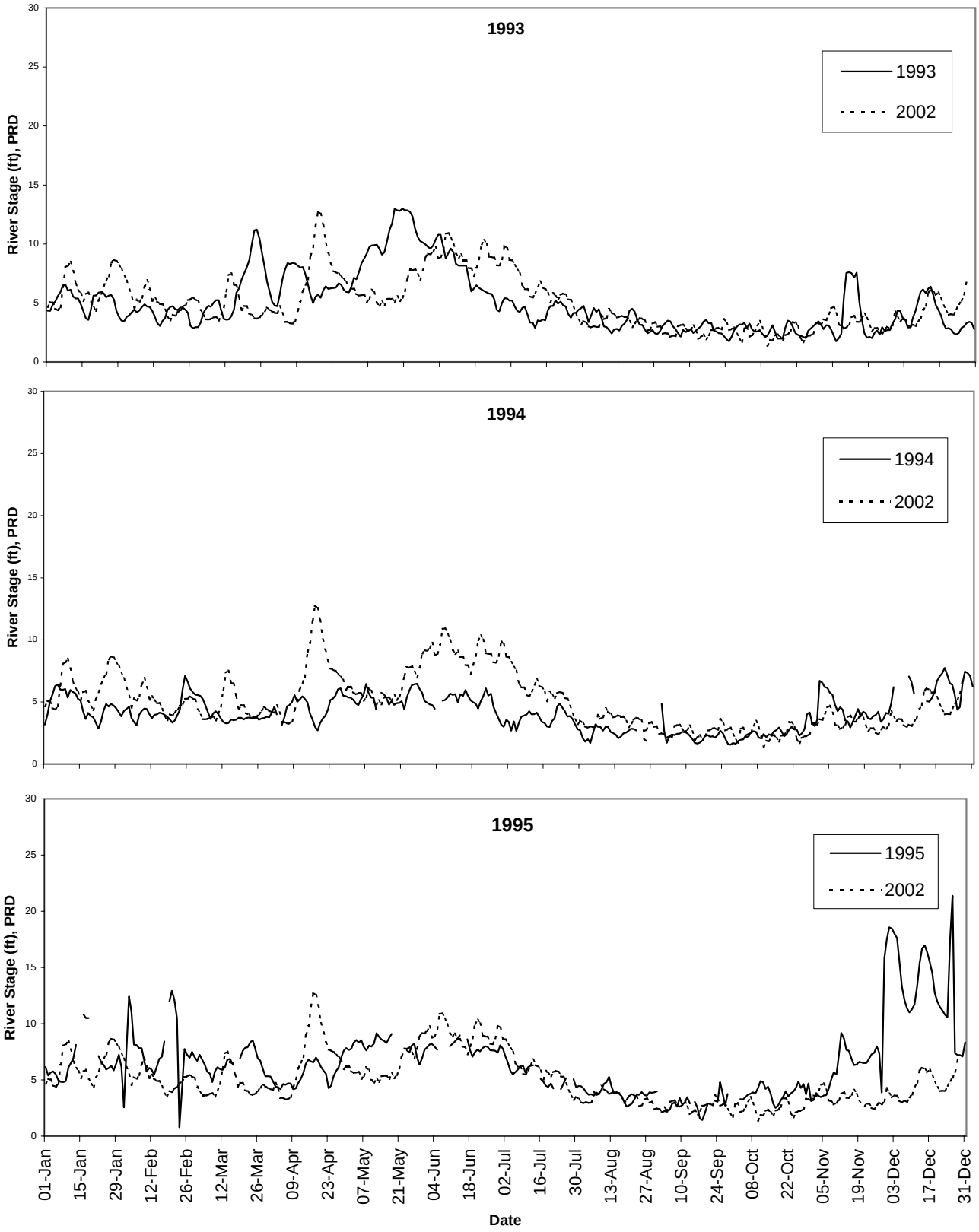


Figure 2-2g. Portland Harbor RI/FS. Daily Mean Willamette River Stage Height (ft, PRD) at Portland (RM 12.8) for 1993-95.

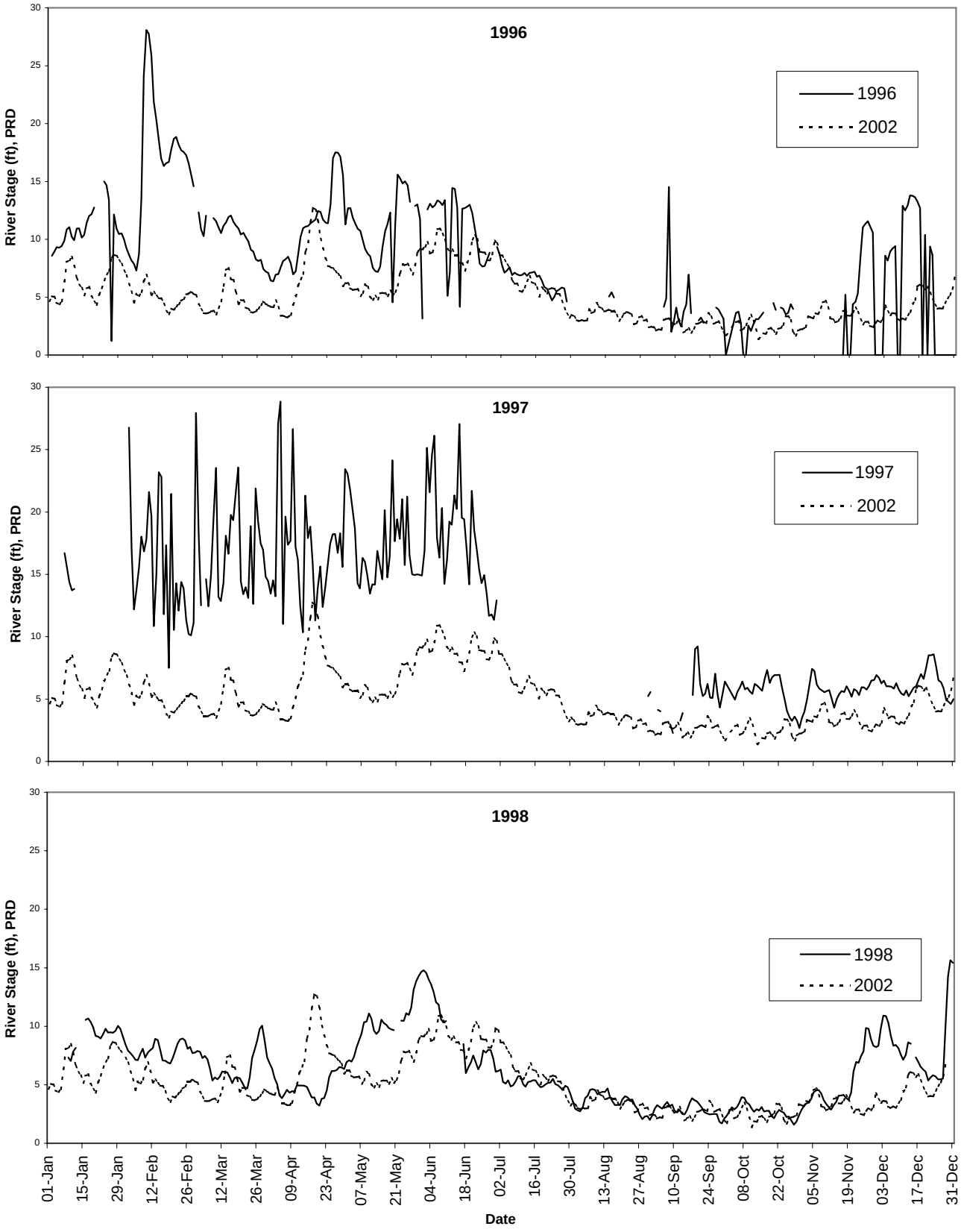


Figure 2-2h. Portland Harbor RI/FS. Daily Mean Willamette River Stage Height (ft, PRD) at Portland (RM 12.8) for 1996-98.

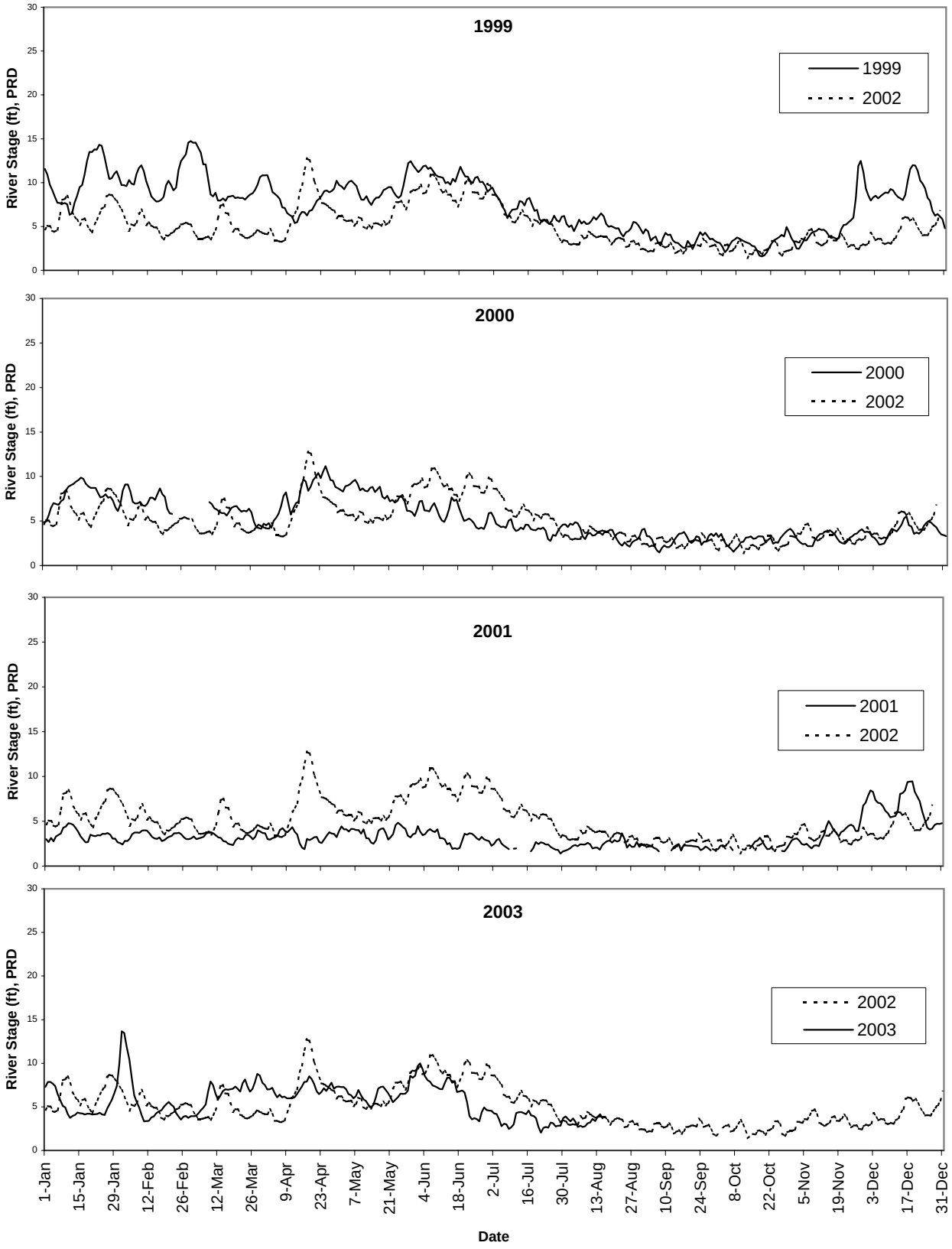


Figure 2-2i Portland Harbor RI/FS. Daily Mean Willamette River Stage Height (ft, PRD) at Portland (RM 12.8) for 1999-2001, 2003.

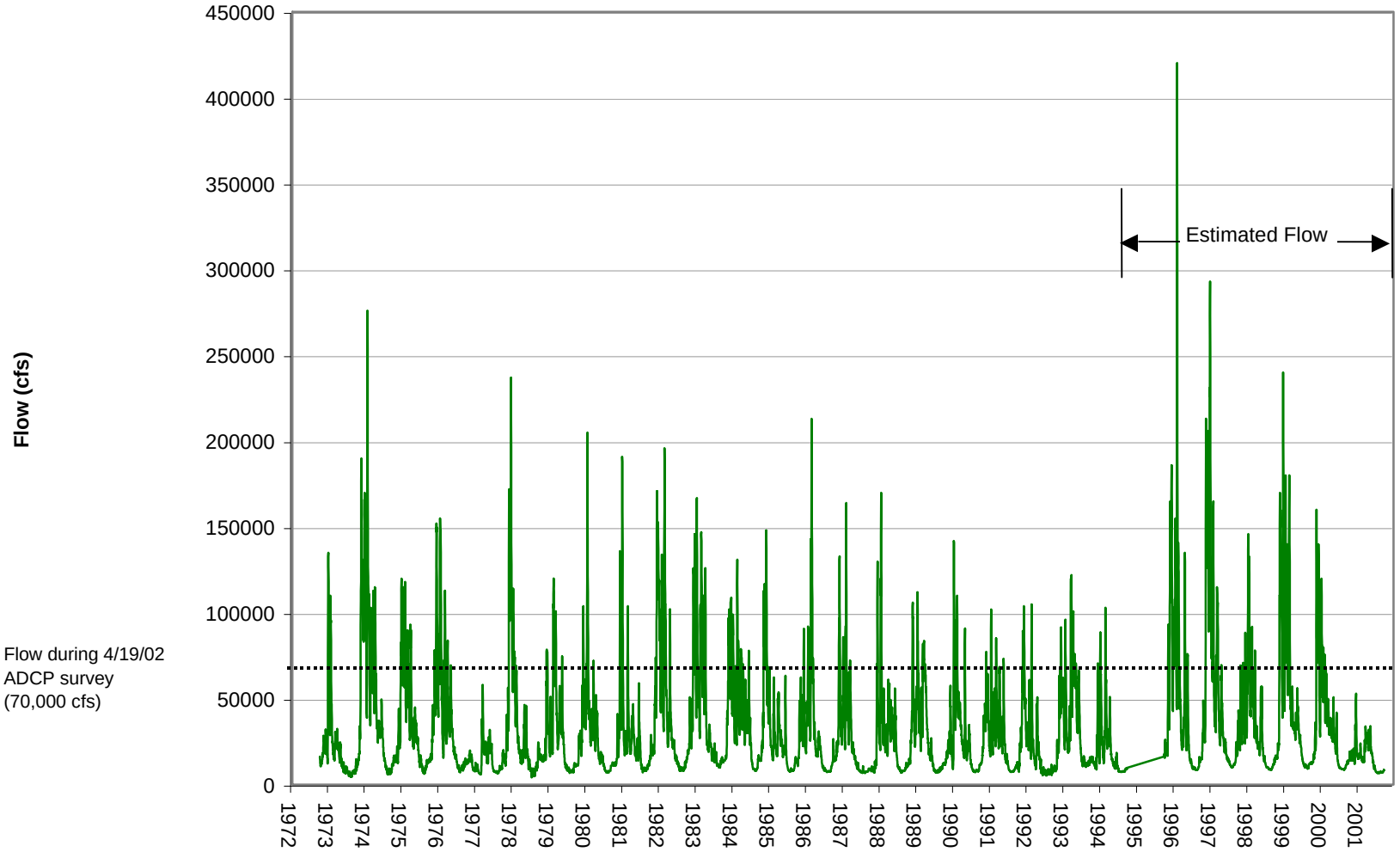


Figure 2-3
Portland Harbor RI/FS
Willamette River Flow at Morrison Street Bridge (USGS Station 14211720) for Years 1972-2001

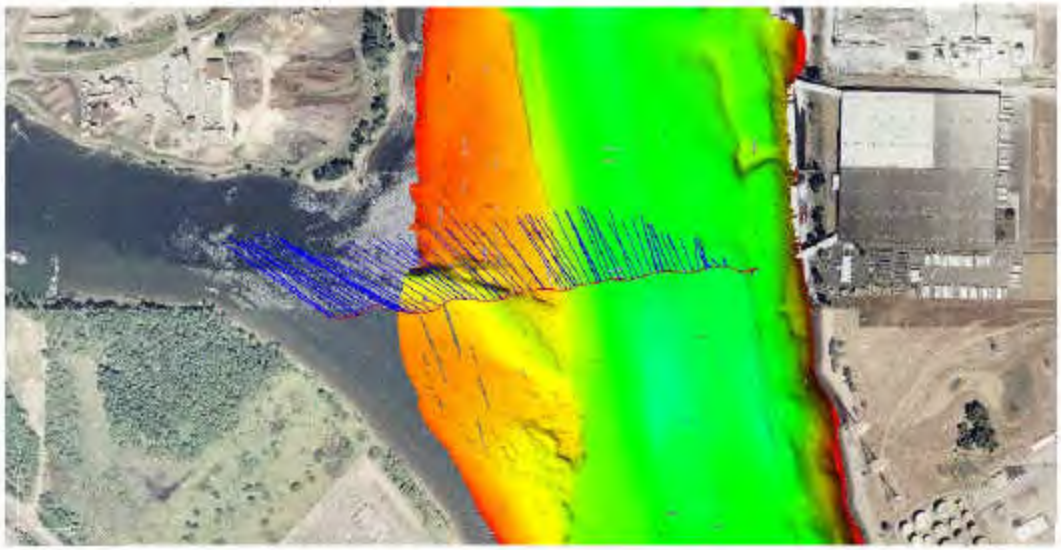


Figure 2-4
Portland Harbor RI/FS
Vector Plot (ADCP Data) of the Water-column-averaged Velocity, Magnitude, and Direction at Transect 4, RM 3.1

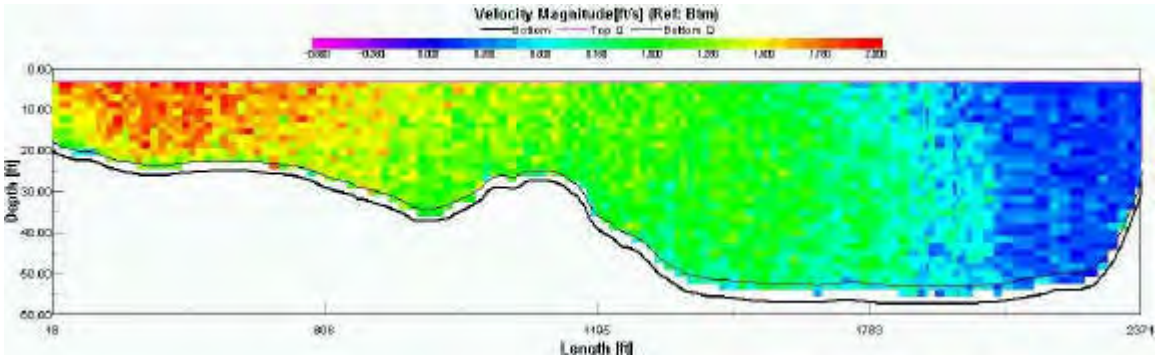


Figure 2-5a
Portland Harbor RI/FS
Vertical Profile of the Velocity Magnitude Measured Perpendicular to Transect 4 (see Figure 2-4) at RM 3.1 on April 19, 2002

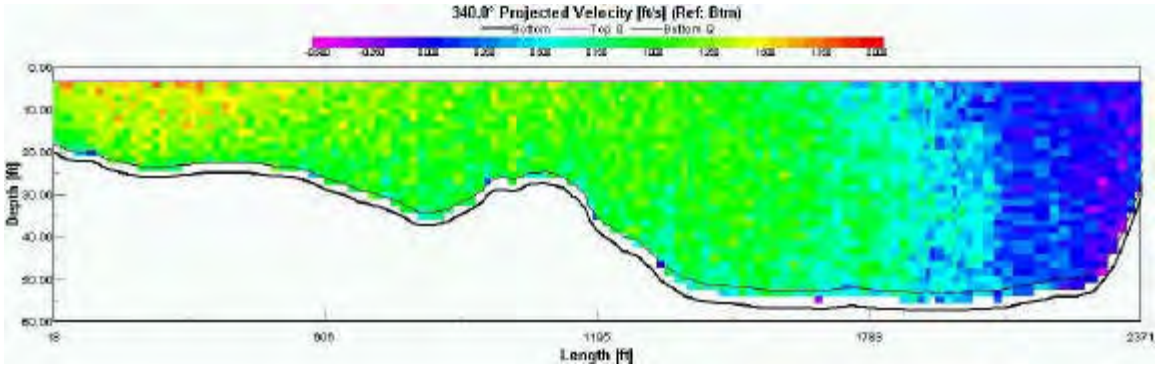


Figure 2-5b
Portland Harbor RI/FS
Vertical Profile of the Velocity Measured Perpendicular to Transect 4 (see Figure 2-4) at RM 3.1 on April 19, 2002

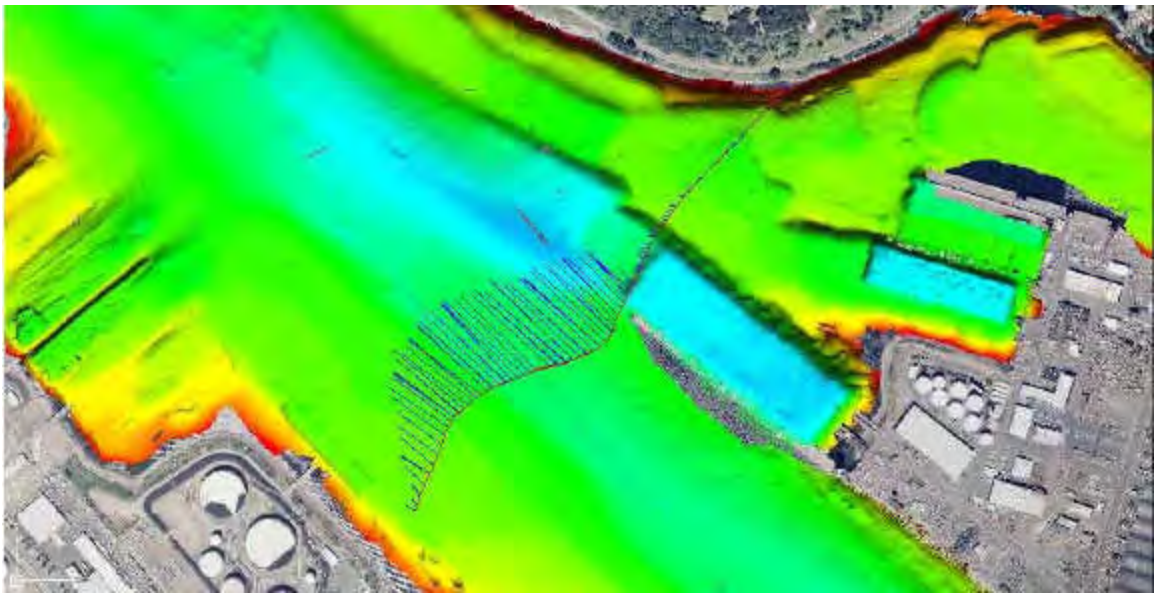


Figure 2-6a
Portland Harbor RI/FS
Vector Plot (ADCP Data) of the Water-column-averaged Velocity, Magnitude, and Direction at Transect 11, RM 8

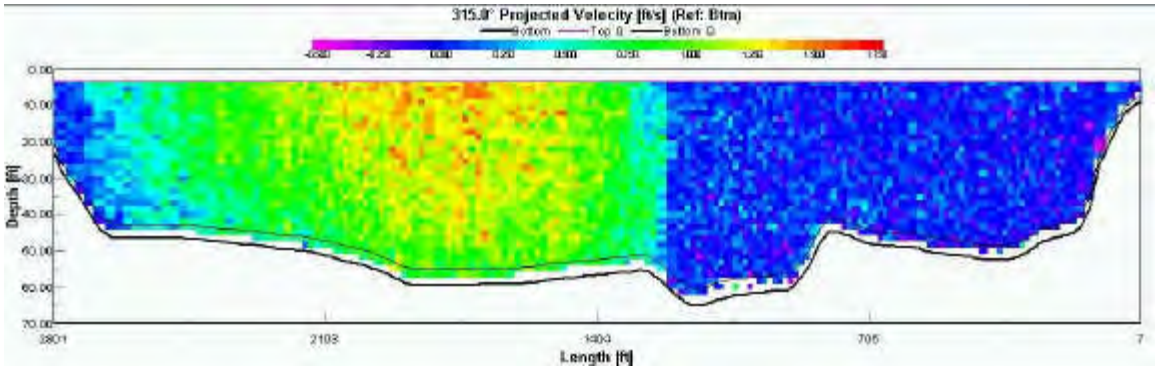


Figure 2-6b
Portland Harbor RI/FS
Vertical Profile of the Velocity Measured Perpendicular to Transect 11 (see Figure 2-4) at RM 8 on April 19, 2002

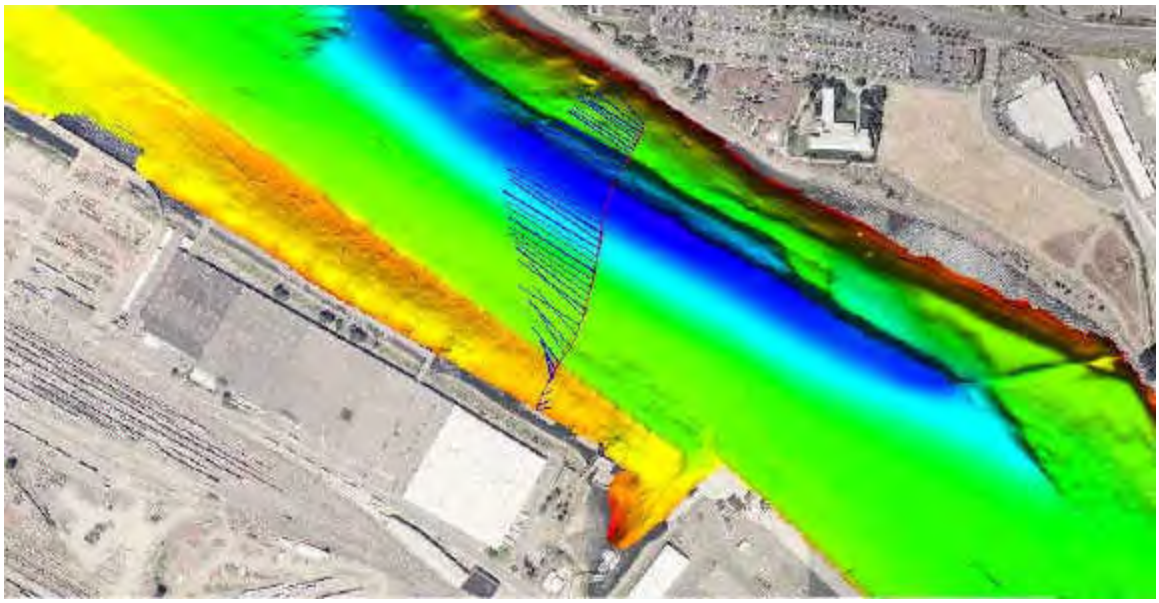


Figure 2-7a
Portland Harbor RI/FS
Vector Plot (ADCP Data) of the Water-column-averaged Velocity, Magnitude, and Direction at Transect 14, RM 9.6

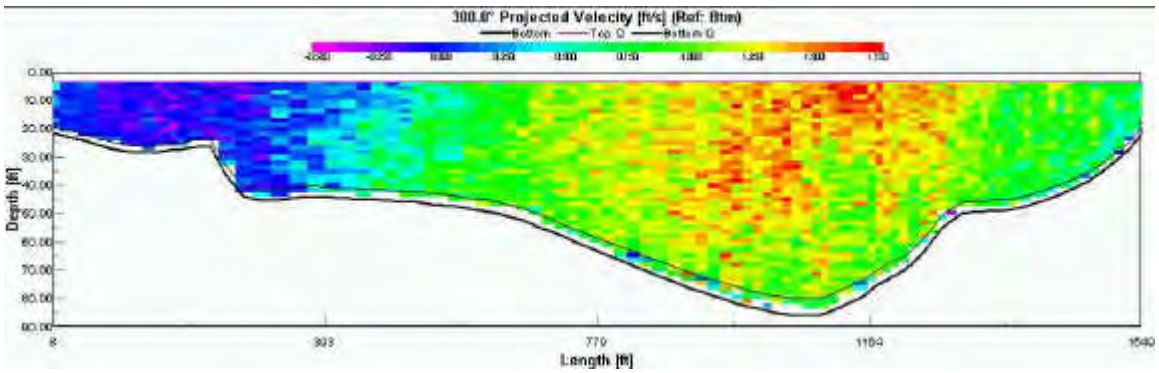


Figure 2-7b
Portland Harbor RI/FS
Vertical Profile of the Velocity Measured Perpendicular to the Transect 14 (see Figure 2-4) RM 9.6 on April 19, 2002

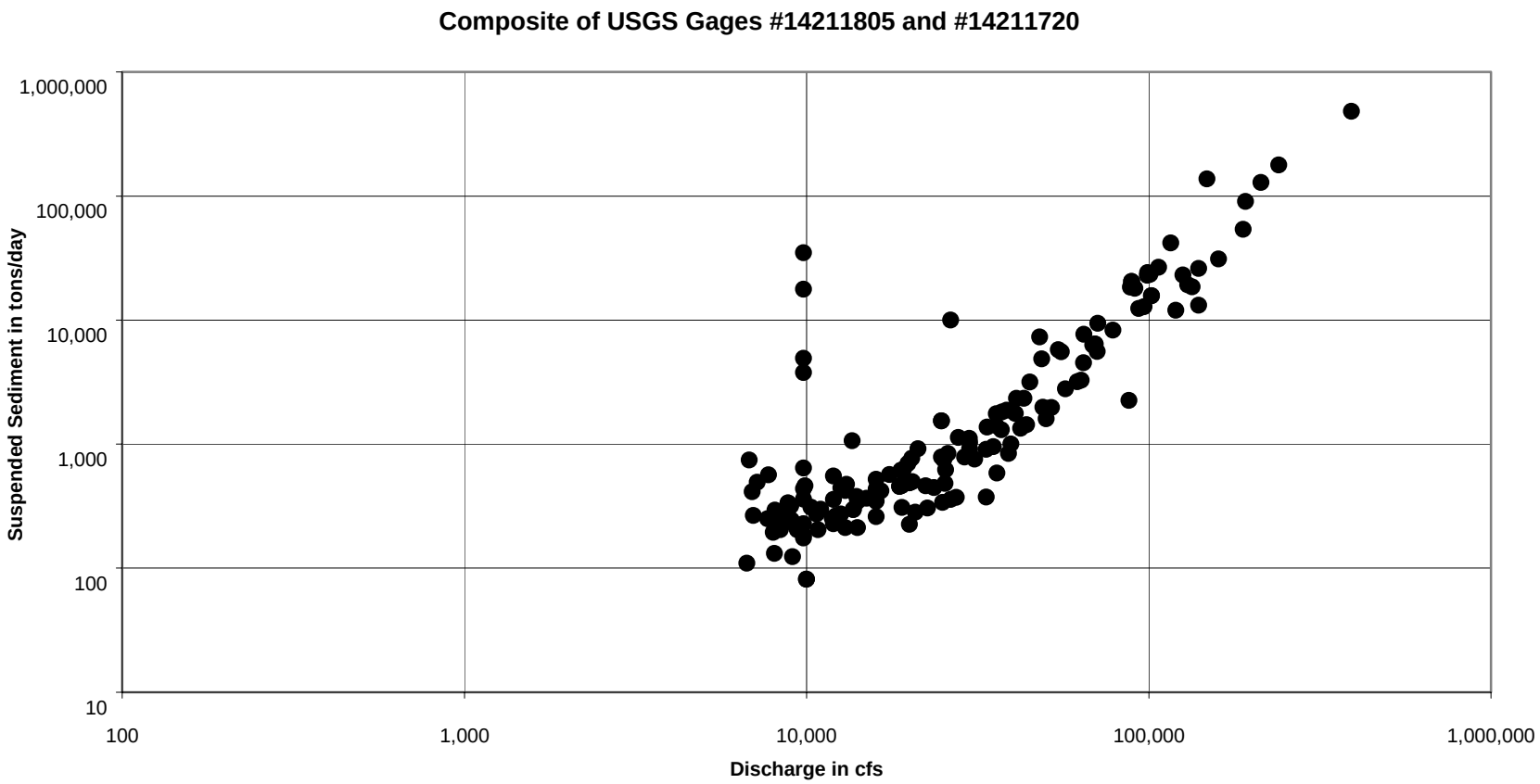
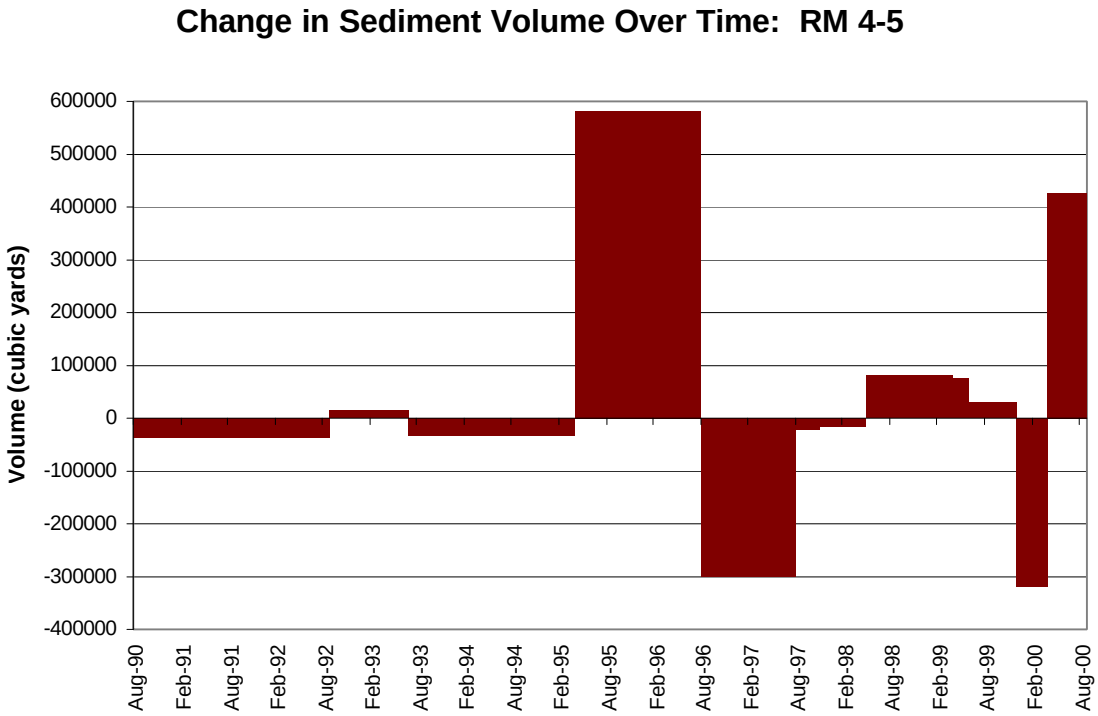


Figure 2-8
Portland Harbor RI/FS
Discharge Versus Suspended Sediment in Lower Willamette River



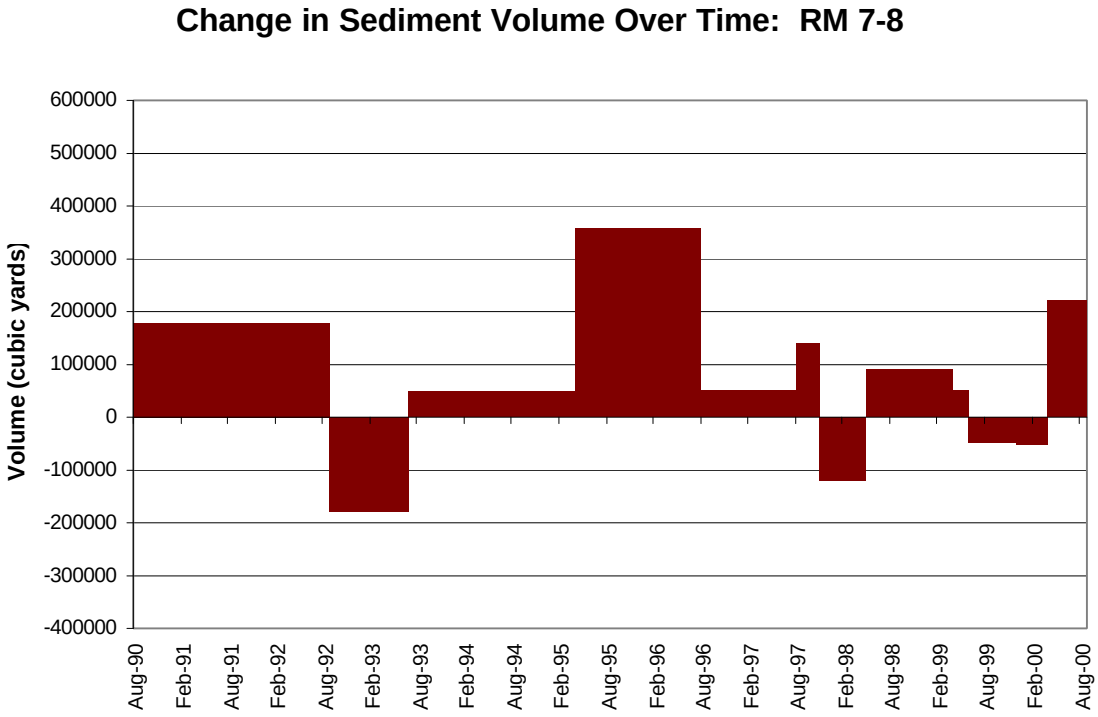


Figure 2-9
Portland Harbor RI/FS
Changes in Sediment Volume Over Time for River Miles 4-5 and 7-8
(based on comparisons of bathymetric survey data collected by the Corps from 1990 through 2000)

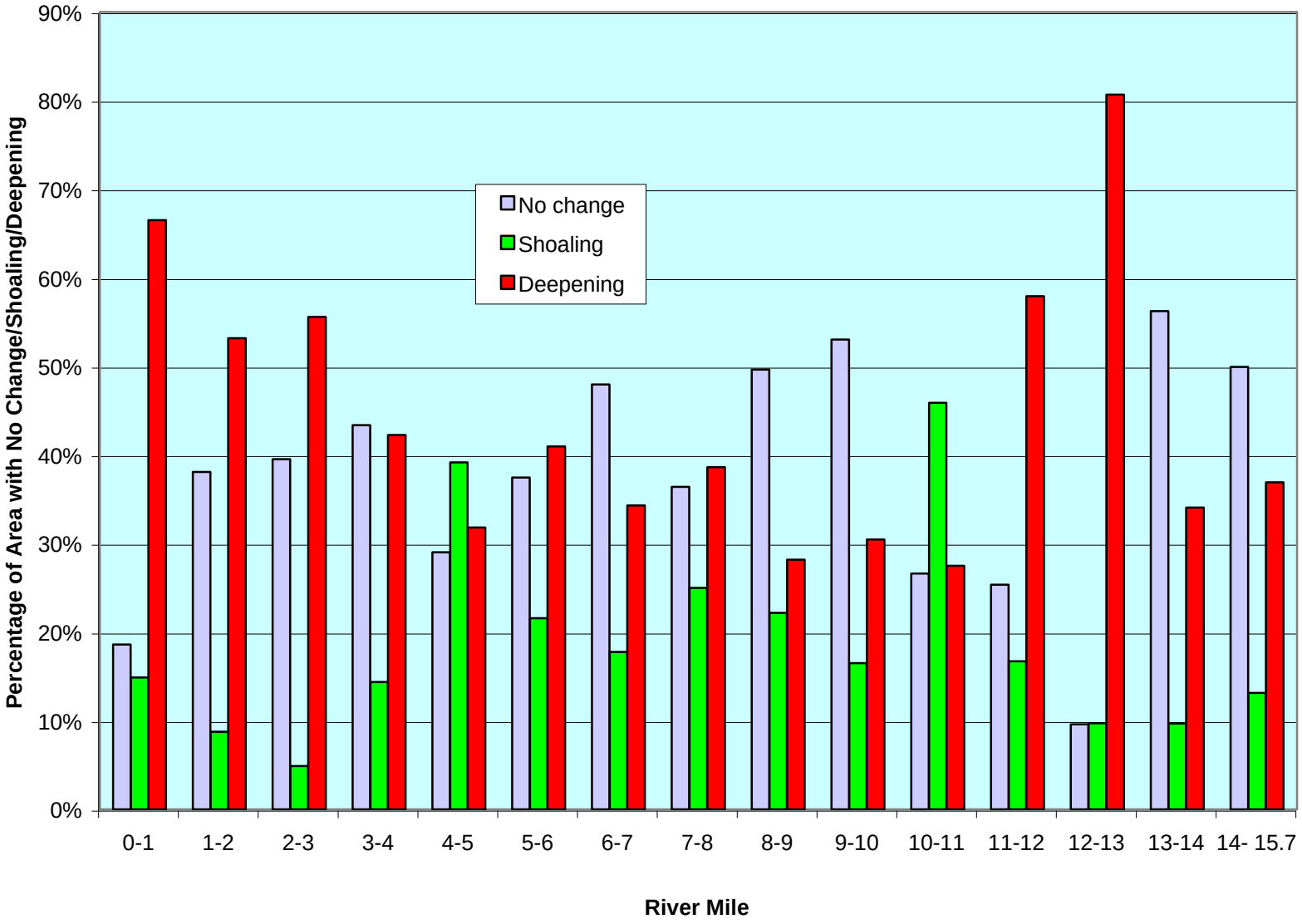


Figure 2-10a
Portland Harbor RI/FS
Nearshore (< 20' CRD) Bathymetric Changes (December 2001 to September 2002)

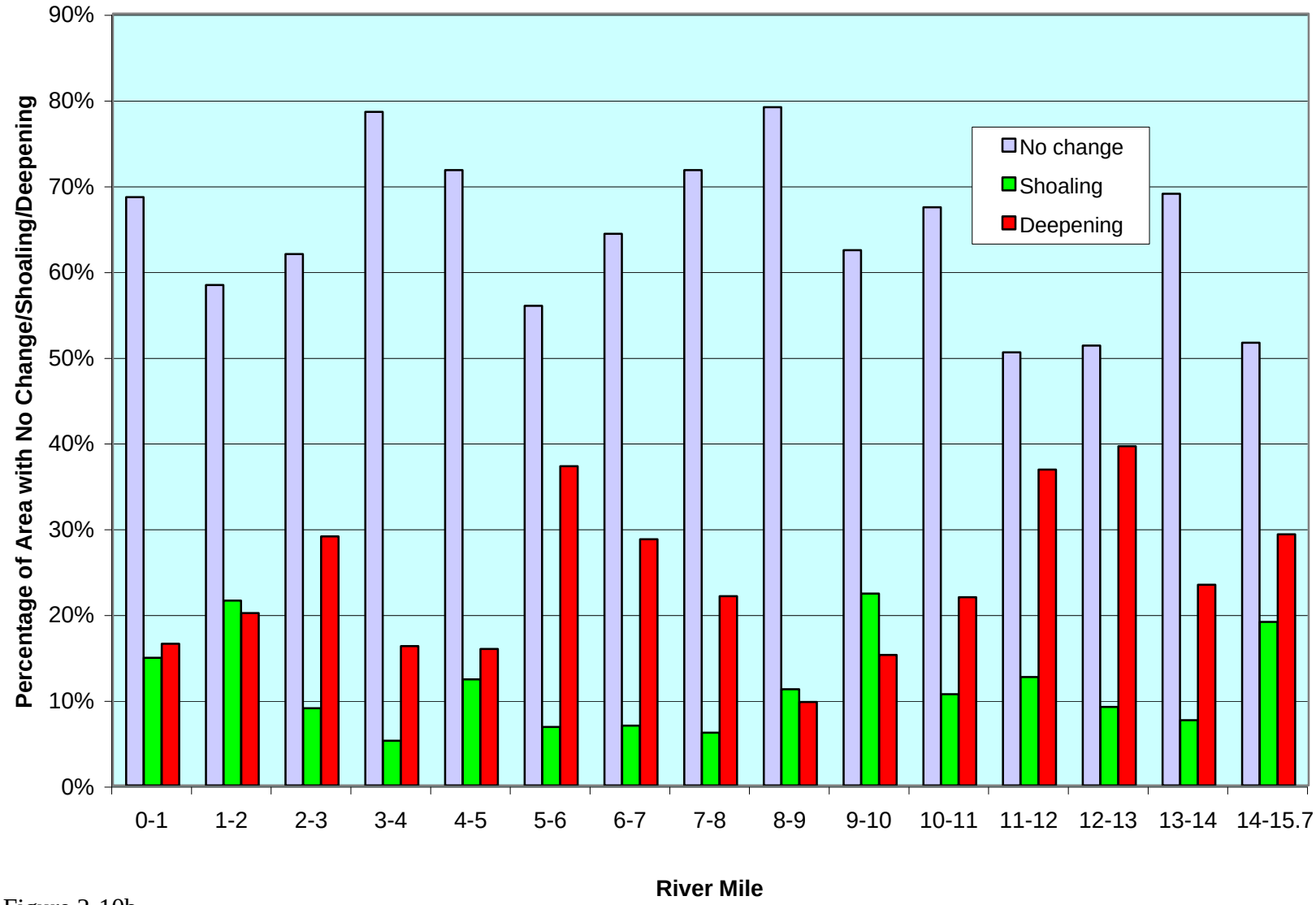


Figure 2-10b
Portland Harbor RI/FS
Offshore (> 20' CRD) Bathymetric Changes (December 2001 to September 2002)

Chemical Detected in >10% of Historical Surface or Subsurface Samples	River Mile Segment(s) - Surface Sediment											River Mile Segment(s) - Subsurface Sediment										
	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11
Dioxins/Furans	■				■		■	■						■		■		■	■	■	■	
2,4-D							■															
2,4-DB							■															
Acetone									■	■	■									■		
alpha-Hexachlorocyclohexane																		■				
Benzoic Acid						■			■		■			■			■	■	■	■	■	■
Bromine																■		■	■	■	■	
Chlorine																■		■	■	■	■	
Chlorobenzene							■	■	■	■	■								■			
Cyanide							■											■				
Dibenzothiophene				■	■																	
Ethylbenzene							■		■									■				
gamma-Hexachlorocyclohexane			■								■							■				
Heavy Oil							■	■										■				
Lube Oil			■		■		■		■					■								
Methylene chloride					■				■													
Methylethyl ketone																						
Pencil Pitch					■											■						
Phytane					■																	
Pristane					■																	
trans-Chlordane									■													
trans-Nonachlor									■													
Xylene							■		■													

Chemical Detected in 5-10% of Historical Surface or Subsurface Samples	River Mile Segment(s) - Surface Sediment											River Mile Segment(s) - Subsurface Sediment										
	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11
1,3,5-Trimethylbenzene																			■			
Aldrin		■	■	■			■		■			■		■				■				
alpha-Chlordane					■				■													
Benzene							■		■									■				
cis-Nonachlor									■													
Endosulfan sulfate						■			■													
Endrin																		■		■	■	
Endrin aldehyde			■						■					■								
gamma-Chlordane					■				■		■											
Natural Gas							■											■				
n-Butylbenzene																			■			
p-Cymene																			■			
Pentachlorophenol							■	■	■					■				■		■	■	
Phenol			■	■		■			■		■						■		■	■	■	■
Pseudocumene																			■			
sec-Butylbenzene																			■			
Tetrachlorophenol							■															
Toluene							■			■								■	■		■	

Figure 4-1. Chemicals Detected in Historical LWR Samples Since 1990 that are Unique to Certain River Miles.

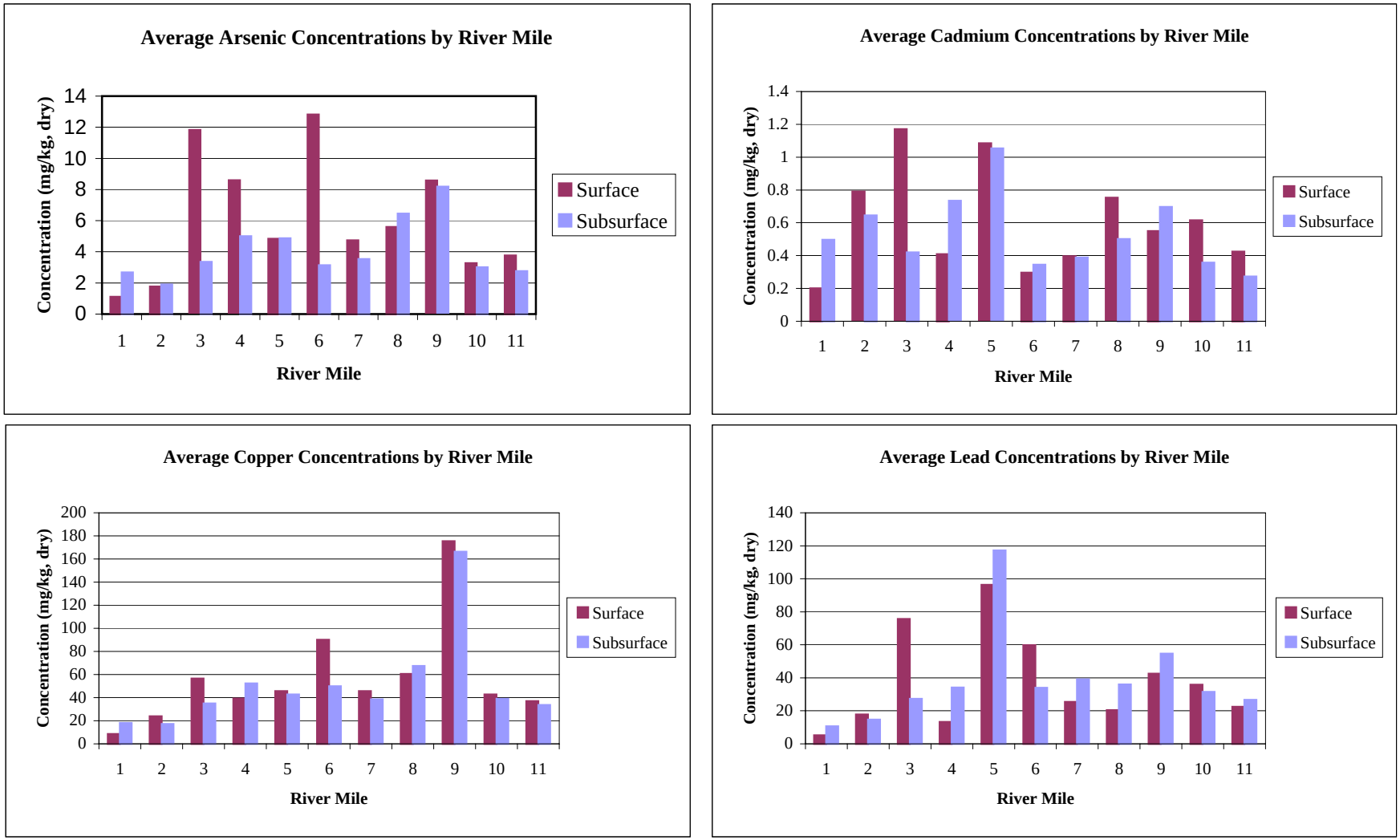


Figure 4-2a.
Portland Harbor RI/FS
Comparison of Average Surface and Subsurface Chemical Concentrations Between RM 0 and RM 11.

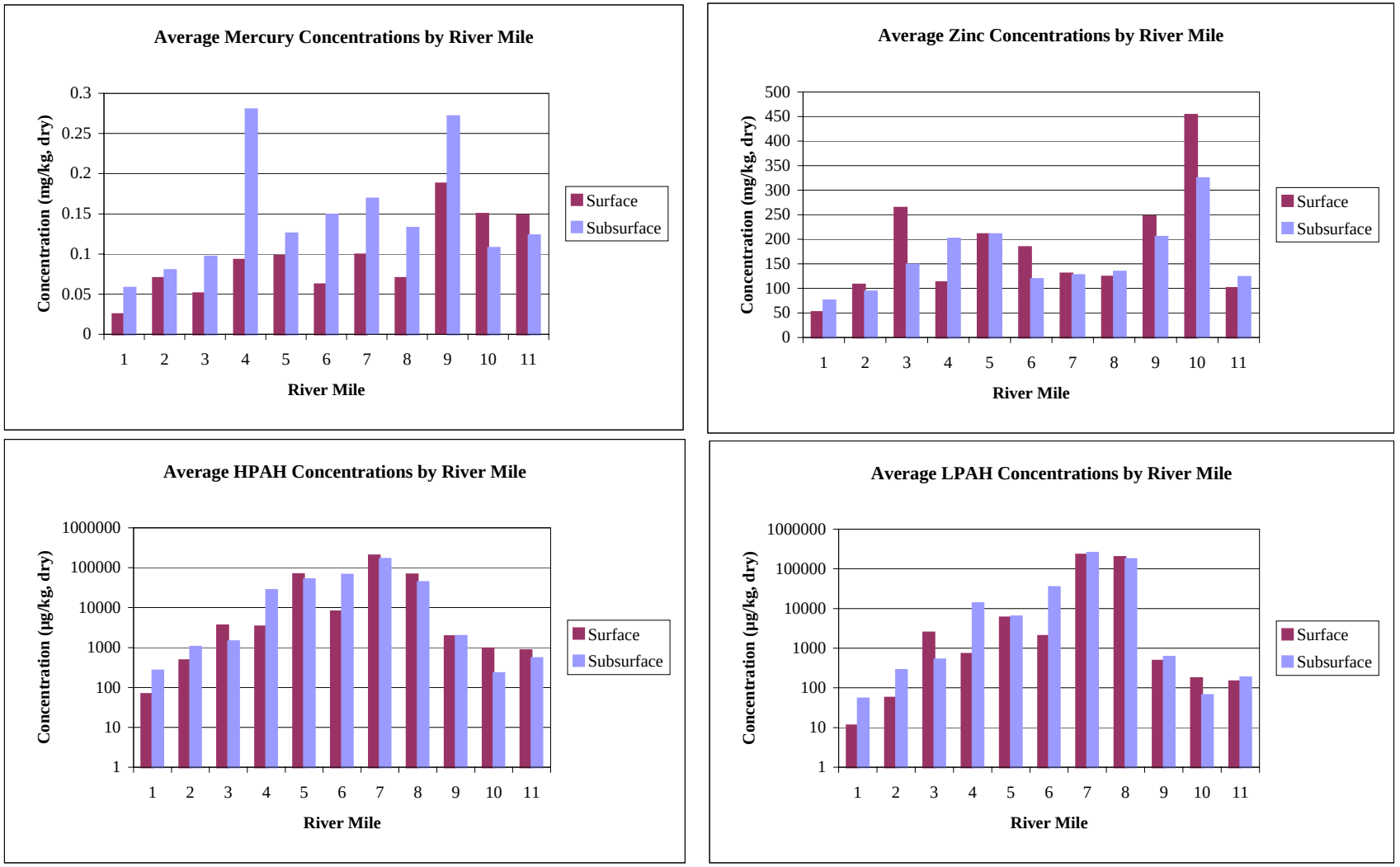


Figure 4-2b.
Portland Harbor RI/FS
Comparison of Average Surface and Subsurface Chemical Concentrations Between RM 0 and RM 11.

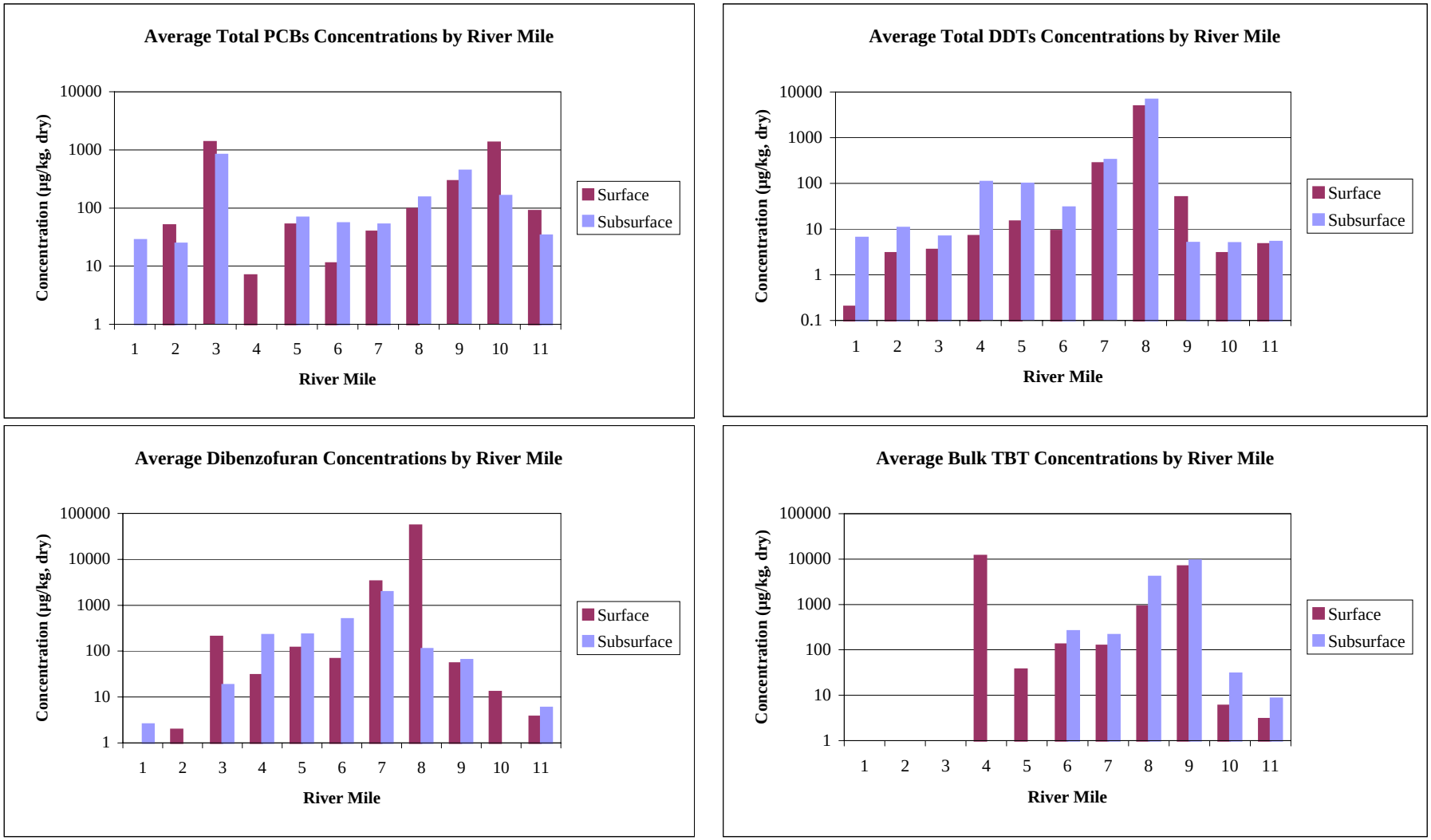
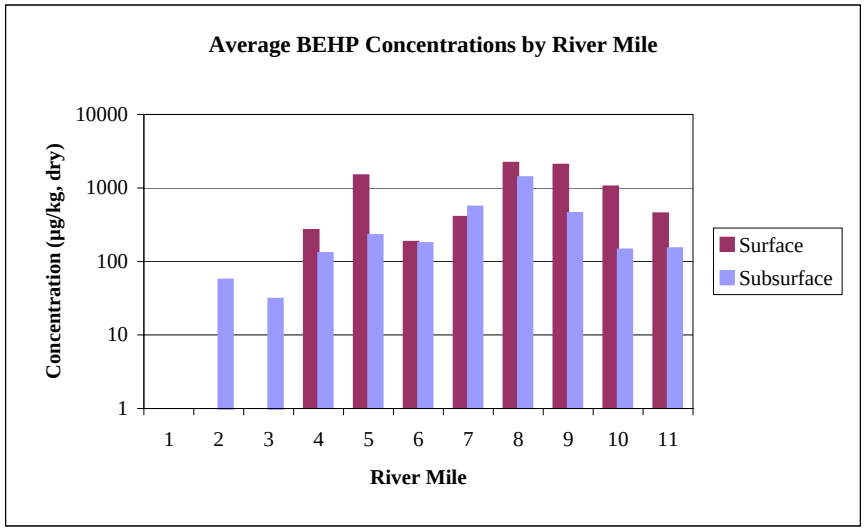
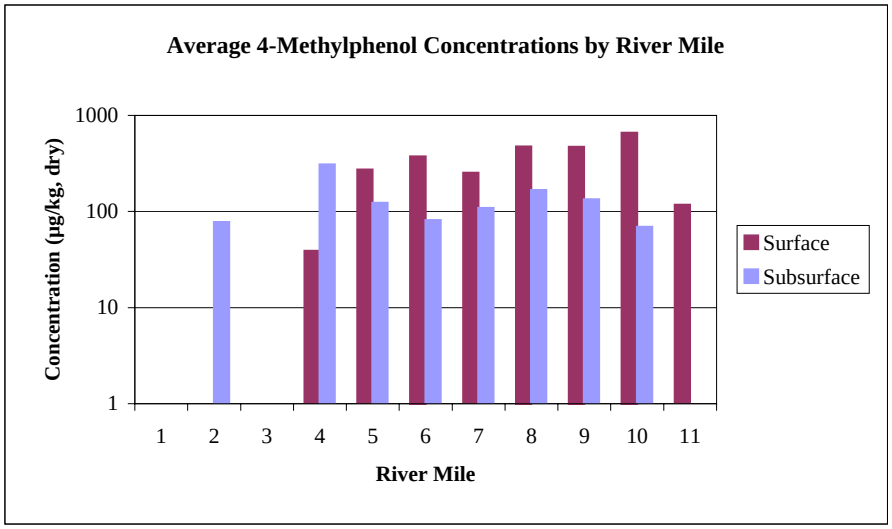
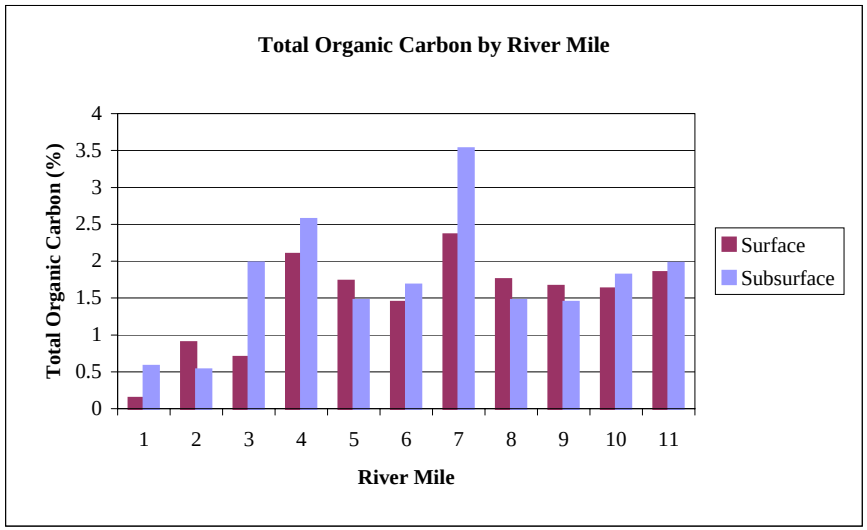


Figure 4-2c.
Portland Harbor RI/FS.
Comparison of Average Surface and Subsurface Chemical Concentrations Between RM 0 and RM 11.







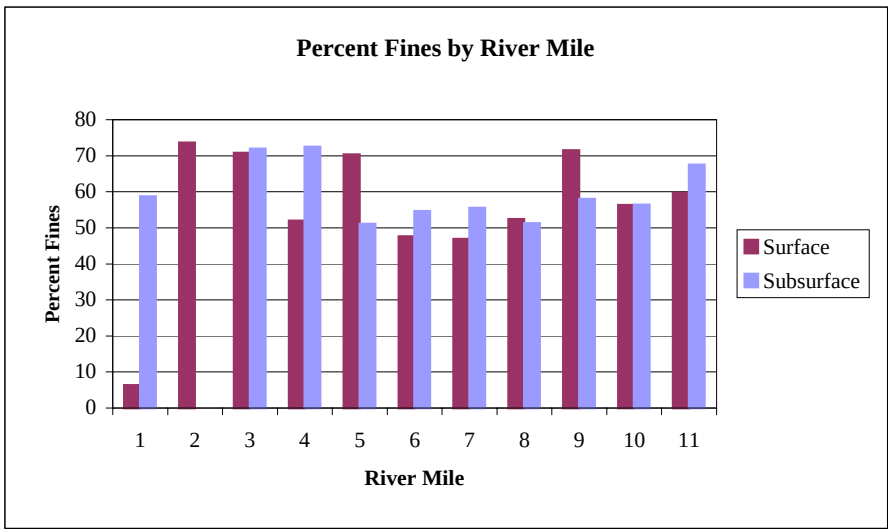
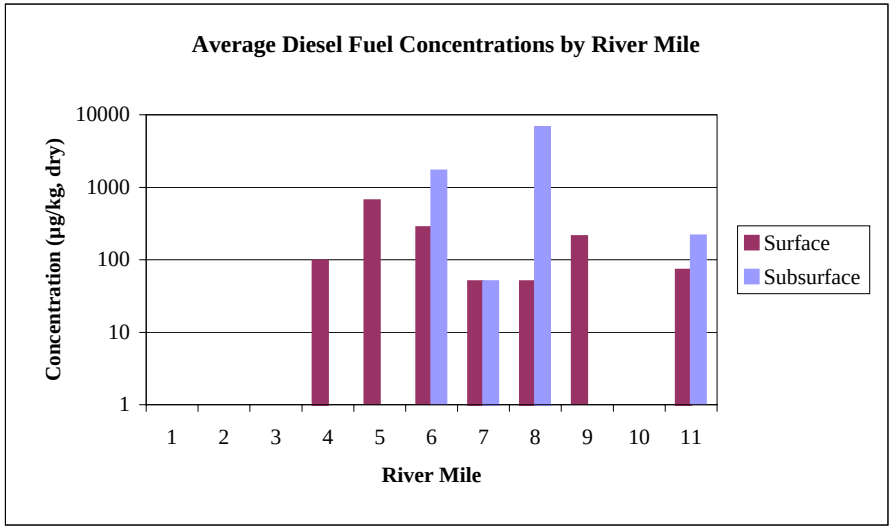
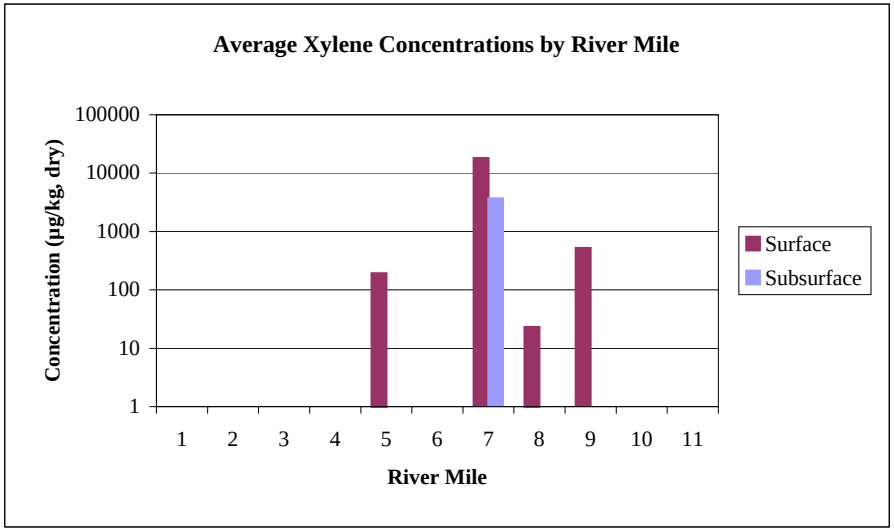


Figure 4-2d.
Portland Harbor RI/FS
Comparison of Average Surface and Subsurface Chemical Concentrations Between RM 0 and RM 11.





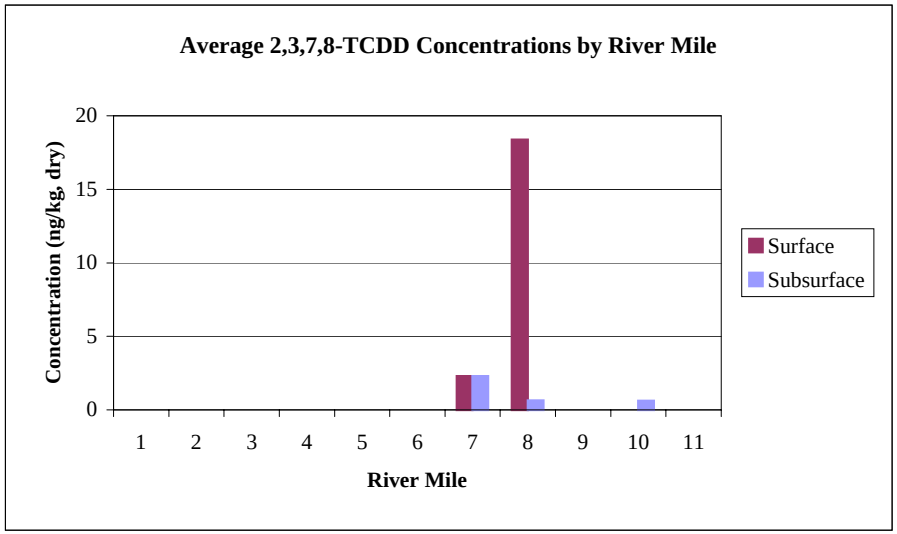


Figure 4-2e.
Portland Harbor RI/FS
Comparison of Average Surface and Subsurface Chemical Concentrations Between RM 0 and RM 11.

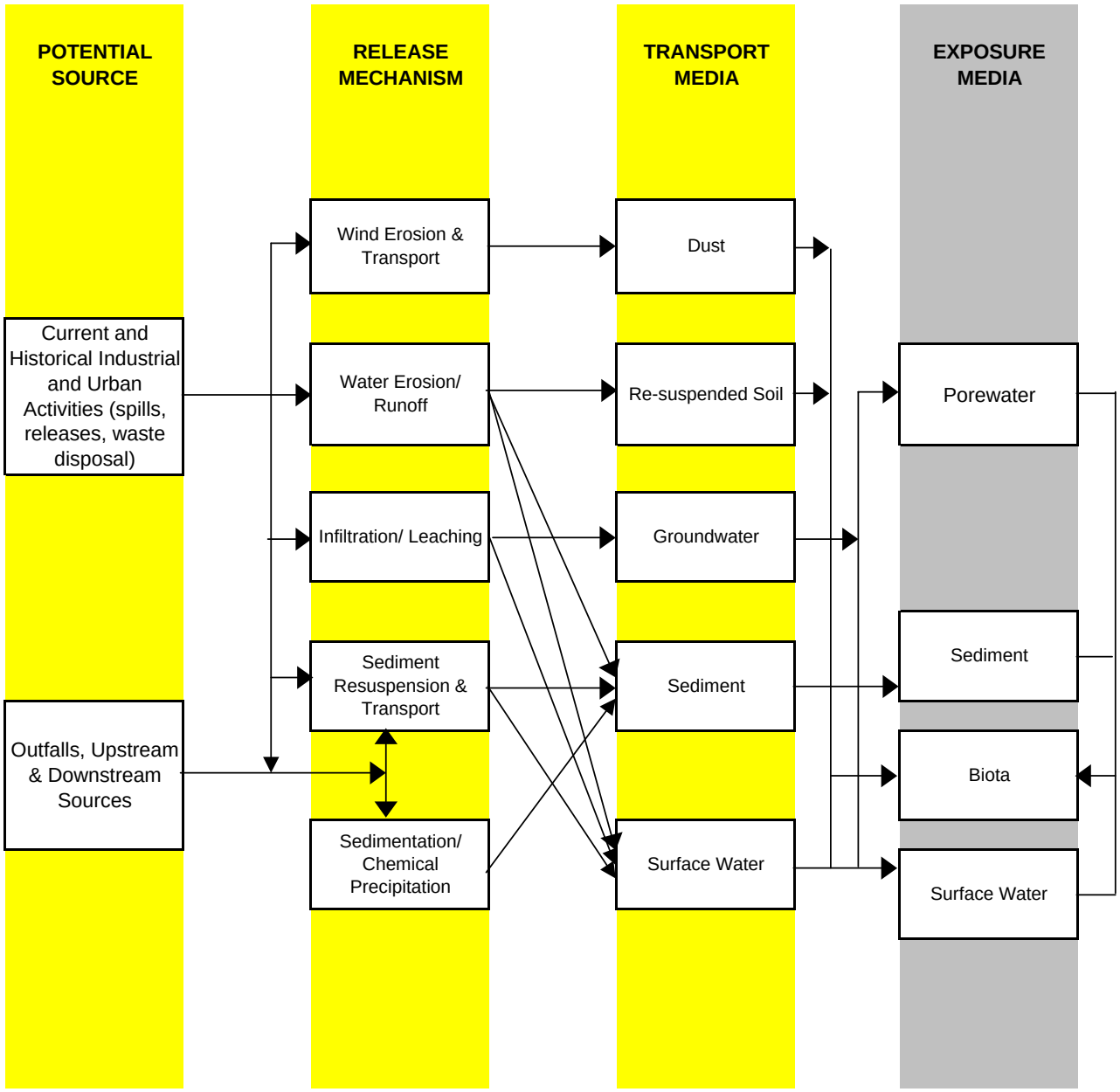


Figure 5-1
Portland Harbor RI/FS
Preliminary Physical Conceptual Site Model

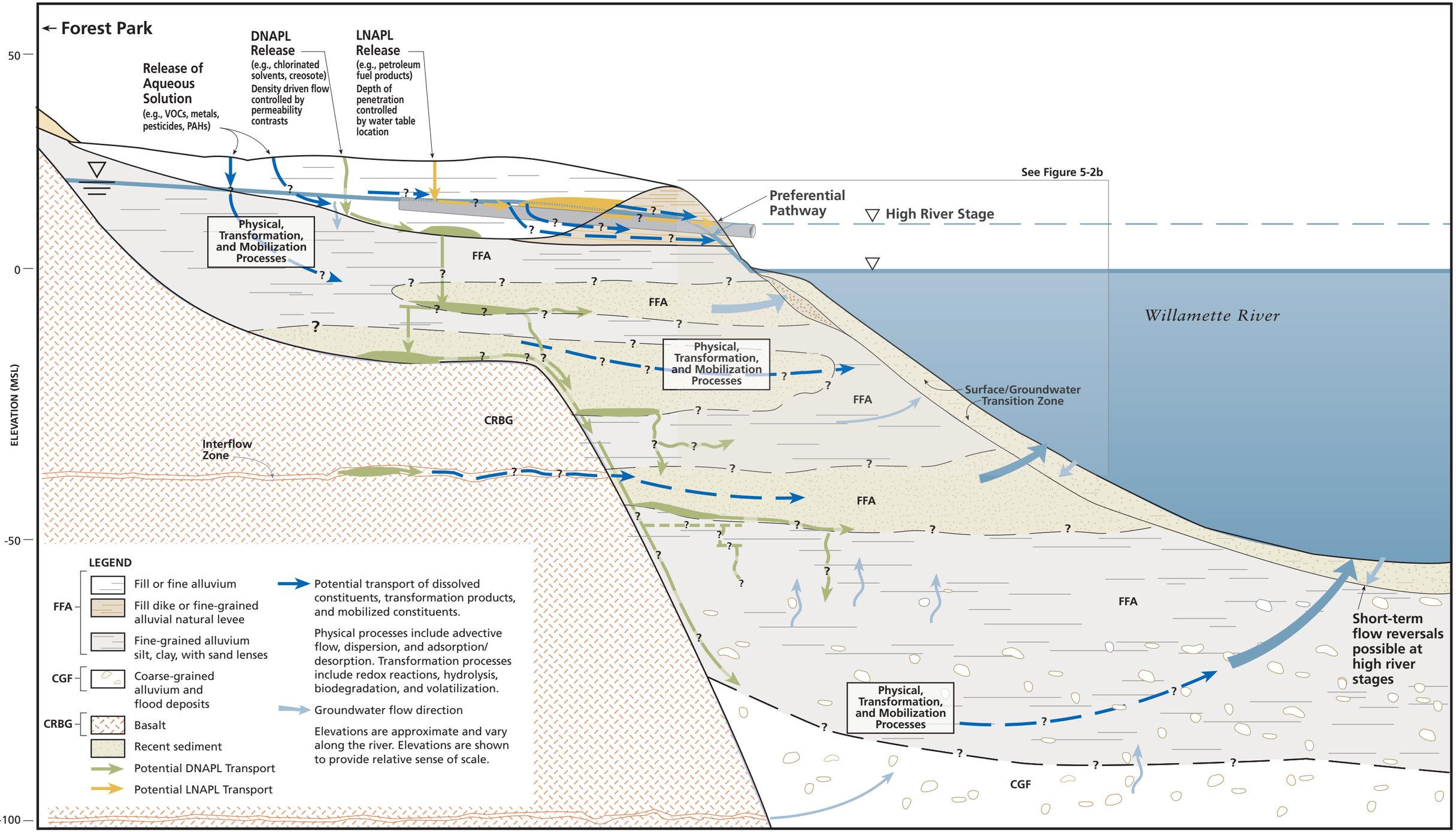
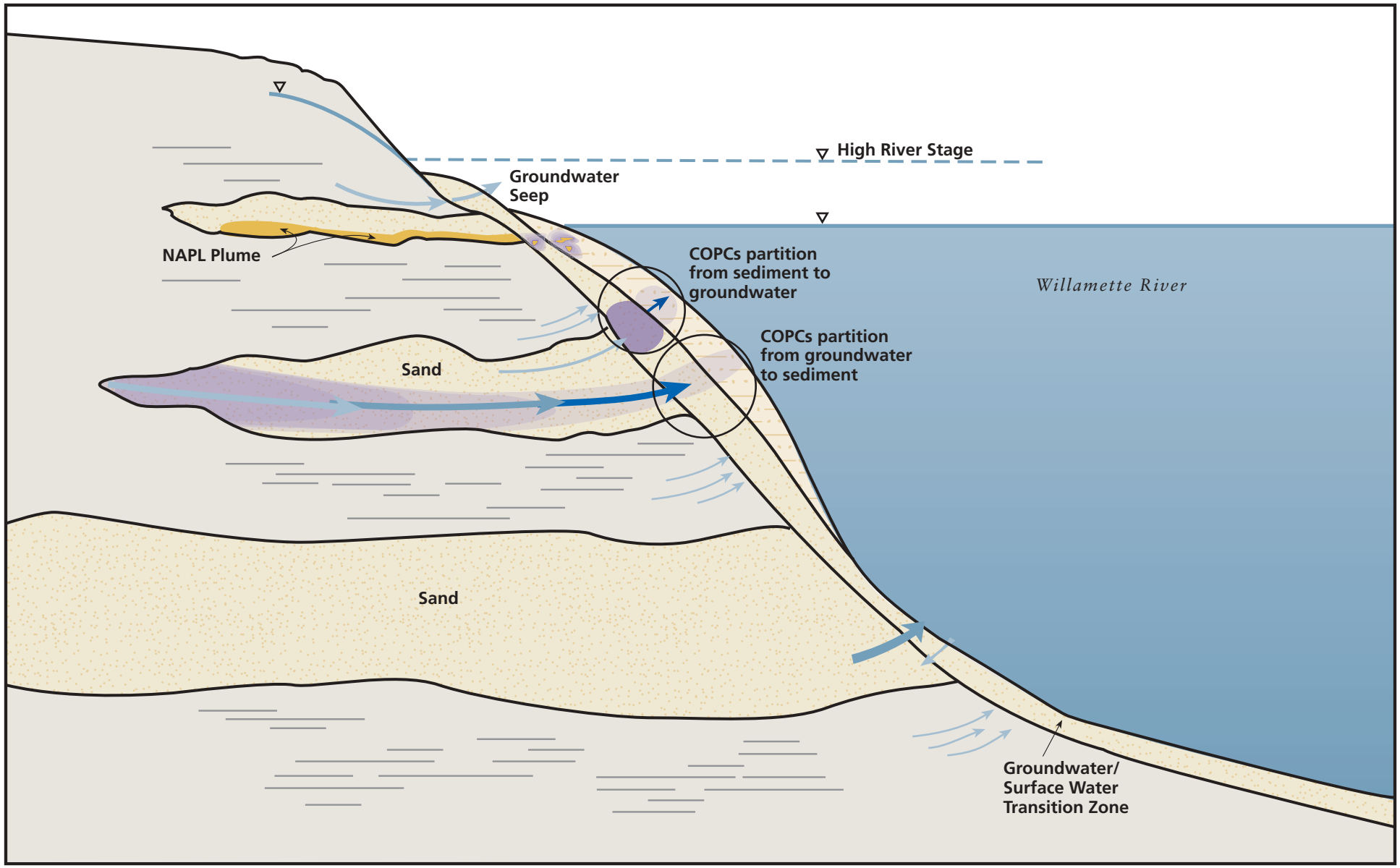


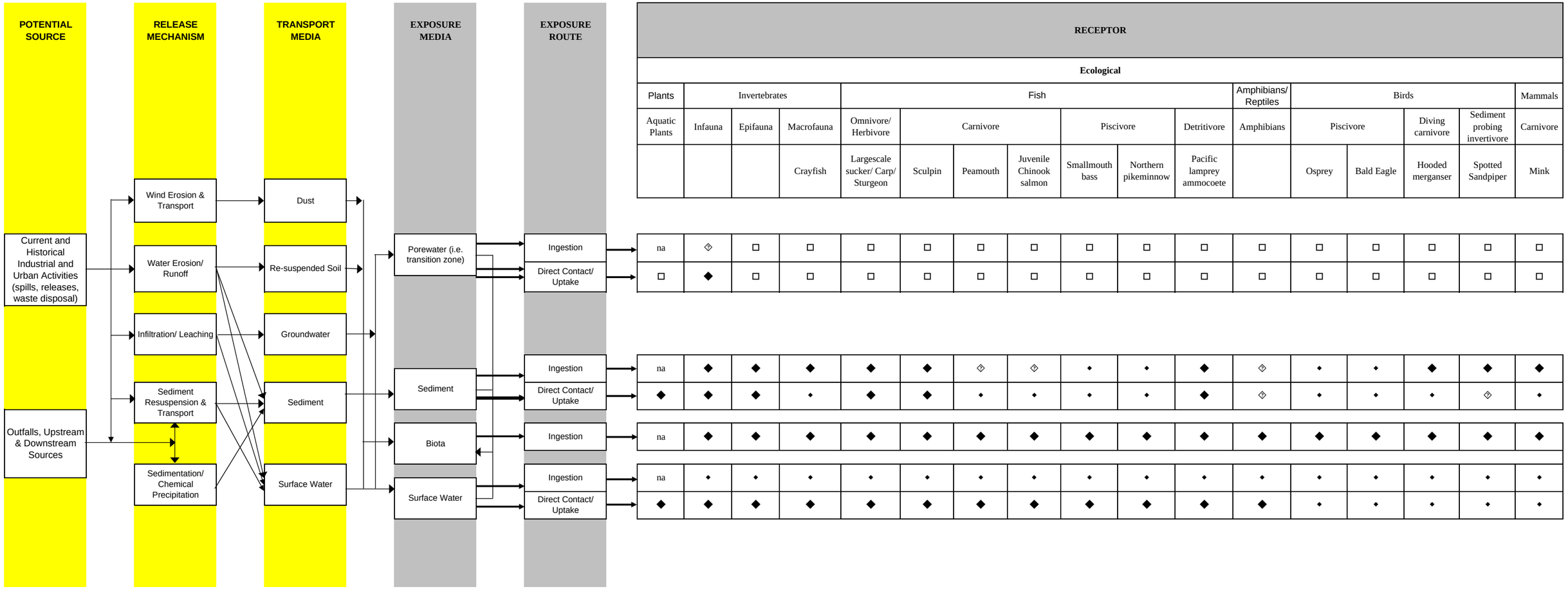
Figure 5-2a
Portland Harbor RI/FS
Conceptual Site Model — Groundwater



Potential transport of dissolved constituents, transformation products and mobilized constituents.

Groundwater flow direction

Figure 5-2b
Portland Harbor RI/FS
Conceptual Site Model — Groundwater, Detail



◆ Complete and major
⬥ Complete and minor
◈ Complete and uncertain
□ Incomplete
[na] not applicable

Figure 5-3
Portland Harbor RI/FS
Preliminary Ecological Conceptual Site Model

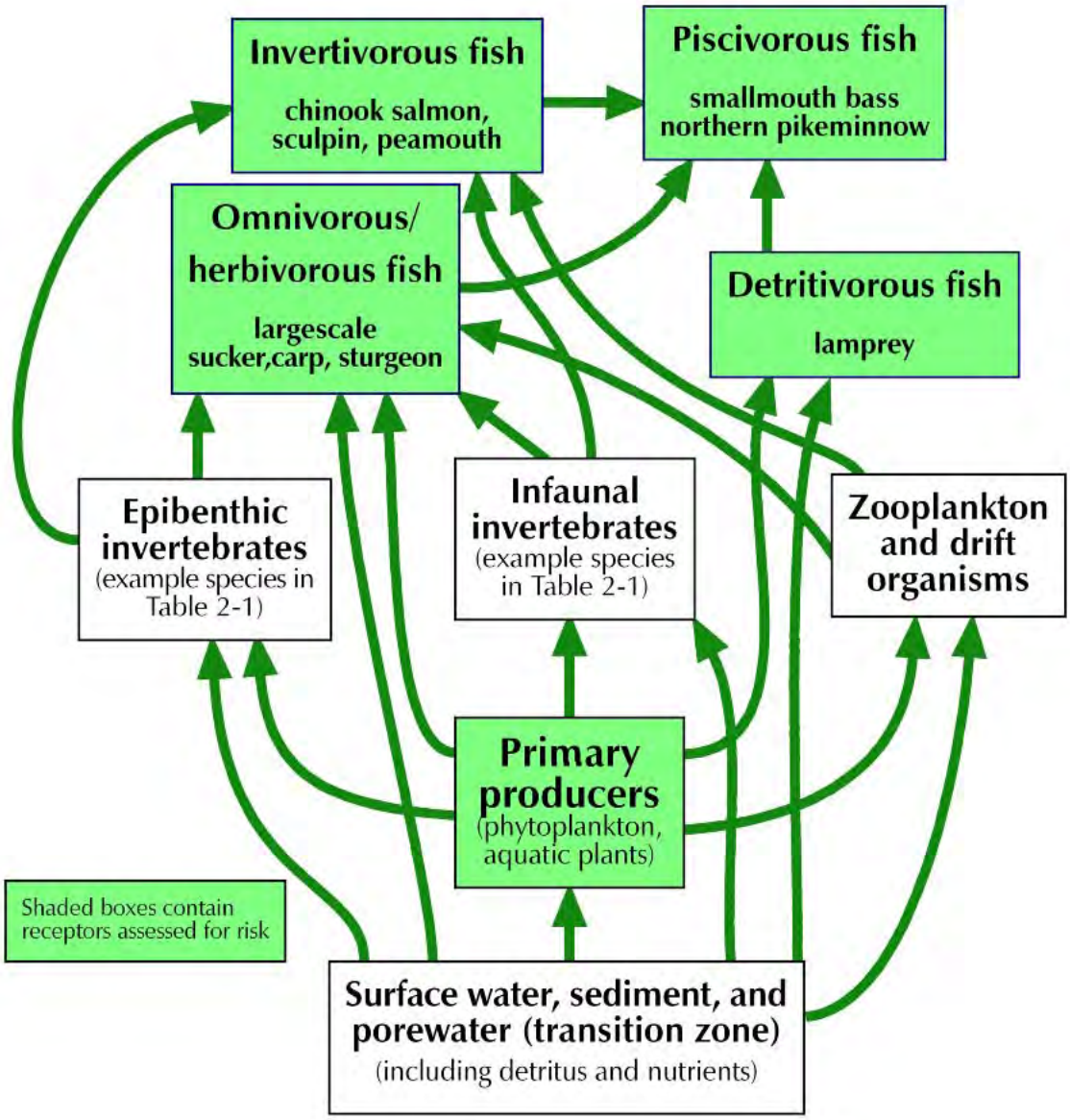


Figure 5-4
Portland Harbor RI/FS
Fish Food Web Model

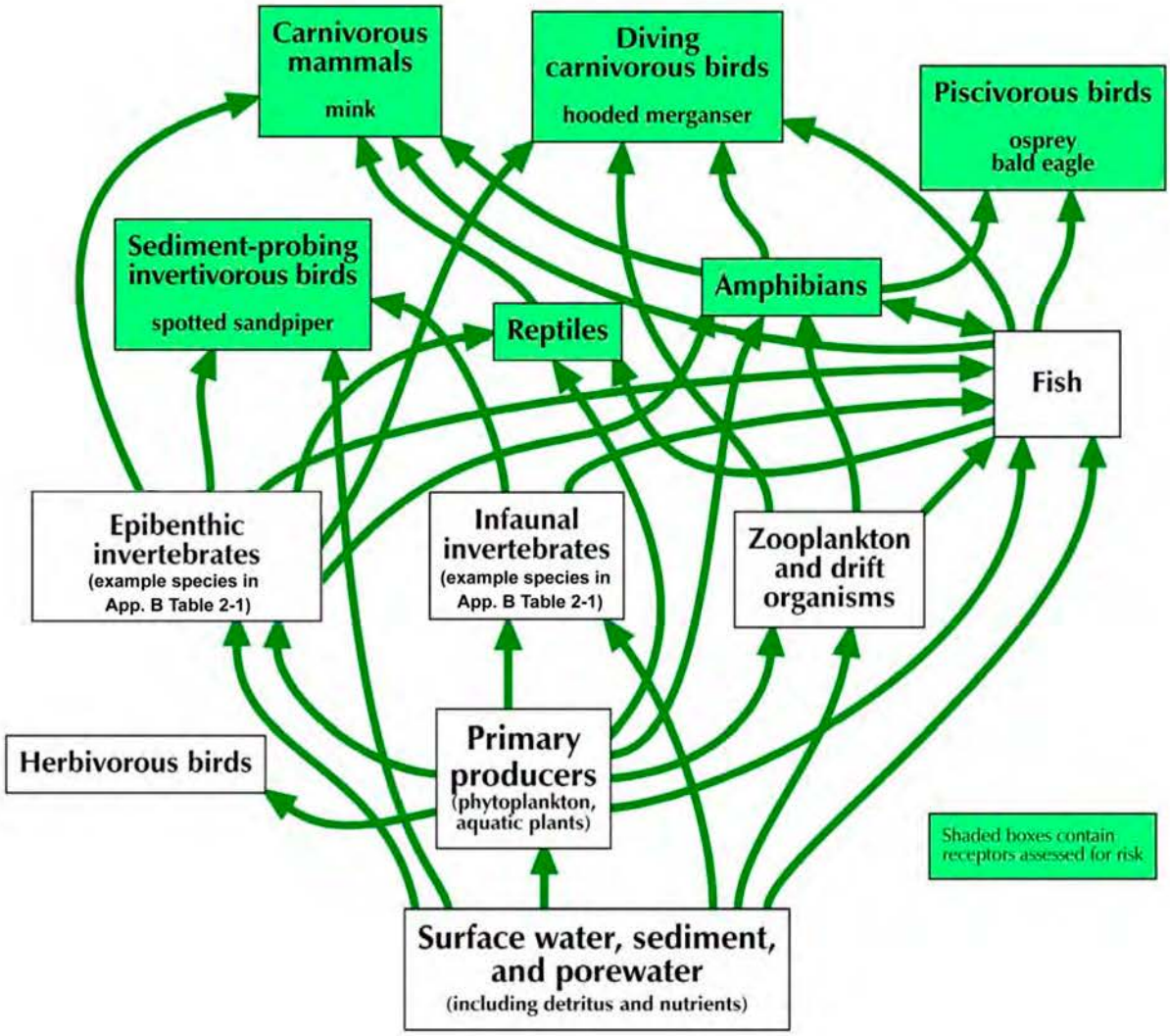
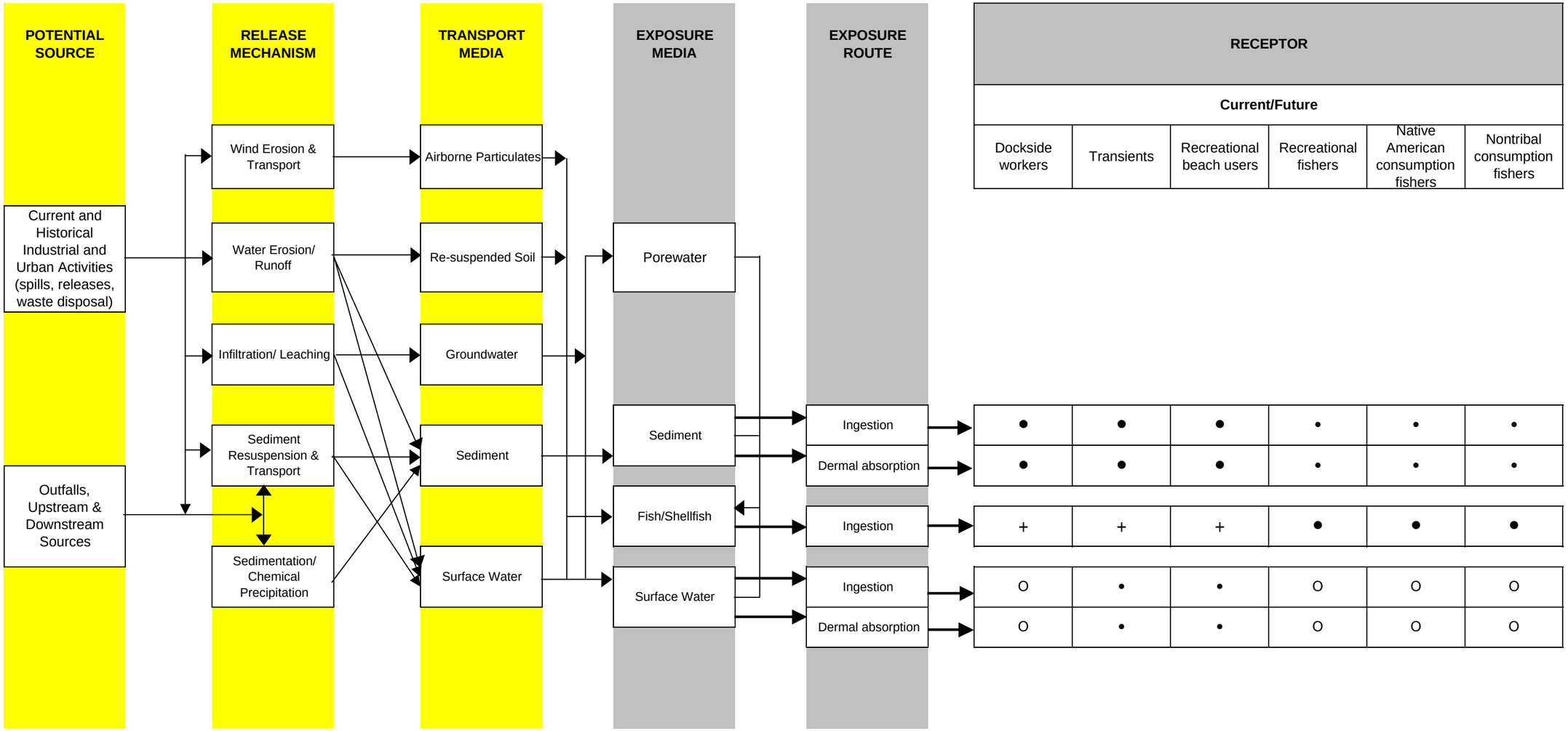


Figure 5-5
Portland Harbor RI/FS
Wildlife Food Web Model



● Potentially complete and significant pathway; quantitatively evaluated in the HHRA

• Potentially complete and significance unknown pathway; quantitatively evaluated in the HHRA to determine significance

O Potentially complete and insignificant pathway; not evaluated in the HHRA

\+ Potentially complete pathway, but not included for this receptor category; pathway evaluated under a different receptor category

Figure 5-6
Portland Harbor RI/FS
Preliminary Human Health Conceptual Site Model

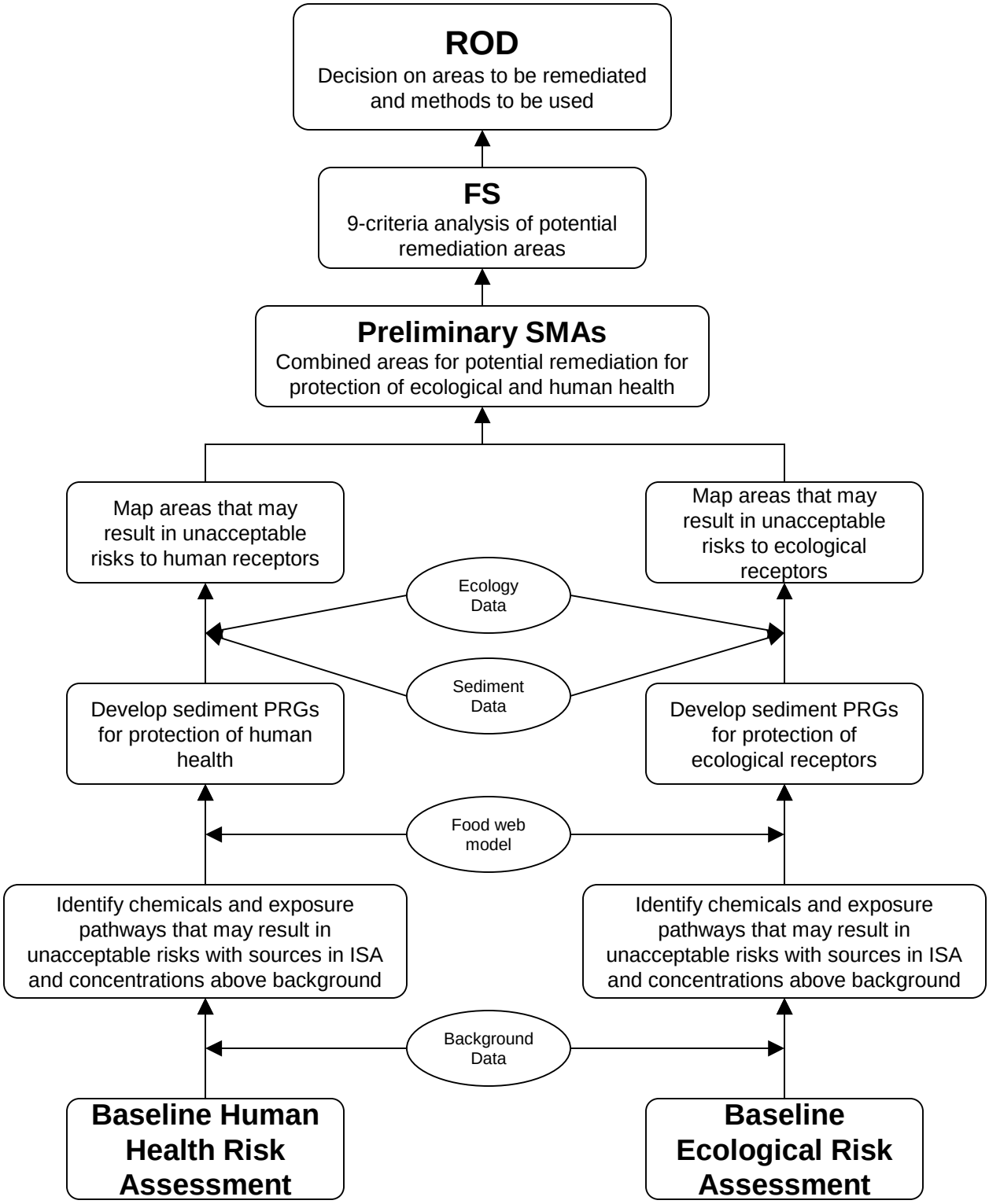
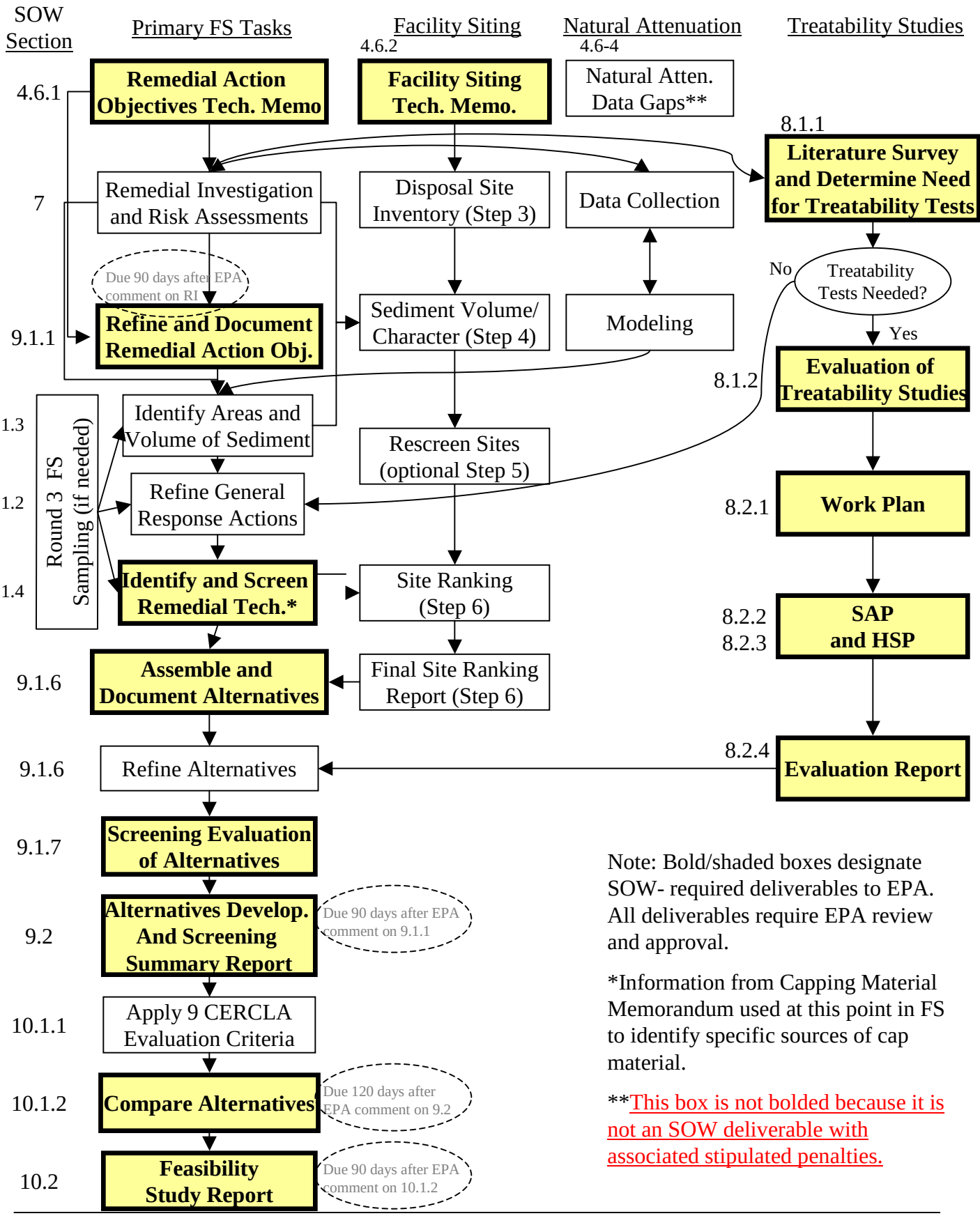


Figure 6-1
Portland Harbor RI/FS
Risk-based Approach to RI/FS



Note: Bold/shaded boxes designate SOW- required deliverables to EPA. All deliverables require EPA review and approval.

*Information from Capping Material Memorandum used at this point in FS to identify specific sources of cap material.

**This box is not bolded because it is not an SOW deliverable with associated stipulated penalties.

Figure 8-1. Portland Harbor RI/FS Flow Chart - Feasibility Study Tasks

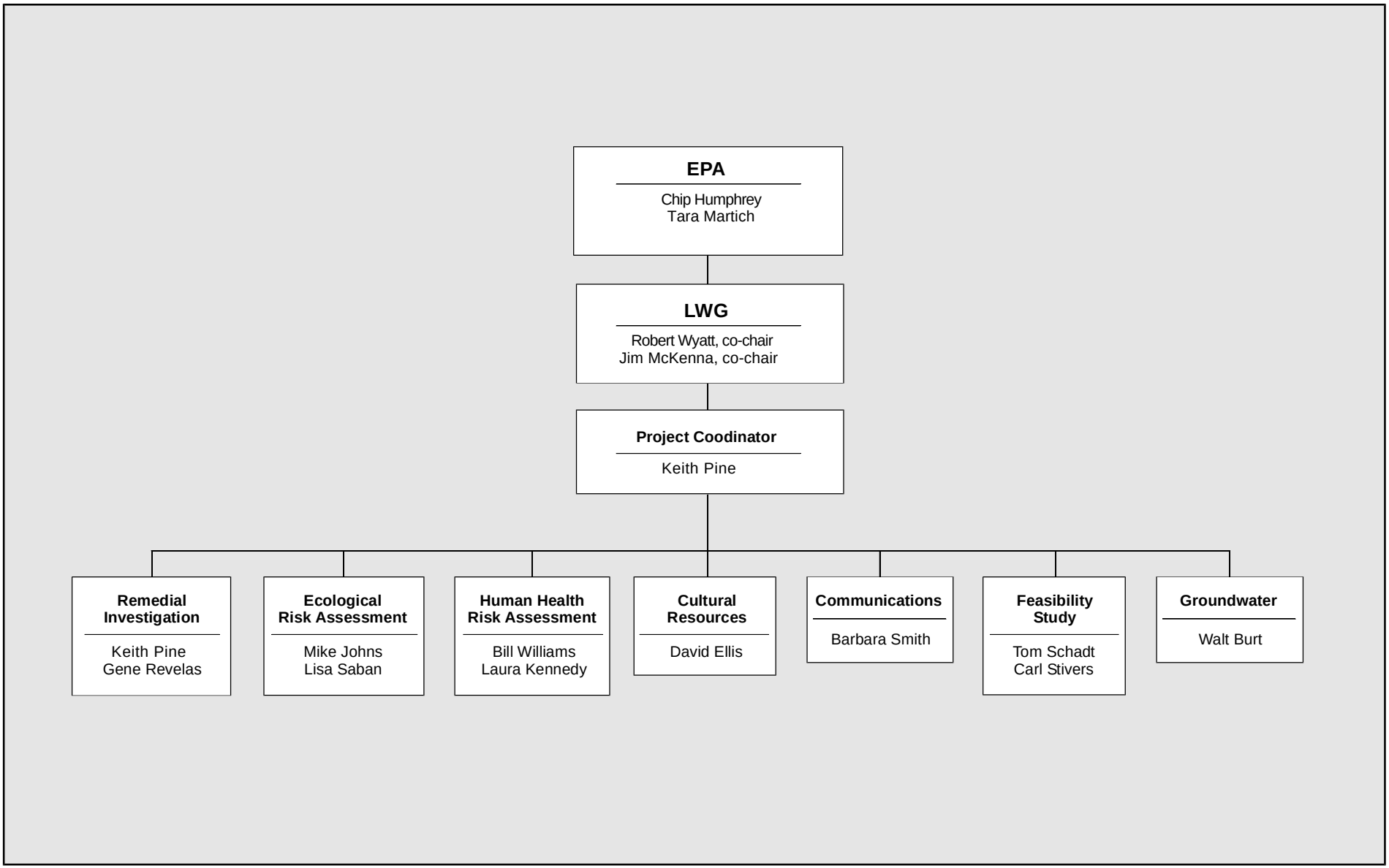


Figure 9-1.
Portland Harbor RI/FS
Project Organization Chart

Copy of the LWG Portland Harbor RI/FS Programmatic Work Plan Maps not included in this copy due to volume.

Table 1-1. Portland Harbor RI/FS Reports and Deliverables Provided to EPA through April 2004.

Deliverable Date	Deliverable
2001	
April 24, 2001	Combined Sampling and Analysis Plan/Quality Assurance Plan for the Lower Willamette River Sediment Profile Image Survey
July 2, 2001	Multibeam Bathymetric Survey of the Lower Willamette River Work Plan
November 20, 2001	Memorandum: Meeting with US EPA, ODEQ, and LWG on DEQ File Information
December 20, 2001	Technical Memorandum: Proposed Database Approach
December 20, 2001	Data Quality Objectives for Historical Data
December 21, 2001	LWG Shared Server Established
December 27, 2001	Site Visit Report / Narrated Video
2002	
January 25, 2002	Documentation of Risk Assessment Scoping Meeting December 19, 2001
February 4, 2002	Preliminary Planning, Scoping, and Problem Formulation Document
February 15, 2002	Technical Memorandum: Juvenile Salmonid Residence Time in Portland Harbor
February 2002	Capping Material Evaluation Technical Memorandum
March 2002	Disposal Facility Siting Technical Memorandum
April 1, 2002	Preliminary Analytical Concentration Goals for Target Analytes in Sediment, Tissue and Water Samples
April 10, 2002	Lower Willamette River Multibeam Bathymetric Survey Report – December 2001/January 2002
April 22, 2002	Round 1A Field Sampling Plan
April 26, 2002	Integration of Sediment Trend Analysis (STA®) Survey Results with Historic Bathymetry in the Lower Willamette River
April 26, 2002	Sediment Profile Image Survey of the Lower Willamette River
April 26, 2002	Historical Database
June 7, 2002	Draft Round 1 Portland Harbor RI/FS Work Plan
June 14, 2002	Round 1 Field Sampling Plan
June 14, 2002	Round 1 Health and Safety Plan
July 19, 2002	Fish Tissue Sampling Standard Operating Procedure (SOP) for Round 1A
August 8, 2002	Fish Tissue Compositing & Shipping SOP
August 8, 2002	Fish Tissue Homogenization & Shipping and Axys Homogenization SOPs
November 22, 2002	Round 1 Quality Assurance Project Plan. Final Report
2003	
February 18, 2003	Technical Memorandum: Results of Seep Reconnaissance Survey River Mile 2-10.5 Lower Willamette River
February 26, 2003	Lower Willamette River Summer 2002 Multibeam Bathymetric Survey Report
	Multiplate Report
	Plant and Amphibian Reconnaissance

Table 1-1. Portland Harbor RI/FS Reports and Deliverables Provided to EPA through April 2004.

Deliverable Date	Deliverable
	Adult Lamprey Survey
February 28, 2003	Summary of Round 1 Field Sampling Activities
March 6, 2003	2002 Sediment Stake Erosion/ Accretion Monitoring Report
March 14, 2003	Round 1 Field Sampling Report
March 31, 2003	Portland Harbor RI/FS Programmatic Work Plan - Revised
April 4, 2003	Technical Memorandum: Hydrodynamic/Sedimentation Modeling
	Technical Memorandum: Adult Lamprey Harvest
April 17, 2003	Round 2A Quality Assurance Project Plan Addendum - Draft
	Round 2A Field Sampling Plan - Draft
May 9, 2003	Technical Memorandum: Proposed Fish Consumption Rates
May 20, 2003	Technical Memorandum: Benthic Analysis Approach
May 29, 2003	Historical Chemistry Data Category Reclassification Technical Memorandum
June 2, 2003	Upland Groundwater Data Review Report
June 3, 2003	Round 1 Sediment Chemistry Data Validation Reports
	Round 1 Validated Sediment Data Technical Memorandum
August 1, 2003	Framework for Evaluating Exposure to the Benthic Community and Humans from Chemicals Transported in Groundwater
October 8, 2003	Lower Willamette River May 2003 Multibeam Bathymetric Survey Report
November 13, 2003	Portland Harbor RI/FS Programmatic Work Plan - Revised
December 22, 2003	Round 2 FSP/HSP/QAPP Addendum
2004	
February 23, 2004	Technical Memorandum: Hydrodynamic/Sedimentation Modeling - Revised
February 24, 2004	Draft Beach Sampling FSP
March 1, 2004	Sediment Stake Erosion/Accretion Monitoring Report, July 2002 - January 2004
March 31, 2004	Draft Natural Attenuation Technical Memorandum - Step 1 Evaluation and Step 2 FSP and Data Evaluation Methods
March 22, 2004	Round 2 FSP Sediment Sampling and Benthic Toxicity Testing
April 2, 2004	Round 2A FSP Surface Water Sampling
April 12, 2004	Round 2 Quality Assurance Project Plan
April 22, 2004	April 2002 LWR ADCP Survey Results
April 22, 2004	May 2003 LWR ADCP Survey Results

Table 2-1. Portland Harbor Vertical Datum Conversion Table.

River Mile	NAVD88 Elev.	NGVD29/47 Elev.	CRD Elev.
0.4	10.0’	6.8’	5.4’
	0.0'	-3.2'	-4.6'
	-10.0'	-13.2'	-14.6'
1.3	10.0’	6.8’	5.4’
	0.0'	-3.2'	-4.7'
	-10.0'	-13.2'	-14.7'
5	10.0’	6.7’	4.9’
	0.0'	-3.3'	-5.1'
	-10.0'	-13.3'	-15.1'
9.8	10.0’	6.5’	4.7’
	0.0'	-3.5'	-5.3'
	-10.0'	-13.5'	-15.3'
12.8	10.0’	6.5’	4.6’
	0.0'	-3.5'	-5.4'
	-10.0'	-13.5'	-15.4
15.6	10.0’	6.5’	4.6’
	0.0'	-3.5'	-5.4'
	-10.0'	-13.5	-15.4'

Table 2-2. Willamette Basin Reservoir Summary.

Dam	Total Storage ac-ft	Summer Storage ac-ft	Year Completed	Power Generators	River	Comments
Fern Ridge	116,800	93,900	1941	none	Long Tom	High recreational, not drafted for low flow
Cottage Grove	32,900	28,700	1942	none	Coast Fork Willamette	Usually not drafted for low flow
Big Cliff	N/A	N/A	1953	1	North Santiam	Re-regulation dam for Detroit, limited recreation
Detroit	455,100	281,600	1953	2	North Santiam	Rarely drafted for low-flow augmentation
Dorena	77,600	65,000	1949	none	Row	Usually not drafted for low flow
Hills Creek	355,500	194,600	1961	1	Middle Fork Willamette	Drafted for low flow
Foster	60,700	24,800	1968	2	South Santiam	Rarely drafted for low-flow augmentation
Green Peter	428,100	249,900	1968	2	Middle Santiam	Drafted for low-flow augmentation, recreational use
Lookout Point	455,800	324,200	1954	3	Middle Fork Willamette	Drafted for low-flow augmentation, limited recreational use
Dexter	N/A	N/A	1954	1	Middle Fork Willamette	Re-regulation dam for Lookout Point, some recreation
Blue River	89,500	78,800	1969	3	Blue River	Drafted for low-flow augmentation, recreational use
Cougar	219,000	143,900	1964	2	South Fork McKenzie	Drafted for low-flow augmentation, recreational use
Fall Creek	125,000	108,200	1966	none	Fall Creek	High recreational use

Source: U.S. Army Corps of Engineers, Portland District

Table 2-3. Summary of ADCP Transect Time, Location, and Approximate Total Flow[1].

Transect	ADCP File	River Mile	Time (UTC)	Water Level CRD (Morrison Street Gauge)	Flow (ft^3/s)	Location Description
1	A109018R.000	1	1:13	10.87	35405	Columbia Slough
2	A109017R.000	2	1:05	10.9	34727	
3	A109016R.000	2.5	0:48	10.92	34886	
4	A109000R.000	3.1	18:50	11.47	69170	Multnohmah Channel
5	A109015R.000	4	0:42	10.92	67098	
6	A109001R.000	4.6	19:23	11.41	70928	Into Terminal 4 Slip 3
7	A109012R.000	5.8	23:57	10.99	66452	St. John's Bridge
8	A109010R.000	6.3	23:37	11.05	71113	Off Gasco
9	A109002R.000	6.8	20:11	11.18	71356	Into Willamette Cove
10	A109009R.000	7.8	23:00	11.1	67447	Off Willbridge Terminal
11	A109005R.000	8	21:14	11.27	68181	Downstream of PSY
12	A109003R.000		~20:45	11.31	-479	Swan Island Lagoon (mouth)
13	A109004R.000		21:00	11.29	183	Swan Island Lagoon (upper end)
14	A109008R.000	9.6	22:34	11.16	65452	Across deep hole in channel
15	A109007R.000	10	22:22	11.18	67643	
16	A109006R.000	11	22:04	11.19	69461	

[1] The ADCP survey was conducted by David Evans & Associates, Inc. during a high water event on April 19, 2002 (DEA 2002b).

Table 2-4. The Major Benthic Zones in the LWR based on the Results of the December 2001 Sediment-Profile Survey (SEA 2002b) and River Channel Morphology (DEA 2002a).

Zones	Regime	Description
RM 15.7-11.0 (Chute)	Erosional	This segment of river has the smallest cross-sectional areas and lacks large meanders to slow flow. It has low prism penetration depths and coarse-grained sediment is resistant to sediment transport. Apparent RPDs (surface biogenically mixed layers) are thinly developed.
RM 11.0 to 9.7 (Transition Zone)	Transitional	This relatively small stretch of the river represents the transition from the dynamic Upper Willamette River to the Portland Harbor segment. The river widens and cross-sectional areas increase and as a result flow velocities decrease.
RM 9.7 to 7.0 (Deposition Zone 1)	Depositional	As the river widens and cross-sectional areas increase, the river flow velocities decrease and the ability of the river to entrain and transport sediment decreases resulting in the deposition of bedload sediment and possibly sediments in suspension. Bottom sediments are organic, methanogenic silts with deep apparent RPDs that have been thickened by deposition of oxidized fine-grained sediment.
RM 7.0 to 5.1 (Transport Zone)	Static or Erosional	The narrowing river channel creates higher flow velocities in this segment of river. Consequently, the sediments in this segment are coarser grained and show evidence of fine-grained sediment being winnowed from the sediment-water interface. This zone also exhibits some localized depositional areas within the main body of the channel, potentially related to small scale bottom topographic features.
RM 5.1 to 3.0 (Deposition Zone 2)	Depositional	Sediment that passed through the more dynamic RM 7.0 to 5.1 may be deposited in this segment as the flow velocities decrease, associated with river widening. Riverbed sediment is composed primarily of silts with deep, depositional, apparent RPDs. Methane is present in the reach, but it is less widespread than upstream in Deposition Zone 1.
RM 3.0 to 1.1 (Deposition Zone 3)	Depositional	This zone is similar to Depositional Zone 2 in apparent flow regime, sediment type, and benthic community structure. In part, Deposition Zone 3 is separated from Depositional Zone 2 for site assessment purposes (the lower ISA boundary is RM 3.5) and because the Multnomah Channel enters the Willamette at the boundary of these zones (RM 3) and likely influences water and possibly sediment movement up and downstream of this point.
RM 1.1 to 0.0 (Columbia River Zone)	Static or Erosional	RM 1.1 to 0 segment is dominated by fine sands and silts. The fine sandy substrate is related to both the decreased river cross-sectional area and influence from the Columbia River, which modifies the Willamette River bottom and the biological community (e.g., tube-dwelling amphipods are seen only in this portion of the river).
Nearshore Zone (RM 15.7 to 0.0 at depths less than 20 feet CRD)	Mixed Case	At river margins in general, the ratio of river bottom to flow volume increases, with frictional drag lessening flow velocities. Sediments in many areas appear to episodically deposited or eroded (based on stratigraphic layering). Some nearshore areas appea to be modified by non-flow related physical processes (e.g., wind-generated waves) and/or anthropogenic disturbance factors (e.g., prop-wash, nearshore construction).

Table 2-5a. Evaluation of Bathymetric Change in Nearshore (< 20' CRD) Areas based on 1-square-meter Cell Counts.

Bathymetric Change	**River Mile**																
	0-1	**1-2**	**2-3**	**3-4**	**4-5**	**5-6**	**6-7**	**7-8**	**8-9**	**9-10**	**10-11**	**11-12**	**12-13**	**13-14**	**14-15.7**	**Totals**	
No Change (# of cells)																	
+/- 0.25'	12587	32390	54484	59375	20211	20540	43650	32609	64180	87220	10824	10511	2469	78558	164697	694,305	
Shoaling (# of cells)																	% shoaling (cumulative)
-0.5 - -0.25	3871	3970	2929	7661	5131	4648	8221	7529	10564	14318	5623	2697	662	8580	24290	110,694	42.19
-1 - -0.5	4067	2979	2456	6922	7769	4502	4906	6673	8774	8356	6453	2965	678	3824	14877	86,201	75.04
-2 - -1	2049	488	962	3802	8713	2140	2217	5932	6851	3392	4494	861	805	920	3717	47,343	93.08
-3 - -2	75	18	332	762	2487	316	493	1542	1769	704	1104	204	231	158	313	10,508	97.09
-4 - -3	3	1	58	226	1347	147	189	423	424	239	307	100	62	51	57	3,634	98.47
-5 - -4	0	1	5	79	804	53	105	142	145	87	220	69	24	17	3	1,754	99.14
-6 - -5	1	0	0	45	398	9	25	56	47	46	160	24	20	4	11	846	99.46
-7 - -6	0	1	1	34	388	3	3	41	31	23	113	3	9	2	9	661	99.71
-8 - -7	1	0	0	19	163	3	0	25	19	4	81	4	4	0	16	339	99.84
-9 - -8	0	0	1	23	67	0	2	8	17	2	67	3	3	0	6	199	99.92
-10 - -9	0	0	0	24	6	2	0	7	16	0	39	2	4	0	2	102	99.96
-30 - -10	0	0	0	61	4	5	0	6	23	3	3	0	3	1	3	112	100.00
-55 - -30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100.00
Total cells shoaling	10067	7458	6744	19658	27277	11828	16161	22384	28680	27174	18664	6932	2505	13557	43304	262,393	
Deepening (# of cells)																	% deepening (cumulative)
0.5-0.25	7887	24221	49959	36267	5470	7599	14689	17601	16901	27326	3524	10514	1915	26937	52622	303,432	46.91
0.5-1	19808	12119	17244	14227	7524	8061	10358	12470	11433	13485	3388	7470	5748	12162	39041	194,538	76.98
1-2	11482	5685	7978	5167	7172	5326	4803	3356	5281	6863	2833	4029	7858	6647	23617	108,097	93.69
2 - 3	3376	1726	812	1465	1305	1048	1055	831	1808	1949	1047	1258	2598	1276	4312	25,866	97.69
3 - 4	1643	776	393	433	359	270	231	266	498	418	227	438	1100	353	1121	8,526	99.01
4 - 5	537	339	127	123	119	77	57	49	217	43	94	151	641	106	321	3,001	99.47
5 - 6	169	176	43	61	48	29	4	19	95	18	43	70	388	24	117	1,304	99.67
6 - 7	49	69	15	32	47	6	2	7	62	0	11	43	273	9	90	715	99.78
7 - 8	15	40	13	19	23	8	0	0	33	0	6	18	131	12	119	437	99.85
8 - 9	5	28	12	16	23	2	3	2	21	0	2	6	62	8	176	366	99.91
9 - 10	5	26	6	10	11	5	0	0	15	0	0	5	16	4	131	234	99.94
10-45	4	29	0	27	42	25	14	0	50	0	0	9	32	26	108	366	100.00
Total cells deepening	44980	45234	76602	57847	22143	22456	31216	34601	36414	50102	11175	24011	20762	47564	121775	646,882	
TOTAL CELLS	67634	85082	137830	136880	69631	54824	91027	89594	129274	164496	40663	41454	25736	139679	329776	1,603,580	

Percentages	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	12-13	13-14	14-15.7	
No change	19%	38%	40%	43%	29%	37%	48%	36%	50%	53%	27%	25%	10%	56%	50%	43.3%
Shoaling	15%	9%	5%	14%	39%	22%	18%	25%	22%	17%	46%	17%	10%	10%	13%	16.4%
Deepening	67%	53%	56%	42%	32%	41%	34%	39%	28%	30%	27%	58%	81%	34%	37%	40.3%

Total Shoaling, Deepening (> +/- 1ft)/Total cells: 13.4%
Total Nearshore Area with Shoaling, Deepening (> +/- 1ft): 214,410 square meters

Table 2-5b. Evaluation of Bathymetric Change in Channel (> 20' CRD) Areas based on 1-square-meter Cell Counts.

Bathymetric Change	**River Mile**																
	0-1	**1-2**	**2-3**	**3-4**	**4-5**	**5-6**	**6-7**	**7-8**	**8-9**	**9-10**	**10-11**	**11-12**	**12-13**	**13-14**	**14-15.7**	**Totals**	
No Change (# of cells)																	
+/- 0.25'	349841	368620	445942	564581	555357	296804	356247	622603	865419	399479	355772	209970	229735	286754	294186	6,201,310	
																	% shoaling
Shoaling (# of cells)																	(cumulative)
-0.5 - -0.25	52529	111435	52141	24510	53768	19958	22585	35391	79310	98041	32439	29464	23874	21135	50335	706,915	64.61
-1 - -0.5	18109	23359	10375	9738	33285	11212	11848	13742	27735	31432	16137	13324	11524	7334	39634	278,788	90.10
-2 - -1	4902	1056	1661	2972	6868	4027	3633	4153	12343	11849	5672	6675	4259	2159	16467	88,696	98.20
-3 - -2	336	190	276	126	1061	699	491	193	2340	1529	777	2228	797	513	2007	13,563	99.44
-4 - -3	16	17	130	62	388	284	60	24	615	241	262	619	244	194	200	3,356	99.75
-5 - -4	2	1	41	39	148	81	14	5	194	45	172	79	120	110	28	1,079	99.85
-6 - -5	1	2	34	16	59	6	5	3	48	16	131	34	76	47	12	490	99.89
-7 - -6	0	0	51	18	43	1	1	2	28	1	153	29	45	26	9	407	99.93
-8 - -7	0	3	37	7	26	0	0	2	8	1	196	21	24	18	8	351	99.96
-9 - -8	0	1	4	2	16	0	2	0	3	0	180	20	12	9	7	256	99.98
-10 - -9	0	0	0	3	9	0	1	0	2	0	10	15	11	11	2	64	99.99
-30 - -10	0	5	0	2	13	0	1	4	1	0	0	49	1	22	5	103	100.00
-55 - -30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100.00
Total cells shoaling	75895	136069	64750	37495	95684	36268	38641	53519	122627	143155	56129	52557	40987	31578	108714	1,094,068	
																	% deepening
Deepening (# of cells)																	(cumulative)
0.5-0.25	36073	83466	151562	88251	89875	142140	122040	149565	76964	78010	87573	109063	97349	72778	81995	1,466,704	69.11
0.5-1	36759	36982	47815	24602	25576	48992	31534	31167	23287	12560	15880	30739	57520	19609	58823	501,845	92.75
1-2	8659	5561	8875	3282	6112	6191	3749	5413	4831	3771	7963	9140	17782	3735	23578	118,642	98.34
2 - 3	1373	469	479	529	962	221	762	1748	966	1418	2951	2767	2349	569	1646	19,209	99.25
3 - 4	493	159	78	80	189	61	317	907	215	1224	1219	456	996	239	142	6,775	99.57
4 - 5	312	101	75	31	112	17	102	787	47	365	210	238	431	128	75	3,031	99.71
5 - 6	340	80	53	16	74	1	65	531	12	1	22	264	149	59	141	1,808	99.80
6 - 7	239	77	28	18	62	0	46	508	6	0	12	122	99	38	305	1,560	99.87
7 - 8	81	31	16	3	36	0	47	415	2	0	4	103	62	22	117	939	99.91
8 - 9	0	22	18	0	25	0	42	318	3	0	0	106	61	25	2	622	99.94
9 - 10	0	4	12	1	20	0	46	134	11	0	0	68	52	17	1	366	99.96
10-45	1	0	8	2	51	0	196	36	20		0	65	408	64	5	856	100.00
Total cells deepening	84330	126952	209019	116815	123094	197623	158946	191529	106364	97349	115834	153131	177258	97283	166830	2,122,357	
TOTAL CELLS	510066	631641	719711	718891	774135	530695	553834	867651	1094410	639983	527735	415658	447980	415615	569730	9,417,735	

Percentages	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	12-13	13-14	14-15.7	
No change	69%	58%	62%	79%	72%	56%	64%	72%	79%	62%	67%	51%	51%	69%	52%	65.8%
Shoaling	15%	22%	9%	5%	12%	7%	7%	6%	11%	22%	11%	13%	9%	8%	19%	11.6%
Deepening	17%	20%	29%	16%	16%	37%	29%	22%	10%	15%	22%	37%	40%	23%	29%	22.5%

Total Shoaling, Deepening (> +/- 1ft)/Total cells: 2.8%

Total Channel Area with Shoaling, Deepening (> +/- 1ft): 262,173 square meters

Table 2-6. Federal and Port of Portland LWR Dredging Projects (1980-2001).

Description	Fiscal Year Dredged	Dredge Location			Purpose	Quantity (Cubic Yards)
		River Mile or Channel Station Positioning	Terminal	Berth		
POP Willamette River Dredging	1980	1	5	501	Maintenance	1,200
POP Willamette River Dredging	1980	10	2	205,206	Maintenance	30,000
POP Willamette River Dredging	1980	11	1	101,102,105,106	Maintenance	5,700
POP Willamette River Dredging	1981	8	PSY	DD 3	Maintenance	7,000
POP Willamette River Dredging	1981	10		Ports 'o Call	Borrow-fill	176,000
POP Willamette River Dredging	1982	1.5	5	503	Construction	30,000
POP Willamette River Dredging	1982	9+50+00 to 10+00+30		Entrance to Lagoon	Borrow-fill	631,000
POP Willamette River Dredging	1983	10	2	205,206	Maintenance	11,000
POP Willamette River Dredging	1984	4.5	4	410,411	Maintenance	5,000
POP Willamette River Dredging	1984	10	2	205,206	Maintenance	4,500
FY 84 Corps Manhattan Island (Hopper	1984	8 to 10			Maintenance	517,073
POP Willamette River Dredging	1985	9	PSY	315	Maintenance	153,416
POP Willamette River Dredging	1985	10	PSY	301,302,303,304,305	Maintenance	23,667
POP Willamette River Dredging	1985	10	2	203,204,205	Construction	237,000
POP Willamette River Dredging	1985	10		203,204,205	Borrow-fill	1,285,000
FY 85 Corps D.B. Seattle	1985	9+05 to 10+10			Maintenance	890,171
POP Willamette River Dredging	1986	8.5	PSY	306,307,308	Maintenance	1,200
POP Willamette River Dredging	1987	1	5	501	Maintenance	2,000
POP Willamette River Dredging	1987	4	4	401	Maintenance	2,000
POP Willamette River Dredging	1987	5	4	416	Maintenance	1,800
POP Willamette River Dredging	1988	1	5	501	Maintenance	1,600
FY 88 Corps Sundial Marine D.B. Vulture	1988	8			Maintenance	97,808
POP Willamette River Dredging	1988	10	2	205,206	Maintenance	7,500
POP Willamette River Dredging	1988	11	1	102,103	Maintenance	6,000
POP Willamette River Dredging	1988	11		Near T2	Borrow-fill	876,000
POP Willamette River Dredging	1988	4 to 4.5	4	401,403-408,414-416	Maintenance	28,900
POP Willamette River Dredging	1989	1	5	502	Construction	5,437
FY 89 Corps Smith Rice Super Scoop	1989	11+30+90 to 11+35+40			Maintenance	2,457
FY 89 Corps Smith Rice Super Scoop	1989	2+05 to 2+29+90			Maintenance	34,890
FY 89 Corps Smith Rice Super Scoop	1989	8+39 to 10+01			Maintenance	518,473
FY 89 Corps Smith Rice Super Scoop	1989	9+48 to 10+08			Maintenance	23,288
POP Willamette River Dredging	1990	10	2	204,205,206	Maintenance	13,000
FY 90 Corps Sea Vulture (debris removal)	1990	6+45			Debris removal	1,777
POP Willamette River Dredging	1992	1	5	501	Maintenance	1,250
POP Willamette River Dredging	1992	8	PSY	DD 1, DD 4	Maintenance	95,184
POP Willamette River Dredging	1992	11	1	104	Maintenance	2,000
POP Willamette River Dredging	1993	10	2	204,206	Maintenance	22,000
POP Willamette River Dredging	1994	4	4	408	Maintenance	2,300
POP Willamette River Dredging	1994	4.5	4	410, 411, 412	Maintenance	35,000
POP Willamette River Dredging	1994	8	PSY	DD 3	Maintenance	21,000
POP Willamette River Dredging	1994	10	2	203	Maintenance	1,410
FY 94 Corps by Dutra Marine D.B. #24 9	1994	8 to 10			Maintenance	499,897
POP Willamette River Dredging	1995	1.5	5	503	Maintenance	4,903
POP Willamette River Dredging	1995	10	2	204, 206	Maintenance	18,000
POP Willamette River Dredging	1996	1	5	501	Maintenance	1,250
POP Willamette River Dredging	1996	10	2	204, 206	Maintenance	22,297
POP Willamette River Dredging	1996	11	1	104	Maintenance	7,120
POP Willamette River Dredging	1997	4.5	4	410, 411	Maintenance	5,454
FY 97 Corps by Great Lakes #53 Clam	1997	8.5 to 10			Maintenance	346,000
POP Willamette River Dredging	2001	1	5	503	Maintenance	1,750

Notes: PSY = Portland Ship Yard
DD = Dry dock
POP = Port of Portland
Corps = U.S. Army Corps of Engineers
FY = Fiscal Year
T = Terminal

Table 3-1. Potential Contaminant Sources within the ISA.

Industrial Activity
Raw Materials Handling/Treatment
Chemical Manufacturing/Storage
Bulk Petroleum Storage/Distribution
Metal Salvage/Recycling
Marine Construction/Repair
Electric Power Generation
Railroad Operations/Maintenance
Marine Activities and Shipping
Ship Building and Ship Dismantling
Urban Activity
Waterfront Construction
Aquatic Recreation/Boating/Marinas
Automobiles
Development & Urbanization
Point Source Discharges
Industrial
Combined Sewer Overflows
Storm Drains
Non-point Source Discharges
Spills (Upland/Aquatic)
Stormwater Runoff
Exhaust and Emissions
Historic Practices
Direct Waste Disposal
Over-water Construction
Vessel Construction & Repair

Table 3-2. Chemicals Associated with Selected Industries Located in the LWR[1].

Industry	**Contaminant Type/Use**
Bulk petroleum storage/distribution	Total petroleum hydrocarbons (TPHs), polycyclic aromatic hydrocarbons (PAHs), benzene, ethylbenzene, toluene, and total xylenes (BTEX)
Chemical manufacturing/storage	Multiple organic chemicals, depending on process
Metals salvage/recycling (including automobiles)	Metals, polychorinated biphenyls (PCBs), TPHs, phthalates
Metals forging, fabrication, plating	Metals, TPHs, PCBs, cyanide, volatile organic compounds (VOCs)
Marine construction/repair	TPHs, metals, tributyltin (TBT), PCBs, phthalates, VOCs, semivolatile organic compounds (SVOCs)
Electrical power generation	TPHs, BTEX, PCBs, PAHs
Electric power substation operation and maintenance	TPHs, SVOCs, PCBs, herbicides
Railroad switching, shipping, maintenance	TPHs, PAHs, metals, VOCs, SVOCs, herbicides, multiple chemicals depending on materials handled
Shipping	TBT, TPHs, multiple chemicals depending on materials handled
Ship building and ship dismantling	Metals, TPHs, PAHs, PCBs, solvents, BETX compounds

[1]Additional facility-specific information is contained in Appendix E.

Table 3-3. Active NPDES Permitted Discharges to the ISA[1].

File No.	Facility	Location		Permit		River Mile
		Latitude	Longitude	Category	Type	
Major NPDES - Individual Permit						
68471	ATOFINA Chemicals, Inc. (CLOSED)	45.5708	-122.7448	IND	NPDES	7.4
108015	Portland, City of - Municipal Storm Water Permi	45.5506	-122.6204	STM	NPDES	multiple
93450	Wacker Siltronic Corporation	45.5767	-122.7506	IND	NPDES	6.3
Minor NPDES - Individual Permit						
100025	Kinder Morgan/Portland Bulk Terminal 4	45.6014	-122.7669	IND	NPDES	4.6
108460	Columbia River Sand & Gravel - Linnton Dist. Facility	45.5991	-122.7819	IND	NPDES	4.8
47430	Koppers Industries, Inc.	45.5686	-122.7528	IND	NPDES	6.4
70596	Cascade General, Inc.	45.5658	-122.7208	IND	NPDES	6.5
74995	Aventis CropScience	45.5664	-122.7475	IND	NPDES	7
100517	Univar	45.5500	-122.7171	IND	NPDES	9
General Permits						
111395	Boydstun Metal Works - N. Time Oil Rd.	45.6168	-122.7773	STM	GEN12Z	3.5
111952	CalBag Metals	45.6075	-122.7733	STM	GEN12Z	3.6
32876	Morse Bros.-Linnton Terminal	45.5972	-122.7995	STM	GEN12Z	3.8
108995	SAIA Motor Freight	45.5667	-122.7084	STM	GEN12Z	4
109845	Jefferson Smurfit Corporation	45.6117	-122.7727	STM	GEN12Z	4
6739	Northwest Pipe Company	45.6079	-122.7663	STM	GEN12Z	4
111236	Portland Container Repair, Inc.	45.6133	-122.7720	STM	GEN12Z	4
108103	Schnitzer Steel Products Co.	45.6081	-122.7663	STM	GEN12Z	4
6739	Northwest Pipe Company	45.6079	-122.7663	IND	GEN01	4
109186	Time Oil Co.	45.6164	-122.7821	STM	GEN12Z	4.1
65589	Owens Corning Linnton	45.6091	-122.791	IND	GEN01	4.2
65589	Owens Corning Linnton	45.6091	-122.791	IND	GEN05	4.2
65589	Owens Corning Linnton	45.6091	-122.791	IND	GEN13	4.2
4248	BP West Coast (formerly ARCO)	45.5944	-122.7791	IND	GEN15A	4.3
4248	BP West Coast (formerly ARCO)	45.5944	-122.7791	IND	GEN13	4.3
111396	Boydstun Metal Works - Sever Ct	45.6097	-122.7698	STM	GEN12Z	4.3
57374	Shore Terminals (formerly ExxonMobil)	45.5936	-122.7765	IND	GEN13	4.4
108460	Columbia River Sand & Gravel-Linnton Dist. Facility	45.5991	-122.7819	STM	GEN12Z	4.8
50782	Linnton Plywood Association	45.5992	-122.7847	STM	GEN12Z	4.8
107640	Port of Portland-Terminal 4	45.6000	-122.7669	IND	GEN15A	5
100726	Toyota Logistic Services/Vehicle Processors Inc	45.6011	-122.7623	STM	GEN12Z	5
106458	Borden Chemical, Inc.	45.6061	-122.7657	IND	GEN01	5
110170	International Raw Materials	45.6091	-122.7667	STM	GEN12Z	5
112017	ExxonMobil	45.5916	-122.7776	STM	GEN12Z	5.3
80841	Kinder Morgan-Willbridge Terminal	45.5661	-122.7451	IND	GEN13	5.4
109938	Shore Terminals Llc	45.6306	-122.7733	STM	GEN12Z	5.5
90845	ConocoPhillips (fomerly Tosco)	45.5723	-122.7424	IND	GEN13	5.7

Table 3-3. Active NPDES Permitted Discharges to the ISA[1].

File No.	Facility	Location		Permit		River Mile
		Latitude	Longitude	Category	Type	
100475	Crown Cork And Seal Co	45.5997	-122.7631	STM	GEN12Z	6
109794	Mar Com, Inc.	45.5875	-122.7626	STM	GEN12Z	6.2
87693	Equilon Enterprises-Portland Bulk Terminal	45.5333	-122.7276	IND	GEN15A	6.3
87693	Equilon Enterprises-Portland Bulk Terminal	45.5333	-122.7276	IND	GEN13	6.3
111880	Shell Oil Products	45.5493	-122.7273	IND	GEN15A	6.3
93450	Wacker Siltronic Corporation	45.5767	-122.7506	STM	GEN12Z	6.3
93450	Wacker Siltronic Corporation	45.5767	-122.7506	STM	GEN12C	6.3
62231	Northwest Natural Gas Company (LNG Plant)	45.5792	-122.7580	IND	GEN15A	6.4
111157	Fuel And Marine Marketing - Portland Terminal	45.5803	-122.7575	IND	GEN13	6.4
62231	Northwest Natural Gas Company (LNG Plant)	45.5792	-122.7580	IND	GEN01	6.4
70596	Cascade General, Inc.	45.5658	-122.7208	STM	GEN12Z	6.5
106456	SFPP, L.P. - Portland Station	45.5756	-122.7529	IND	GEN15A	7
8550	GS Roofing Products Company, Inc.	45.5689	-122.7487	STM	GEN12Z	7
8550	GS Roofing Products Company, Inc.	45.5689	-122.7487	IND	GEN01	7
107922	Air Liquide (See Liquid Air File 50791)	45.5709	-122.7449	STM	GEN12Z	7.3
110646	Metro Central Transfer Station	45.5680	-122.7463	STM	GEN12Z	7.5
107172	Quadra Chemicals	45.5667	-122.7368	STM	GEN12Z	7.5
54175	McCall Oil And Chemical Corporation Marine Terminal	45.5611	-122.7358	IND	GEN13	7.8
54175	McCall Oil And Chemical Corporation Marine Terminal	45.5611	-122.7358	IND	GEN05	7.8
100122	Willbridge Distribution Center (Chevron)	45.5658	-122.7415	IND	GEN13	7.9
110757	Chevron U.S.A.-Willbridge Yard	45.5617	-122.7405	STM	GEN12Z	8
16055	Chevron U.S.A. Products Company (Abn) - Willbridge Asphalt Refine	45.5611	-122.7175	STM	GEN12Z	8
107564	Chevron U.S.A.-Willbridge Transportation (Chevron)	45.5667	-122.7390	STM	GEN12Z	8
108053	Distribution, Inc.-FTL	45.5542	-122.7223	STM	GEN12Z	8
108673	Fred Meyer Dairy Plant	45.5583	-122.6984	STM	GEN12Z	8
110778	Rose City Moving & Storage Company	45.5606	-122.7002	STM	GEN12Z	8
104856	Tube Forgings of America	45.5667	-122.7326	STM	GEN12Z	8
101536	United Parcel Service Co.	45.563	-122.7036	STM	GEN12Z	8
101536	United Parcel Service, Inc.	45.5725	-122.7166	STM	GEN12Z	8
108394	USACE - US Government Moorings; St. Helens Road, Portland	45.5820	-122.7566	STM	GEN12Z	8
111878	RM Beverage Delaware (Maletis Beverage	45.5733	-122.7097	STM	GEN12Z	8.1
107658	ABF Freight System, Inc	ND	ND	STM	GEN12Z	8.5
101321	Freightliner, LLC	45.5675	-122.7030	STM	GEN12Z	8.5
100408	Freightliner, LLC	45.5736	-122.7157	STM	GEN12Z	8.5
107748	G. I. Trucking Company	45.5583	-122.7055	STM	GEN12Z	8.5
30386	Gunderson, Inc.	45.5486	-122.7196	STM	GEN12Z	8.5
101853	Mt. Hood Chemical Corp	45.5550	-122.7316	STM	GEN12Z	8.5
100408	Freightliner, LLC	45.5736	-122.7157	IND	GEN01	8.5
101321	Freightliner, LLC	45.5675	-122.7030	IND	GEN01	8.5

Table 3-3. Active NPDES Permitted Discharges to the ISA[1].

File No.	Facility	Location		Permit		River Mile
		Latitude	Longitude	Category	Type	
109872	Western Wire Works	45.5519	-122.7261	STM	GEN12Z	8.6
108730	HAJ, Inc. (DBA Christenson Oil)	45.5495	-122.7269	STM	GEN12Z	8.6
111221	A.G.G. Enterprises, Inc.	45.5629	-122.7144	STM	GEN12Z	8.8
111845	Becker Trucking	45.5658	-122.7085	STM	GEN12Z	8.9
103803	Owens Corning	45.5486	-122.7083	IND	GEN13	9
103380	Burlington Northern Portland Hub Ctr	45.5514	-122.7168	STM	GEN12Z	9
104250	Columbia Distributing Company-Elm Realty Partners	45.5717	-122.7056	STM	GEN12Z	9
110272	Container Recovery, Inc.	45.5358	-122.7258	STM	GEN12Z	9
101620	Active USA	45.5686	-122.7086	STM	GEN12Z	9
110199	Fed Express Mria Station	45.5550	-122.6961	STM	GEN12Z	9
109831	Fedex Ground	45.5703	-122.7018	STM	GEN12Z	9
111009	Mt. Hood Beverage Company	45.5466	-122.7153	STM	GEN12Z	9
103803	Owens Corning	45.5486	-122.7083	STM	GEN12Z	9
107443	Roadway Express Inc - Portland	45.5717	-122.7061	STM	GEN12Z	9
103803	Owens Corning	45.5486	-122.7083	IND	GEN05	9
110322	Oregon Transfer Co.	45.5670	-122.7106	IND	GEN01	9
103803	Owens Corning	45.5486	-122.7083	IND	GEN01	9
100447	Carson Oil	45.5452	-122.7172	STM	GEN12Z	9.1
100721	Wilhelm Trucking Co.	ND	ND	STM	GEN12Z	9.2

[1]Compiled April 2002 (DEQ 2002); updated March 2003 (Sanders et al. 2003).

DEFINITIONS:

GEN01	Cooling water/heat pumps	GEN15A	Petrolem hydrocarbon cleanups
GEN05	Boiler blowdown	IND	Industrial
GEN12C	Construction that disturbs five or more acres	DOM	Domestic
GEN12Z	Industrial stormwater	AGR	Agricultural
GEN13	Oil/water separators	ND	No Data

Table 3-4. Active NPDES Permitted Discharges to the LWR, Outside the ISA[1].

File No.	Facility	Location		Permit		River Mile
		Latitude	Longitude	Category	Type	
Major NPDES - Individual Permit						
108015	Portland, City of - Municipal Storm Water Permit	45.5506	-122.6204	STM	NPDES	multiple
16590	Clackamas Co./Kellogg Creek STP	45.5408	-122.7681	DOM	NPDES	18.5
62795	Oak Lodge STP	45.425	-122.6528	DOM	NPDES	20.1
70735	Tryon Creek WWTP (City Of Portland)	45.4167	-122.6625	DOM	NPDES	20.2
Minor NPDES - Individual Permit						
70613	Kinder Morgan (Portland Bulk Terminal 5)	45.6391	-122.777	IND	NPDES	1.5
64905	Oregon Steel Mills, Inc.	45.6292	-122.7797	IND	NPDES	2.7
3690	Ash Grove Cement	45.61861	-122.7808	IND	NPDES	3
110220	Union Station Housing Project	45.5333	-122.675	IND	NPDES	11.9
106060	OMSI	45.51	-122.6647	IND	NPDES	13.5
109444	Willamette Oaks Building	45.475	-122.6699	IND	NPDES	15.8
General Permits						
111283	Columbia Grain, Inc.	45.6411	-122.7689	STM	GEN12Z	1.1
105370	Alcatel Submarine Networks, Inc.	45.6416	-122.7626	IND	GEN01	1.5
102016	Statesman Journal	44.9583	-123.033	IND	GEN15A	2
100483	ESCO Corporation-Lower Finishing Area	45.5375	-122.7029	STM	GEN12Z	2
108730	Christenson Oil	45.5533	-122.7269	STM	GEN12Z	2
32300	Kinder Morgan Liquid Terminals-Linnton Terminal	45.60416	-122.7896	IND	GEN13	2.6
64905	Oregon Steel Mills, Inc.	45.6292	-122.7797	STM	GEN12Z	2.7
100514	Consolidated Metco Inc.	45.6248	-122.7802	STM	GEN12Z	3
100415	J. R. Simplot Company - Rivergate Terminal	ND	ND	STM	GEN12Z	3
100415	J. R. Simplot Company - Rivergate Terminal	ND	ND	IND	GEN01	3
84885	Steinfeld's Products Company	45.3964	-122.7725	STM	GEN12Z	3.1
84855	Morse Bros-Coffee Lake Division	45.3489	-122.8199	STM	GEN12A	3.1
111395	Boydstun Metal Works - N. Time Oil Rd.	45.6168	-122.7773	STM	GEN12Z	3.5
111029	Truax Harris Energy-Pacific Pride Cardlock Facility	45.5597	-122.7008	IND	GEN15A	9.4
111065	Container Management Services, LLC - St Helens Rd	45.5425	-122.7186	STM	GEN12Z	9.5
108997	Columbia American Plating Company (Abn)	45.544	-122.7177	STM	GEN12Z	9.5
109852	Portland Terminal Railroad Company	45.5517	-122.71	STM	GEN12Z	9.5
109872	Western Wire Works, Inc.	45.5522	-122.7261	STM	GEN12Z	9.7
104892	Galvanizers Company	45.54	-122.7125	STM	GEN12Z	9.9
107213	Goldendale Aluminum Company	45.5536	-122.6939	STM	GEN12Z	10

Table 3-4. Active NPDES Permitted Discharges to the LWR, Outside the ISA[1].

File No.	Facility	Location		Permit		River Mile
		Latitude	Longitude	Category	Type	
110261	Lincoln & Allen Company	45.545	-122.7013	STM	GEN12Z	10
109851	Peninsula Truck Lines, Inc.	45.545	-122.7036	STM	GEN12Z	10
107985	Stevedoring Services Of America, Inc.	45.5464	-122.7045	STM	GEN12Z	10
109737	Time Oil Site Grading	45.6156	-122.67	STM	GEN12C	10
110258	McCracken Motor Freight, Inc.	45.5444	-122.6999	STM	GEN12Z	10.2
104836	ESCO Corporation	45.5425	-122.7	STM	GEN12Z	10.5
107655	Savage Transload System	45.55	-122.68	STM	GEN12Z	10.5
102334	Sulzer Pumps	45.5458	-122.6976	STM	GEN12Z	10.5
102334	Sulzer Pumps	45.5458	-122.6976	IND	GEN01	10.5
460	CalBag (formerly ACME Trading & Supply Company)	45.55722	-122.73	STM	GEN12Z	11
111331	Sakrete of The Pacific Northwest	45.5402	-122.6814	STM	GEN12Z	11
105307	Jacobsen & Co. Inc., K.F.	45.5389	-122.6799	STM	GEN12A	11
44571	Glacier Northwest-River St. Cement Terminal	45.53694	-122.6769	IND	GEN01	11.1
100571	Tarr, Inc.	45.5416	-122.6725	STM	GEN12Z	11.2
110908	Hoyt Street Yards Infrastructure Improvements	45.5318	-122.6803	IND	GEN15A	11.4
110908	Hoyt Street Yards Infrastructure Improvements	45.5318	-122.6803	STM	GEN12C	11.4
111356	Cargill, Inc.	45.5357	-122.6736	STM	GEN12Z	11.5
109826	USNRPC (Amtrak) - Union Station, Portland	45.5306	-122.6747	STM	GEN12Z	11.5
107179	Calbag Metals Co	45.5411	-122.7	STM	GEN12Z	11.6
107609	USPS - Vehicle Maintenance Facility; Portland	45.6916	-122.68	STM	GEN12Z	12
38192	Hercules	45.5464	-122.7093	IND	GEN01	12
104545	Norcrest China Company; Wheat Marketing Center, Inc.	ND	ND	IND	GEN01	12
111290	Oregon Convention Center Expansion	45.5281	-122.6617	STM	GEN12C	12.3
106750	East Side Plating, Inc.	45.5139	-122.6639	STM	GEN12Z	13
107211	Darigold, Inc.	45.5028	-122.6389	STM	GEN12Z	14
104861	Zidell Marine Corporation	45.5	-122.6699	STM	GEN12Z	14
111433	Union Pacific Railroad-Track & Signal Improvements	45.4932	-122.6567	STM	GEN12C	14.5
109995	Minnesota Corn Processors, LLC	45.4852	-122.6438	STM	GEN12Z	15
108792	Oregon Coachways, Inc.	44.0443	-123.1794	STM	GEN12Z	15
109175	Raz Transportation Company	45.4739	-122.6947	IND	GEN15A	16.3
109175	Raz Transportation Company	45.4739	-122.6947	STM	GEN12Z	16.3
105053	Staff Jennings Inc.	ND	ND	IND	GEN15A	16.7
109735	Beaver Heat Treating Corporation	45.4583	-122.6358	STM	GEN12Z	17
62795	Oak Lodge STP	45.425	-122.6528	STM	GEN12Z	20.1

Table 3-4. Active NPDES Permitted Discharges to the LWR, Outside the ISA[1].

File No.	Facility	Location		Permit		River Mile
		Latitude	Longitude	Category	Type	
111407	Centex Homes-Falling Creek	45.4487	-122.7203	STM	GEN12C	20.1
107631	Barbur Texaco	45.4553	-122.7	IND	GEN15A	20.2
107659	Fort James - Lake Oswego Chip Reload	45.375	-122.6567	STM	GEN12Z	20.4
108705	Delco Petroleum Co., L.L.C.	45.3958	-122.6137	IND	GEN15A	20.5
107164	Ace Iron Works (Abn)	45.4173	-122.64	STM	GEN12Z	21
107661	Lake-Shore Concrete Co.	45.4203	-122.6613	STM	GEN12A	21
109386	Rivergate Development Company-Trillium Park Estates Project	45.3583	-122.5667	STM	GEN12C	22
111022	YAMCO	45.3	-122.96	STM	GEN12A	22
111287	Lake Oswego Block 136 Project	45.25	-122.4	IND	GEN15A	22.5
101733	Stanley Hydraulic Tools	45.4014	-122.624	STM	GEN12Z	23
48480	Lake Oswego WTP	45.3889	-122.6333	IND	GEN02	23
108243	Koss-Brod-Goodrich & Associates, Inc.-Cascade Summit Subdivision	45.3625	-122.648	STM	GEN12C	24
110296	W C R Company-Oatfield Estates	45.4139	-122.6142	STM	GEN12C	24.3

[1]Compiled April 2002 (DEQ 2002); updated March 2003.

DEFINITIONS:

GEN01	Cooling water/heat pumps
GEN02	Filter backwash
GEN03	Fish hatcheries
GEN05	Boiler blowdown
GEN12A	Stormwater from gravel mining
GEN12C	Construction that disturbs five or more acres
GEN12Z	Industrial stormwater
GEN13	Oli/water separators
GEN15A	Petrolem hydrocarbon cleanups
IND	Industrial
DOM	Domestic
AGR	Agricultural
ND	No Data

Table 3-5. Discharge Monitoring Requirements for Individual NPDES Permits in the LWR[1]

Facility	Conventional Monitoring Parameters	Chemical Monitoring Requirements
ISA		
ATOFINA Chemicals, Inc.	flow, pH, TSS, and oil & grease	total residual chlorine, lead, zinc, copper
Columbia River Sand & Gravel	suspended solids, turbidity, temperature	
Wacker Siltronic Corporation	flow, TSS, pH, temp, BOD, total phosphates, fluoride	total chromium, hexavalent chromium, total organics
Koppers Industries, Inc.	flow, oil & grease, pH, temp,	phenols, total PAH
Cascade General, Inc.	flow, pH, TSS, oil and grease	copper, lead, zinc
ACS-Portland (Phone-Poulenc)	flow, TSS, pH	phenols and chlorinated phenols, bromoxynil octanoate, arsenic, lead, chromium, mercury, methylene chloride, trichloroethene, 1,1,1,-trichloroethane, 1,4-dichlorobenzene, dioxin/furans
Vopak USA Inc.	pH, oil & grease	benzene, 1,2-dichloroethene, 1,1,1-TCA, 1,1,2-TCA, trichloroethene, tetrachloroethene, vinyl chloride
Portland, City of - Municipal Stormwater Permit	best management practices[2]	
Outside ISA		
Kellogg Creek Sewage Treatment Plant	flow, pH, TSS, BOD, nutrients, ammonia, bacteria, residual chlorine	metals, total phenols, total organic pollutants
Oak Lodge Sewage Treatment Plant	flow, pH, TSS, BOD, coliform, residual chlorine	
Tryon Creek WWTP (City of Portland)	flow, pH, BOD, TSS, total residual chlorine, E. coli, nutrients	metals (pretreatment, not outfall requirement)
Kinder Morgan (Portland Bulk Terminal 5)	flow, pH, TSS, oil and grease, TOC, sulfide, sulfate, ammonia	copper, lead, zinc, iron, manganese
Oregon Steel Mills, Inc.	flow, TSS, total dissolved solids, turbidity, oil & grease, pH, temp	lead, zinc
Ash Grove Cement	flow, TSS, pH	
GSL Properties (Union Station Housing Project)	pH	iron
OMSI	flow, temp, pH	
Willamette Oaks Building	flow, pH	halogenated volatile organics

[1] Permits may include multiple outfalls; not all parameters are monitored at each. Monitoring frequency ranges from daily to semi-annually.

[2] Examples of Best Management Practices (BMPs) include the City's Industrial Stormwater Management Program to control the discharge of pollutants from existing and developing industries to the public conveyance system, developing stormwater standards for new development, monitoring to eliminate illicit discharge, street sweeping, and public involvement and education.

Table 3-6. Summary of Basic Monitoring Requirements in General NPDES Permits.

Type		No. in ISA	Conventional Monitoring Parameters[1]	Chemicals Monitoring Requirements[1]	
				Parameter	Frequency
GEN01	Cooling water/heat pumps	9	flow, temp, pH, total residual chlorine	---	---
GEN05	Boiler blowdown	3	flow, temp, pH, TSS, total residual chlorine*	---	---
GEN12C	Construction that disturbs five or more acres	1	inspection/visual characteristics	---	---
GEN12Z	Industrial stormwater	56	pH, TSS, oil & grease, E. coli*, visual monitoring	copper, lead, zinc	twice per year
GEN13	Oil/water separators	10	flow, pH*, TSS*, oil & grease	copper*, lead*, zinc*, MTBE*, ethanol*	twice per year
GEN15A	Petrolem hydrocarbon cleanups	6	flow, pH, visual monitoring	TPH, BETX, benzene, lead*	weekly to quarterly

[1] Permits for specific facilities may include other parameters.

* Not applicable to all facilities.

Table 3-7. General Permit Waste Discharge Benchmarks or Limitations.

Parameter	**Benchmark[1]**	**Limitations[2]**
Total copper	0.1 mg/L	---
Total lead	0.4 mg/L	---
Total zinc	0.6 mg/L	---
TPH	---	1 mg/L
BETX	---	0.25 mg/L
Benzene	---	0.025 mg/L

[1] Guideline concentrations to assist the permittee in determining if the implementation of their Stormwater Prevention Control Plan is reducing pollutant concentrations below levels of concern.

[2] Concentration not to be exceeded.

Table 3-8. Summary of Industrial and Municipal Discharge Enforcement Actions in the ISA (1990-2000).

Year	Name	Discharge Type	Action	Penalty	Status
1999	Elf-Atochem North America	Industrial waste	Notice of permit violation	--	Response accepted
1997	Cascade General, Inc.	Industrial waste	Civil penalty	$3,600	Paid
	Cascade General, Inc.	Industrial waste	Notice of permit violation	NA	Response accepted

Source: DEQ (1995-2000)
NA = Not Available.

Table 3-9. Summary of Willamette River Subbasin TMDLs.

Subbasin	Parameter						
	Temperature	**Dissolved Oxygen**	**Bacteria**	**pH**	**Nutrient Related**	**Toxics**	**Other**
Due in 2003[1]							
Clackamas Subbasin	x[2]						habitat modification
McKenzie Subbasin	x						
North Santiam	x						
South Santiam	x		x				
Coast Fork	x		x		x	mercury	
Middle Fork	x						
Upper Willamette	x	x	x			mercury, PAHs, arsenic	turbidity, biological criteria, flow
Middle Willamette	x		x			mercury, dieldrin	biological criteria, flow
Lower Willamette	x	x	x	x	x	DDE, PCBs, DDT, lead, dieldrin, mercury	biological criteria, flow, habitat modification
Due in 2007							
Molla-Pudding	x	x	x			arsenic, iron, manganese, DDT	flow
Yamhill	x	x	x		x	chlorophyrifos	flow
Completed							
Tualatin	x	x	x	x	x	arsenic, manganese, iron	biological criteria
Columbia and Willamette						dioxin	

Source: DEQ 2000b, 2001.

[1]DEQ is currently developing TMDLs for the Willamette main stem for fecal coliform, mercury, and temperature. The remaining parameters will be addressed later.

[2]Indicates that one or more stream segments are listed for the parameter within the subbasin.

Table 4-1. Historical Sediment, Tissue, and Willamette River Water Chemical Investigations in Portland Harbor.

LWG Survey Code	Avocet QA	Data Useability Category	Rationale for Category 2	Survey Name	Begin Date	End Date
Sediment						
1.CLBC8494*	--	2	methods unknown, no COC, no laboratory QC data	Columbia River Basin Contaminant Sediment Data	1/1/1984	1/1/1994
2.COLWIL90	--	2	no COC or reference to COC procedures; holding conditions unknown	Columbia & Lower Willamette Rivers Channel Deepening Reconnaissance	5/3/1990	5/18/1990
3.MBCREOS1	--	1,2	Cr (VI) - extended holding times and low recovories of MS/MSD and LCS	McCormick & Baxter RI Phase 1	9/21/1990	10/17/1990
4.MBCREOS2	--	1,2	Cr (VI) - extended holding times and low recovories of MS/MSD and LCS	McCormick & Baxter RI Phase 2	9/1/1991	1/30/1992
5.MCAL0986	Y	1,2	most parameters - methods unknown, no COC, holding time unknown, no precision and limited accuracy documentation from laboratory QC data	McCall Oil Dock 9/1986	9/18/1986	9/18/1986
6.MCAL1286	Y	1,2	most parameters - methods unknown, no COC, holding time unknown, no precision and limited accuracy documentation from laboratory QC data	McCall Oil Dock 12/1986	12/15/1986	12/15/1986
7.MOOR0595	Y	1,2	grain size - method unknown	US Moorings May 1995	5/16/1995	5/17/1995
8.MOOR0694	Y	1,2	grain size - method unknown	US Moorings June 1994	6/14/1994	6/14/1994
9.MOOR1089	--	1,2	grain size - no COC and no replicates	US Moorings Sediment Quality Evaluation	10/12/1989	10/12/1989
10.MOOR1294	--	1	--	US Moorings Preliminary Assessment Sampling	12/20/1994	12/20/1994
11.PPTLDT24	--	1	--	Sediment Study Marine Terminals 2 and 4	9/15/1998	10/15/1998
12.PSBTH311	Y	1,2	most parameters - methods unknown, no COC, holding time unknown, no precision or accuracy documentation from laboratory QC data	Port of Portland Berth 311 Dredge Data	9/9/1990	4/8/1992
13.PSYD&M97	Y	1	--	Portland Shipyard Env. Audit	11/26/1997	1/22/1998
14.PSYDD3	Y	1	--	Portland Shipyard DD-3 Post-Dredge Data	12/15/1994	12/15/1994
15.PSYDD4	Y	1,2	metals - no documentation of accuracy (MS, LCS, Surrogates)	Portland Shipyard DD-4 Post-Dredge Data	12/15/1992	12/15/1992
16.PSYSEA98	Y	1	--	Portland Shipyard Sediment Investigation	3/31/1998	4/16/1998
17.RIEDEL96		2	no source document and no supporting QC data	Focused ESA Riedel	9/3/1996	9/3/1996
18.RIEDEL97	Y	1	--	Baseline Sediment Assessment Riedel	8/12/1997	8/13/1997
19.TOSCO99	Y	1	--	TOSCO Sediment Sampling Results 1999	1/20/1999	1/22/1999

Table 4-1. Historical Sediment, Tissue, and Willamette River Water Chemical Investigations in Portland Harbor.

LWG Survey Code	Avocet QA	Data Useability Category	Rationale for Category 2	Survey Name	Begin Date	End Date
20.WBWRIR98	--	2	dioxins/furans - method unknown, no COC, holding time unknown, no precision or accuracy documentation from laboratory QC data	USGS - Bonn	1/1/1992	1/1/1995
21.WLCAYH00	--	1	--	Union Pacific Railroad Albina Yard Expanded Preliminary Assess.	8/9/2000	8/17/2000
22.WLCARI99	--	*2 pending*	*Delivery of supporting documentation pending*	Assessment of Nearshore Sediments, ARCO Terminal 22T	9/1/1999	9/1/1999
23.WLCCIF01	--	1,2	grain size - no COC, holding time unknown, no replicates	Cargill Irving Elevator Permit Applications	6/29/2001	6/29/2001
24.WLCCPF01	--	1	--	Chevron Dredging Permit Application	6/6/2001	6/7/2001
25.WLCDRE87	--	2	methods unknown, no COC, holding time unknown, no precision or accuracy documentation from laboratory QC data	Organic Compounds in Willamette Sediments	1/1/1982	12/31/1984
26.WLCGAF00	--	1	--	Goldendale Aluminum Dredge Phase 1	6/12/2000	6/12/2000
27.WLCGAL00	--	1	--	Goldendale Aluminum Dredge Phase 2	12/21/2000	12/21/2000
28.WLCGPE00	--	2	no COC, holding time unknown, no precision or accuracy documentation from laboratory QC data	G-P Linnton Site Preliminary Assessment	5/16/2000	5/17/2000
29.WLCGSA96	--	1	--	Gasco PI Remedial Investigation	1/23/1996	1/24/1996
30.WLCGSD01	--	1	--	Gasco Source Control Evaluation	4/10/2001	4/11/2001
31.WLCGXV99	--	1	--	Environmental Site Assessment GATX Terminals Corp.	10/8/1999	10/8/1999
32.WLCMBA01	--	1	--	McCormick & Baxter RI Phase 4	1/5/2001	2/5/2001
33.WLCMBJ99	--	1	--	McCormick & Baxter RI Phase 3	10/1/1999	10/1/1999
34.WLCMCB02	--	1	--	MarCom Expanded Preliminary Assessment	2/8/2002	2/8/2002
35.WLCMFH00	--	1	--	Marine Finance Expanded Preliminary Assessment Data Report	8/8/2000	8/9/2000
36.WLCOFH02	--	1,2	grain size - no replicates for M-1 or 18; no COC for M-1; mercury - no precision QC data for 18	City of Portland Outfall Pilot Project, Outfall 18 and Outfall M-1	8/21/2002	8/23/2002
37.WLCOSJ00	--	1	--	Pre-Remedial Inv. Field Activities Data Report for Oregon Steel Mills	10/10/2000	10/11/2000
38.WLCRFE95	--	1,2	grain size - laboratory unknown, no COC, no replicates, holding time unknown	Rose Festival Fleet Moorage	5/11/1995	5/11/1995
39.WLCRIJ99	--	1	--	Ross Island Lagoon Baseline	10/26/1999	10/28/1999
40.WLCRIL99	--	1	--	Ross Island Site Investigation (Hart Crowser)	11/2/1999	4/28/2000
41.WLCRIV99	--	1	--	Ross Island Phase 1 (Landau)	10/7/1999	10/28/1999

Table 4-1. Historical Sediment, Tissue, and Willamette River Water Chemical Investigations in Portland Harbor.

LWG Survey Code	Avocet QA	Data Useability Category	Rationale for Category 2	Survey Name	Begin Date	End Date
42.WLCRPB95	--	1	--	Rhône-Poulenc St Helens Road Facility Q1,95	2/1/1995	2/1/1995
43.WLCT0F01	--	1	--	Terminal 2 and Terminal 5 2001 Dredge Characterization Study	6/27/2001	6/29/2001
44.WLCT0I98	Y	1	--	Sed Char Local Sponsors of Columbia/Willamette Chan Deep	9/14/1998	9/14/1998
45.WLCT0K96	--	1	--	Port of Portland T1, T2, and T5 Sediment Characterization Study	11/12/1996	11/13/1996
46.WLCT1F00	--	1	--	T1 South Sediment Study	6/22/2000	6/22/2000
47.WLCT1L91	--	1,2	grain size - no replicates	Port of Portland 1992 Terminal 1 Sediment Characterization Results	12/17/1991	12/17/1991
48.WLCT4J97	--	1,2	grain size - laboratory unknown, no COC, no replicates, holding time unknown	Port of Portland Terminal 4 Berth 416 1997 Sediment Characterization	10/23/1997	10/24/1997
49.WLCT4J98	Y	1	--	Port of Portland T4 RI	10/12/1998	10/15/1998
50.WLCT4K99	--	2	laboratory unknown, methods unknown, no COC, holding time unknown, no precision or accuracy documentation from laboratory QC data	Port of Portland T4 - Slip 1 & Berth 401 Sediment Characterization	11/18/1999	11/19/1999
51.WLCT4L93	--	1,2	metals - no precision or accuracy documentation from laboratory QC data	T4 Berth 408 Maintenace Dredging	12/7/1993	12/7/1993
52.WLCT5K99	--	1,2	grain size - no replicates	1999, T5, Berths 501, 503 Sediment Characterization Study	11/22/1999	11/22/1999
53.WLCWCJ95	Y	1	--	Willamette Cove SA	10/19/1995	10/19/1995
54.WLCWTI00	--	1	--	Revised 60-Inch Storm Sewer Interim Remedial Actions Report, Tosco	9/21/2000	9/22/2000
55.WLFL0496	Y	2	metals & SVOCs - no COC, no precision of accuracy documentation from laboratory QC data; grain size - methods unknown	Willamette Falls Locks 1996 Flood Deposits Sediment Quality Evaluation	4/18/1996	4/18/1996
56.WLLRSH01	--	1,2	grain size - no COC, no replicates	Willamette River Reference Area Study (Phase I)	8/29/2001	8/29/2001
57.WLR0277	--	2	no COC, holding time unknown, no precision or accuracy documentation from laboratory QC data; metals - methods unknown	Analyses of Bottom Materials from the Willamette River Portland Harbor	2/1/1977	2/1/1977
58.WLR0388	--	2	methods unknown, no COC, holding time unknown, no precision or accuracy documentation from laboratory QC data	Broadway Bridge Evaluation of Sediment Lead Levels	3/22/1988	3/22/1988
59.WLR0488	Y	1,2	most parameters - methods unknown, no COC, holding time unknown, no precision and limited accuracy documentation from laboratory QC data	Lower Willamette River (March & April 1988)	3/30/1988	4/18/1988

Table 4-1. Historical Sediment, Tissue, and Willamette River Water Chemical Investigations in Portland Harbor.

LWG Survey Code	Avocet QA	Data Useability Category	Rationale for Category 2	Survey Name	Begin Date	End Date
60.WLR0499	--	1,2	metals - no precision or accuracy documentation from laboratory QC data; TOC - no replicates	Willamette River Sediment Quality Evaluation - April	4/29/1999	4/29/1999
61.WLR0577	--	2	methods unknown, no COC, holding time unknown, no precision or accuracy documentation from laboratory QC data	Elutriation Study of Willamette River Bottom Material and…River Water	5/17/1977	5/17/1977
62.WLR0692	Y	1,2	most parameters - method unknown, no COC holding time unknown, no precision and limited accuracy documentation from laboratory QC data	Lower Willamette River, Portland Harbor 1992	6/3/1992	6/3/1992
63.WLR0789		2	methods unknown, no COC, holding time unknown, no precision or accuracy documentation from laboratory QC data	Willamette River Burlington Northern RR Bridge Sediment Quality Eval.	7/19/1989	7/19/1989
64.WLR0797	Y	1,2	grain size & TVS - no COC, no replicates	CRCD - Willamette River Channel Deepening	7/22/1997	7/25/1997
65.WLR0988	--	1,2	most parameters - method unknown, no COC holding time unknown, no precision and limited accuracy documentation from laboratory QC data	Lower Willamette River (Sept. 1988)	9/7/1988	9/7/1988
66.WLR1083	--	2	no COC, holding time unknown, no precision or accuracy documentation from laboratory QC data	Quality of Bottom Materials & Elutriates in the LWR, Portland Or	10/1/1983	10/1/1983
67.WLR1196	Y	1,2	grain size - no COC, no replicates	Lower Willamette Portland Harbor 1996	11/13/1996	11/14/1996
68.WLR1199	--	1,2	metals & TOC - No precision or accuracy documentation from laboratory QC data	Willamette River Sediment Quality Evaluation - November	11/29/1999	11/29/1999
69.WLRELF99	Y	1	--	Elf Atochem Willamette River, 1999	11/23/1998	1/20/1999
70.WLRPT294	--	1	--	Terminal 2, Berth 203	3/15/1994	5/20/1994
71.WLRWQH92	--	2	methods unknown, laboratory unknown, no COC, holding time unknown, no precision or accuracy documentation from laboratory QC	Willamette River Toxic Pollutants Summary	1/1/1987	1/1/1992
72.WLRWTF98	Y	1	--	Willbridge Terminal Facility Remedial Investigation	12/17/1998	12/18/1998
73.WRD&M98	Y	1	--	Willamette River, 1998 Data	1/19/1998	1/21/1998
74.WRSTRM94	Y	1	--	Characterization of Stormwater Outfalls	7/15/1994	7/19/1994
75.WR-WSI98	--	1,2	chlorinated phenoxy herbicides - laboratory unknown, holding time unknown, no precision or accuracy documentation from laboratory QC	Portland Harbor Sediment Investigation	9/17/1997	2/2/1999

Table 4-1. Historical Sediment, Tissue, and Willamette River Water Chemical Investigations in Portland Harbor.

LWG Survey Code	Avocet QA	Data Useability Category	Rationale for Category 2	Survey Name	Begin Date	End Date
76.WLLRSI01	--	1	--	Willamette Reference Area Study (Phase 2)	9/17/2001	9/17/2001

Table 4-1. Historical Sediment, Tissue, and Willamette River Water Chemical Investigations in Portland Harbor.

LWG Survey Code	Avocet QA	Data Useability Category	Rationale for Category 2	Survey Name	Begin Date	End Date
Tissue						
CLBC8494*	--	2	laboratory unknown, no COC, holding time unknown, no precision and limited accuracy documentation; for most parameters - methods unknown	Columbia River Basin Contaminant Biota/Sediment Data	1/1/1984	1/1/1994
CLWLTC94	--	2	no COC, holding time unknown, no precision or accuracy documentation	Environmental Contaminants Great Blue Herons Lower Columbia/Willamette	3/1/1994	4/30/1995
PGERAP88	--	2	methods unknown, no COC, holding time unknown, no precision or accuracy documentation	Remedial Action Plan , Station "L" Site, Willamette River Sediments	--	1/1/1988
DEQWQP97	--	2	methods unknown, no COC, holding time unknown, no precision or accuracy documentation	DEQ Water Quality Program - Mercury (Gene Foster per Avocet)	1/1/1997	1/1/1997
ORRORS00	--	2	methods unknown, no COC, holding time unknown, no precision or accuracy documentation	The Oregonian's River of Risk Series	7/1/2000	7/1/2000
MBCREOS2	--	1,2	chlorinated pesticides & PCBs - no COC, holding time unknown, no precision or accuracy documentation	McCormick & Baxter Creosoting Remedial Investigation Report	9/1/1991	1/30/1992
WBWRIR98	--	2	no COC, holding time unknown, no precision or accuracy documentation	USGS - Bonn	1/1/1992	1/1/1995
WLLRSI01	--	1	--	Willamette Reference Area Study (Phase 2)	9/17/2001	9/17/2001
* Includes Curtis et al. 1993, Willamette River Toxics Study, Schmitt et al. 1990, Schmitt and Brumbaugh 1990						
Willamette River Water						
WLCMBJ99	--	1	--	McCormick & Baxter RI Phase 3	10/1/1999	10/1/1999
WLCRIL99	--	1	--	Ross Island Phase I	11/2/1999	4/28/2000
WLCRPB95	--	1	--	Rhône-Poulenc St Helens Road Facility Q1,95	2/1/1995	2/1/1995
WLR0577	--	2	methods unknown, no COC, holding time unknown, no precision or accuracy documentation	Elutriate Study of Willamette River Bottom Material and…River Water	5/17/1977	5/17/1977
WLCMBI02	--	1,2	petroleum hydrocarbons - no precision or accuracy documentation	Surface Water, Sediment, and Groundwater Sampling Report	9/5/2002	9/26/2002
Note: EPA's STORET water quality data, DEQ's Ambient Monitoring Data (LASAR), and USGS data are not included in the database. These data are Category 2 due to lack of supporting QA/QC information. USGS data may be reviewed in Anderson et al. 1996, Fuhrer et al. 1996, and Tetra Tech 1992.						

Table 4-2. Summary of Sediment Investigations Conducted in the Lower Willamette River Since 1990.

Survey Name	Survey ID	Study Objective	River Mile(s)	Begin Date	End Date	Number of Samples	Sample Intervals (cm)	Composite (Y/N)	Dredged (Y/N)	Conv.	Metals	Butyltins	SVOCs	PCBs	Pest.	PCB Cong.	Dioxin/ Furan	VOCs	Other	Comment	Reference
City outfall pilot project	WLCOFH02	Sediment quality study off Outfalls M1 and 18 (9 sediment grabs taken at each outfall)	9	8/21/2002	8/23/2002	18 surface sediment	0-15 cm	N	N	X	X		X	X	X				X	herbicides and petroleum also analyzed	City of Portland, 2002
MarCom Expanded Preliminary Assessment	WLCMCB02	Expanded Preliminary Assessment of MarCom property	6	2/8/2002	2/8/2002	3 surface sediment	0-15 cm	N	N		X	X	X							SVOCs limited to PAHs	Parametrix, 2002
Willamette Ref Area P2	WLLRSI01	Phase II reference area reconnaissance study	16, 19, 23, 24	9/17/2001	9/17/2001	8 surface sediment	0-10 cm or 0-30 cm	N	N	X	X	X	X	X	X					five samples analyzed for conventionals only; porewater analyzed for butyltins	Hart Crowser, 2002
Willamette Ref Area P1	WLLRSH01	Phase I reference area reconnaissance study	16, 17, 18, 19, 24	8/29/2001	8/29/2001	9 surface sediment	0-10 cm	N	N	X				X	X				X	Petroleum also analyzed	Hart Crowser, 2001b
Cargill Irving Elevator Permit Applications	WLCCIF01	Dredged material characterization	12	6/29/2001	6/29/2001	5 subsurface, 1 subsurface porewater	up to 109 cm	Y - 1 sample	Y	X	X	X	X	X	X					porewater analyzed for butyltins	Harding ESE, 2001
T2/T5 2001 Dredge Characterization Study	WLCT0F01	Dredged material characterization	2, 10	6/27/2001	6/29/2001	4 subsurface porewater, 7 subsurface sediment	up to 182 cm	Y	Y	X	X	X	X	X	X					porewater analyzed for butyltins	Hart Crowser, 2001a
Chevron Dredging Permit Application	WLCCPF01	Dredged material characterization	8	6/6/2001	6/7/2001	15 subsurface sediment	up to 244 cm	N	Y	X	X	X	X	X	X			X	X	petroleum analyzed	PNG Environment,al 2001
Gasco Source Control Evaluation	WLCGSD01	Characterization of nearshore conditions to validate groundwater modeling predictions	7	4/10/2001	4/11/2001	18 subsurface sediment, 9 surface sediment	surface 0-10 cm, subsurface to 40 cm	N	N	X	X		X					X		SVOCs limited to PAHs	Anchor Environmental, 2001
McCormick & Baxter RI Phase 4	WLCMBA01	Phase IV remedial investigation of McCormick & Baxter Creosoting Co.	8	1/5/2001	2/5/2001	32 subsurface sediment, 1 upriver reference surface sediment	0-38 cm	N	N	X			X							SVOCs limited to PAHs and phenols	Ecology & Environment, 2001
Goldendale Aluminum Phase 2	WLCGAL00	Dredged material characterization	11	12/21/2000	12/21/2000	4 surface sediment	0-30 cm	N	Y	X			X								CH2M Hill, 2001
Oregon Steel Mills Pre-Remedial Investigation Field Activities Data Report	WLCOSJ00	Pre-remedial investigation; sediments collected off outfalls to investigate storm water as potential pathway	2, 3	10/10/2000	10/11/2000	1 subsurface sediment, 15 surface sediment	surface 0-10 or 0-30 cm, subsurface 0-60	N	N	X	X		X	X					X	petroleum analyzed	Exponent, 2001
Willbridge 60-in outfall	WLCWTI00	Remedial investigation of sediments at 60-inch outfall location, Willbridge Terminal	8	9/21/2000	9/22/2000	13 subsurface sediment	up to 229 cm	N	N	X	X		X					X	X	Only one sample analyzed for metals, SVOCs and VOCs, petroleum analyzed	KHM Environmental Management, 2001
UP RR Albina Yard Expanded Preliminary Assessment Data Report	WLCAYH00	Expanded Preliminary Assessment of UPRR's Albina Yard	11, 12	8/9/2000	8/17/2000	3 subsurface sediment, 6 surface sediment	surface 0-20 cm; subsurface to 69 cm	N	N	X	X	X	X	X					X	petroleum analyzed	Jacobs Engineering, 2000b
Marine Finance Expanded Preliminary Assessment Data Report	WLCMFH00	Expanded Preliminary Assessment of Marine Finance Site	6	8/8/2000	8/9/2000	3 subsurface sediment, 6 surface sediment	surface 0-20 cm; subsurface to 66 cm	N	N	X	X	X	X	X					X	petroleum analyzed	Jacobs Engineering, 2000a
T1 South Sediment Study	WLCT1F00	Baseline sediment investigation associated with potential lease arrangement	11, 12	6/22/2000	6/22/2000	9 surface porewater, 9 surface sediment	0-10 cm	N	N	X	X	X	X	X	X			X		porewater analyzed for butyltins	SEA, 2000
Goldendale Aluminum Phase 1	WLCGAF00	Dredged material characterization	11	6/12/2000	6/12/2000	5 surface sediment, 1 reference surface sediment	0-30 cm	N	Y	X	X	X	X	X	X			X			CH2M Hill, 2001
G-P Linnton Site Preliminary Assessment	WLCGPE00	Preliminary Assessment of G-P Linnton Site	4	5/16/2000	5/17/2000	13 surface sediment	0-30 cm	N	N	X	X		X						X	SVOCs limited to PAHs and phenols, petroleum analyzed	CH2M Hill, 2000a
Willamette November Sediment Quality Evaluation	WLR1199	Dredged material characterization	9, 10, 12	11/29/1999	11/29/1999	9 subsurface sediment, 7 subsurface porewater, 1 surface sediment	surface 0-15 cm, subsurface up to 386 cm	N	N	X	X	X	X	X	X					porewater analyzed for butyltins	USACE, 2000
T5 1999 Berths 501-503 Sediment Characterization Study	WLCT5K99	Dredged material characterization	1, 2	11/22/1999	11/22/1999	5 subsurface sediment and 5 subsurface porewater	up to 182 cm	Y - 2 samples	Y	X	X	X	X	X	X					porewater analyzed for butyltins	Port of Portland, 2002
T4 Slip 1 Berth 401 Sediment Characterization	WLCT4K99	Dredged material characterization	5	11/18/1999	11/19/1999	19 surface sediment	0-10 cm	N	N	X	X		X	X	X					nine samples analyzed for conventionals only	Port of Portland, 2000b
Ross Island Phase I (Port)	WLCRIL99	Phase I remedial investigation of Ross Island Lagoon	15, 16	11/2/1999	4/28/2000	6 subsurface porewater, 20 subsurface sediment, 38 surface porewater, 41 surface sediment, 4 surface reference sediment	surface 0-10 cm, subsurface up to 1798 cm	Y - 1 sample	N	X	X	X	X	X	X			X	X	porewater analyzed for butyltins, petroleum analyzed	Hart Crowser, 2000
Ross Island Lagoon Baseline	WLCRIJ99	Baseline sediments investigation of Ross Island Lagoon	16	10/26/1999	10/28/1999	4 surface porewater, 12 surface sediment	0-10 cm	Y - 1 sample	N	X	X	X	X	X	X					porewater analyzed for butyltins	Landau Associates, 2000a
GATX Linnton Terminal ESA	WLCGXV99	Environmental site assessment	5	10/8/1999	10/8/1999	4 surface sediment, 4 subsurface sediment	surface 0-10 cm, subsurface to 40 cm	N	N	X	X		X	X	X			X		VOCs not analyzed in all samples	KHM Environmental Management, 1999
Ross Island Phase 1 (Ross Island Sand & Gravel)	WLCRIV99	Phase I remedial investigation of Ross Island Lagoon	15, 16	10/7/1999	10/28/1999	4 surface sediment, 41 subsurface sediment	surface 0-10cm, subsurface up to 79 cm	N	N	X	X	X	X	X	X			X	X	petroleum analyzed in subsurface only	Landau Associates, 2000c
McCormick & Baxter RI Phase 3	WLCMBJ99	Phase III remedial investigation of McCormick & Baxter Creosoting Co.	8	10/1/1999	10/1/1999	44 site and 4 upriver reference surface sediment	0-15 cm	N	N	X	X		X				X			SVOCs limited to PAHs and phenols; dioxinx/furans not analyzed in all samples	Ecology & Environment, 2001
ARCO Terminal 22T	WLCARI99	Forensic study of PAH sources to sediments adjacent to Arco/BP's Terminal 22T	5	9/1/1999	9/1/1999	17 surface sediment	0-10 cm	N	N	X	X		X					X			SECOR, 2002
Willamette April Sediment Quality Evaluation	WLR0499	Dredged material characterization	3, 9, 10	4/29/1999	4/29/1999	11 subsurface sediment and 3 porewater	up to 434 cm	N	N	X	X	X	X	X	X		X		X	all samples also analyzed for herbicides; 2 samples analyzed for dioxins/furans; porewater analyzed for butyltins	USACE, 2000
TOSCO 1999 Sediment Sampling Results	TOSCO99	Dredged material characterization	8	1/20/1999	1/22/1999	4 subsurface sediment, 1 surface reference	up to 304 cm	Y	Y	X	X		X	X	X						Exponent, 1999
Willbridge Terminal Facility RI	WLRWTF98	Remedial investigation of Willbridge Terminal	8	12/17/1998	12/18/1998	15 surface sediment	0-12.7 cm	N	N	X	X		X		X			X		SVOCs sometimes limited to PAHs	KHM Environmental Management, 2000
Elf Atochem 1999 Willamette River	WLRELF99	Sediment investigation of Atofina shoreline	8	11/23/1998	1/20/1999	15 subsurface sediment, 13 surface sediment	surface 0-10 cm, up to 90 cm	N	N	X			X		X			X			Elf Atochem, 1999
Port of Portland T4 RI	WLCT4J98	Remedial investigation of Terminal 4	5	10/12/1998	10/15/1998	18 subsurface sediment, 44 surface sediment, 2 surface reference sediment	surface 0-10 cm, subsurface up to 128 cm	N	N	X	X		X		X			X	X	not all samples analyzed for metals or VOCs, petroleum analyzed	Hart Crowser, 1999a
T2/T4 Sediment Study	PPTLDT24	Dredged material characterization	6, 10	9/15/1998	10/15/1998	3 subsurface porewater, 3 subsurface sediment	0-91 cm	Y	Y	X	X	X	X	X	X						Hart Crowser, 1999a, 1999b
Sediment Characterization Local Sponsors' Berths (conducted with Corps)	WLCT0I98	Dredged material characterization of Port of Portland berths	2, 5-8, 10-12	9/14/1998	9/14/1998	7 subsurface porewater, 7 subsurface sediment, 12 surface porewater, 12 surface sediment	surface 0-10 cm, subsurface up to 152 cm	Y - 6 subsurface	N	X	X	X	X	X	X					porewater analyzed for butyltins	Hart Crowser, 1999c
Portland Shipyard Sed. Inv.	PSYSEA98	Sediment investigation to characterize distribution of chemicals in surface and subsurface sediments, supporting property transfer	8, 9, 10, 11	3/31/1998	4/16/1998	65 subsurface sediment, 60 surface sediment, 61 surface porewater, 3 surface reference	surface 0-10 cm, subsurface to 490 cm	N	N	X	X	X	X	X	X			X		butyltins, pesticides, VOCs not analyzed in all samples; porewater analyzed for butyltins	SEA 1998
Willamette River 1998 Data	WRD&M98	Sediment investigation to identify chemicals in the vicinity of the shipyard and their distribution	7, 8, 9, 10, 11	1/19/1998	1/21/1998	12 surface sediment	0-10 cm	N	N	X	X	X	X	X						SVOCs limited to PAHs and phthalates, butyltins analyzed in 7 samples	Dames & Moore, 1998
Portland Shipyard Env. Audit	PSYD&M97	Sediment investigation to identify chemicals in the vicinity of the shipyard and their distribution	9	11/26/1997	1/22/1998	4 subsurface sediment, 8 surface	surface 0-10 cm; subsurface up to 304 cm	N	N	X	X	X	X	X				X		butyltins and VOCs not analyzed in all samples; SVOCs sometimes limited to PAHs and phthalates	Dames & Moore, 1998

Table 4-2. Summary of Sediment Investigations Conducted in the Lower Willamette River Since 1990.

Survey Name	Survey ID	Study Objective	River Mile(s)	Begin Date	End Date	Number of Samples	Sample Intervals (cm)	Composite (Y/N)	Dredged (Y/N)	Conv.	Metals	Butyltins	SVOCs	PCBs	Pest.	PCB Cong.	Dioxin/ Furan	VOCs	Other	Comment	Reference
T4 Berth 416 1997 Sediment Characterization Study	WLCT4J97	Dredged material characterization	5, 6	10/23/1997	10/24/1997	4 subsurface sediment and 4 subsurface porewater	up to 182 cm	Y - 1 sample	Y	X	X	X	X	X	X					porewater analyzed for butyltins	Hart Crowser, 1998
Portland Harbor Sediment Investigation	WR-WSI98	EPA's sediment inspection	4 - 10	9/17/1997	2/2/1999	158 surface sediment, 28 surface porewater, 39 subsurface sediment	surface 0-10 cm, subsurface 0-90 cm	Y - 12 samples	Y - SD029, SD032	X	X	X	X	X	X	X	X		X	some samples analyzed for herbicides, dioxin/furans, PCB congeners, butyltins; porewater analyzed for butyltins and metals	Roy F. Weston, 1998
Baseline Sediment Riedel	RIEDEL97	Baseline sediment assessment off Riedel's Portland Yard Site	8	8/12/1997	8/13/1997	19 subsurface sediment, 8 surface sediment	surface 0-15 cm, subsurface to 460 cm	N	N	X	X	X	X							limited SVOCs analyses	no source document
CRCD - Willamette River Channel Deepening	WLR0797	Dredged material characterization supporting proposed channel deepening project	1-9, 11, 12	7/22/1997	7/25/1997	18 surface sediment, 17 surface porewater, 50 subsurface sediment, and 1 subsurface porewater	surface up to 25 cm, subsurface up to 609 cm	Y- 3 samples	Y - WRGC30 and WRGC31	X	X	X	X	X	X					porewater analyzed for butyltins	USACE, 1999
Willamette 1996 Portland Harbor	WLR1196	Dredged material characterization	9, 10, 11	11/13/1996	11/14/1996	2 surface sediment, 4 subsurface sediment	surface 0-13 cm, subsurface up to 244 cm	N	Y	X	X	X	X	X	X						USACE, 1998
T1/T2/T5 Sediment Characterization Study	WLCT0K96	Dredged material characterization	2, 10, 11	11/12/1996	11/13/1996	7 subsurface sediment, 1 surface sediment	surface 0-15 cm, subsurface up to 121 cm	Y - 4 subsurface	Y	X	X	X	X	X	X					SVOCs limited to PAHs and phenols	Hart Crowser, 1997
Focused ESA Riedel	RIEDEL96	Environmental site assessment of Riedel's Portland Yard Site	8	9/3/1996	9/3/1996	7 subsurface sediment	up to 45 cm	N	N	X	X	X		X							Maul Foster & Alongi, 1996
Willamette Falls Locks 1996 Flood Deposits Sediment Quality Evaluation	WLFL0496	Dredged material characterization	26	4/18/1996	4/18/1996	1 subsurface composite sample, 3 subsurface for grain size	0-121 cm	Y - 1 sample	Y	X	X		X							three samples analyzed for conventionals only	USACE, 1998
Gasco Phase I Remedial Investigation	WLCGSA96	Phase I remedial investigation of Gasco Site, including a summary of existing information	7	1/23/1996	1/24/1996	10 subsurface sediment, 12 surface sediment	surface 0-15 cm, subsurface to 289 cm	N	N	X	X		X					X	X	SVOCs limited to PAHs, petroleum analyzed	Hahn and Associates, 1998
Willamette Cove SA	WLCWCJ95	Supplemental Environmental Site Assessment of St. Johns Riverfront Property, Willamette Cove	5	10/19/1995	10/19/1995	3 surface sediment	0-15 cm	Y	N		X	X	X	X				X		one sampled analyzed for butyltins	EMCON, 1996
US Moorings May 1995	MOOR0595	Sediment investigation of US Moorings Site	7	5/16/1995	5/17/1995	43 subsurface sediment, 1 surface sediment	up to 351 cm	N	N	X	X	X	X		X		X			dioxin/furans and butyltins not analyzed in all samples	USACE, 1998
Rose Festival Fleet Moorage	WLCRFE95	Dredged material characterization	13	5/11/1995	5/11/1995	5 surface sediment	0-15 cm	N	Y	X	X	X	X	X	X					SVOCs limited to PAHs	AGI Technologies, 1995
Rhône-Poulenc St Helens Road Facility Q1,95	WLCRPB95	Sampling associated with quarterly monitoring at Rhône-Poulenc discharge point	7, 8	2/1/1995	2/1/1995	5 surface sediment	0-15 cm	N	N	X	X		X		X		X	X	X	herbicides also analyzed	Woodward-Clyde Consultants, 1995
US Moorings Preliminary Assessment Sampling	MOOR1294	Preliminary Assessment of US Moorings Site	7	12/20/1994	12/20/1994	9 surface sediment	0-15 cm	N	N	X	X										USACE, 1998
PSY DD3 Post-Dredge Data	PSYDD3	Post-dredged material characterization	9	12/15/1994	12/15/1994	3 subsurface sediment, 8 surface sediment	surface 0-12 cm; subsurface up to 50 cm	N	N	X	X	X	X	X	X			X		Subsurface analyzed for conventionals, metals, and SVOCs only	Hartman & Associates, 1995
Characterization of Stormwater Outfalls	WRSTRM94	Characterization of sediments off stormwater discharges	5, 9, 10, 12, 14	7/15/1994	7/19/1994	25 surface sediment, 4 subsurface sediment	up to 10 cm	N	N	X	X		X	X	X			X			Hartman & Associates, 1995
US Moorings June 1994	MOOR0694	Sediment investigation of US Moorings Site	7	6/14/1994	6/14/1994	31 surface sediment	0-13 cm	Y - 6 samples	N	X	X	X	X	X	X		X				USACE, 1999
T2 Berth 203 Project	WLRPT294	Dredged material characterization	10	3/15/1994	5/20/1994	1 surface and 2 subsurface sediment	lower limit undefined	Y - 3 samples	Y	X	X	X	X	X	X			X		one samples analyzed for conventionals, miscellaneous SVOCs and VOCs	CAS, 1994
T4 Berth 408 Maintenance Dredging	WLCT4L93	Dredged material characterization	5	12/7/1993	12/7/1993	3 subsurface sediment	0-66 cm	N	Y	X	X	X	X	X	X			X			Port of Portland, 1994a
PSY DD4 Post-Dredge Data	PSYDD4	Post-dredged material characterization	8, 9	12/15/1992	12/15/1992	9 surface sediment	0-15 cm	N	N	X	X	X	X	X	X			X			Hartman & Associates, 1995
Willamette 1992 Portland Harbor	WLR0692	Dredged material characterization	9, 10, 11	6/3/1992	6/3/1992	6 subsurface sediment	up to 240 cm	N	N	X	X		X	X	X						USACE, 1998
USGS - Bonn	WBWRIR98	An occurrence and distribution study of dioxins/furans in the Willamette River Basin conducted from 1992 to 1995	5, 13	1/1/1992	1/1/1995	2 surface sediment	0-2 cm	N	N	X							X				USGS, 1998
T1 1992 Sediment Characterization Results	WLCT1L91	Dredged material characterization	11	12/17/1991	12/17/1991	2 subsurface sediment	lower depth unknown	N	Y	X			X	X	X			X			Port of Portland, 2000a
McCormick & Baxter RI Phase 2	MBCREOS2	Phase II remedial investigation of McCormick & Baxter Creosoting Co.	7	9/1/1991	1/30/1992	18 subsurface sediment, 6 surface sediment, 1 upriver reference surface	surface 0-6 cm; subsurface up to 2377 cm	N	N	X	X		X				X			dioxins/furans not analyzed in all samples	PTI, 1992
McCormick & Baxter RI Phase 1	MBCREOS1	Phase I remedial investigation of McCormick & Baxter Creosoting Co.	7	9/21/1990	10/17/1990	16 subsurface sediment,62 surface sediment, 1 upriver reference surface	surface 0-6 cm; subsurface up to 509 cm	Y - 6 surface (TR1-TR6)	Y - 2 locations (SC49, SC85)	X	X		X		X		X			pesticides and dioxins/furans not analyzed in all samples; SVOCs sometimes limited to PAHs	PTI, 1992
Berth 311 Dredge Data	PSBTH311	Dredged material characterization	9	9/9/1990	4/8/1992	8 subsurface sediment, 14 surface sediment	surface 0-20 cm, subsurface up to 40 cm	Y - 5 samples	Y - 4 locations (3, 4, 5, 6)	X	X	X	X	X	X			X		butyltins analyzed in composite samples only	Port of Portland, 1992
Col Wil Channel Deepening Reconnaissance Study	COLWIL90	Sediment quality reconnaissance study for proposed deepening of the navigation channel, primarily focused on extent of dioxins and furans	5, 7-10, 12	5/3/1990	5/18/1990	13 subsurface sediment	up to 142 cm	N	Y - 2 locations (WRGC06, WRGC09)	X								X				USACE, 1990
Columbia Basin Contaminant Data	CLBC8494*	DEQ (1994) - Study to determine presence and effects of toxic pollutants to RM 161; Curtis et al. (1993) - Study to determine extent of TCDD/TCDF to RM 314	11, 12	1/1/1984	1/1/1994	DEQ (1994) - 6 surface below RM 27 and only 1 (RM12) since 1990; Curtis et al. (1993) - 1 surface at RM 11	0-15 cm	N	N	X			X	X		X	X			DEQ (1992) - conv., SVOCs, PCB congeners, pesticides; Curtis et al (1993) - dioxin/furans, conv.	EPA, 1996

* Includes Curtis et al. 1993, Willamette River Toxics Study (DEQ 1994)

Table 4-3. Historical Category 1 and 2 Surface Sediment and Porewater Chemical Data Summary (1990-present).

Analyte	N	N Detected	% Detected	Detected Concentrations					Detected and Nondetected Concentrations				
				Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
Zinc (mg/kg)	574	574	100	17.3 G	2700 L	182	109	479	17.3 G	2700 L	182	109	479
Chromium (mg/kg)	547	547	100	8	819 J	40	31.9	50.6	8	819 J	40	31.9	50.6
Total solids (%)	368	368	100	10.9	98.3	54	49.7	84.8	10.9	98.3	54	49.7	84.8
Aluminum (mg/kg)	192	192	100	3560	46200	32924	37300	43400	3560	46200	32924	37300	43400
Iron (mg/kg)	189	189	100	19100	84900	41196	42100	51700	19100	84900	41196	42100	51700
Manganese (mg/kg)	189	189	100	277	1440	656	664	837	277	1440	656	664	837
Barium (mg/kg)	186	186	100	58.9 G	426	174	178	208	58.9 G	426	174	178	208
Cobalt (mg/kg)	173	173	100	11.3	55.5	19	18.3 J	20.7	11.3	55.5	19	18.3 J	20.7
Magnesium (mg/kg)	173	173	100	3500	14500	6633	6860	7590	3500	14500	6633	6860	7590
Vanadium (mg/kg)	173	173	100	66.6	160	101	103	122	66.6	160	101	103	122
Calcium (mg/kg)	160	160	100	4430 J	53800	8594	8250	9820	4430 J	53800	8594	8250	9820
Potassium (mg/kg)	160	160	100	320	50000	1605	1270	1530	320	50000	1605	1270	1530
Sodium (mg/kg)	160	160	100	330	49000	1704	1090	2420	330	49000	1704	1090	2420
Total volatile solids (%)	160	160	100	0.8	12.9	6.5	6.68	9.7 J	0.8	12.9	6.5	6.68	9.7 J
Titanium (mg/kg)	86	86	100	608	3680	1862	1900	2940	608	3680	1862	1900	2940
Total sulfides (mg/kg)	69	69	100	1	1830 G	92	17 G	249 G	1	1830 G	92	17 G	249 G
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin (ng	33	33	100	26	220000	10586	380	18000	26	220000	10586	380	18000
Octachlorodibenzo-p-dioxin (ng/kg)	33	33	100	250	1700000	68955	2900 J	93000 J	250	1700000	68955	2900 J	93000 J
Barium (mg/l)	28	28	100	0.03	0.18	0.10	0.1	0.16	0.03	0.18	0.097	0.1	0.16
Calcium (mg/l)	28	28	100	10.2	163	78	71.4	136	10.2	163	78	71.4	136
Iron (mg/l)	28	28	100	0.49	43.4	12	8.17	26.9	0.49	43.4	12	8.17	26.9
Magnesium (mg/l)	28	28	100	3.77	55.3	27	24.1	46.6	3.77	55.3	27	24.1	46.6
Manganese (mg/l)	28	28	100	0.88	20.5	8.5	7.68	15.2	0.88	20.5	8.5	7.68	15.2
Potassium (mg/l)	28	28	100	1.2	5.1	3.3	3.4	4.7	1.2	5.1	3.3	3.4	4.7
Sodium (mg/l)	28	28	100	10.1	18.9	15	14.7	17.8	10.1	18.9	15	14.7	17.8
Heptachlorodibenzofuran (ng/kg)	19	19	100	12	39000	2565	160	4100	12	39000	2565	160	4100
Heptachlorodibenzo-p-dioxin (ng/kg)	19	19	100	83	430000	24885	440	11000	83	430000	24885	440	11000
Hexachlorodibenzofuran (ng/kg)	19	19	100	5.2	18000	1259	130	1800	5.2	18000	1259	130	1800
Acid Volatile Sulfides (umol/g)	6	6	100	0.005 G	0.03	0.02	0.01	0.03 G	0.005 G	0.030	0.016	0.01	0.03 G
Moisture (%)	6	6	100	39	220	76	51	54	39	220	76	51	54
pH (pH units)	4	4	100	6.4	7	6.6	6.4	6.6	6.4	7	6.6	6.4	6.6
Specific Gravity (Std_ Units)	4	4	100	2.49	2.75	2.7	2.71	2.74	2.49	2.75	2.7	2.71	2.74
Dioxin/furan TCDD toxicity equivalent (ng/kg)	2	2	100	16.09 T	38.96 T	27.53	16.09 T	16.09 T	16.09 T	38.96 T	28	16.09 T	16.09 T
Acridine (ug/kg)	1	1	100	3160	3160	3160	3160	3160	3160	3160	3160	3160	3160
Azulene (ug/kg)	1	1	100	260	260	260	260	260	260	260	260	260	260
Perylene (ug/kg)	1	1	100	1150	1150	1150	1150	1150	1150	1150	1150	1150	1150
Retene (ug/kg)	1	1	100	940	940	940	940	940	940	940	940	940	940
Total organic carbon (%)	568	567	100	0.04	14 M	1.7	1.5	3.53 J	0.04	14 M	1.7	1.5	3.53 J
Nickel (mg/kg)	504	503	100	9	594	26	24	34	9	594	26	24	34
Copper (mg/kg)	580	573	99	1	2000	78	43	154	1	2000	77	42.8	154
Ammonia (mg/l)	52	51	98	0.24	6.77	2.1	1.75	4.44	0.05 U	6.77	2.1	1.75	4.44
Octachlorodibenzofuran (ng/kg)	33	32	97	15	33000	2549	130	4800 J	15	33000	2473	130	4800 J
C1-Fluoranthene/pyrene (ug/kg)	29	28	97	7.9	3300	381	168	750	5 U	3300	368	160	750

Table 4-3. Historical Category 1 and 2 Surface Sediment and Porewater Chemical Data Summary (1990-present).

Analyte	N	N Detected	% Detected	Detected Concentrations					Detected and Nondetected Concentrations				
				Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
C1-Phenanthrene/anthracene (ug/kg)	29	28	97	6.7	1820	274	106	517	5 U	1820	264	70	517
C2-Phenanthrene/anthracene (ug/kg)	29	28	97	5.3	6000	395	96	467	5 U	6000	381	63	467
Lead (mg/kg)	541	522	96	2.8	1160 E	45	18.8	155	2.8	1160 E	44	19.3	153 E
Aluminum (mg/l)	28	27	96	0.03	19.4	1.7	0.14	6.47	0.02 U	19.4	1.6	0.14	6.47
Arsenic (mg/l)	28	27	96	0.001	0.009	0.003	0.002	0.008	0.001 U	0.009	0.003	0.002	0.008
Tributyltin ion (ug/kg)	141	134	95	0.4 J	47000	2199	100	9660 H	0.4 J	47000	2091	92	9600
Hexachlorodibenzo-p-dioxin (ng/kg)	19	18	95	5	53000	3335	86	2000	5	53000	3160	85	2000
1,2,3,4,6,7,8-Heptachlorodibenzofuran (ng/kg)	33	31	94	6.3	16000	967	58	1800 J	5 U	16000	910	58	1800 J
C1-Chrysene (ug/kg)	29	27	93	3.9	1900	240	78	660	3.9	1900	224	72	660
C3-Phenanthrene/anthracene (ug/kg)	29	27	93	3.2	4200	276	47	448	3.2	4200	257	43	448
Cobalt (mg/l)	28	26	93	0.003	0.02	0.009	0.01	0.01	0.003 U	0.02	0.009	0.008	0.01
Ammonia (mg/kg)	49	45	92	12.2	224	91	85.8	161	12.2	224	93	86.8	167 UJ
High Molecular Weight PAH (ug/kg)	645	582	90	2 A	12268000 A	65500	1613 A	222000 A	2 A	12268000 A	59182	1429 A	180500 A
Polycyclic Aromatic Hydrocarbons (ug/kg)	645	581	90	4.5 A	26408000 A	147246	1950 A	402700 A	4.5 A	26408000 A	132727	1720 A	364840 A
Pyrene (ug/kg)	645	579	90	0.8 G	3400000	16710	332	54000	0.8 G	3400000	15081	310	43400
Pentachlorodibenzofuran (ng/kg)	19	17	89	5.2	2000	163	27	180	0.94 U	2000	146	15	180
Zinc (mg/l)	28	25	89	0.004	0.17	0.017	0.008	0.02	0.004 U	0.17	0.016	0.008	0.02
Fluoranthene (ug/kg)	656	585	89	0.8 G	3000000	18454	342	49000	0.8 G	3000000	16541	324	45000
Total Petroleum Hydrocarbons (mg/kg)	35	31	89	28	470	151	140	240	25 U	470	137	116	240
C2-Naphthalene (ug/kg)	29	25	86	2.4	1080	142	26	520	2.4	1080	124	22 U	520
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin (ng/kg	33	28	85	2	12000	662	21	540	1.3 U	12000	562	16	540
Chrysene (ug/kg)	645	545	84	3 G	1300000	6646	190 G	23000	3 G	1300000	5728	164	16000
Pencil pitch (mg/kg)	44	37	84	310	14000	2274	1500	5200	100 U	14000	1938	1100 E	4500
C1-Fluorene (ug/kg)	29	24	83	3.3	1300	104	22	287	1.7 U	1300	88	17	287
C2-Dibenzothiophene (ug/kg)	29	24	83	5.5	1600	147	34	409	1.7 U	1600	123	20 U	409
C3-Naphthalene (ug/kg)	29	24	83	4.9	9000	538	36	1100	1.7 U	9000	447	22	1100
C4-Naphthalene (ug/kg)	29	24	83	4.3	18000	864	27	740	1.7 U	18000	717	20 U	740
Phenanthrene (ug/kg)	645	532	82	1 G	5400000	32108	200	74000	1 G	5400000	26570	160	40000
Low Molecular Weight PAH (ug/kg)	645	531	82	2.5 A	14140000 A	89320	379 A	165600 A	2.5 A	14140000 A	73632	284 A	90970 A
Benzo(b+k)fluoranthene (ug/kg)	626	515	82	6 A	1280000 A	8015	300 A	27000 A	5 UA	1280000 A	6695	237 A	22000 A
Benzo(b)fluoranthene (ug/kg)	543	446	82	3 G	930000	4349	120	12000 G	3 G	930000	3678	103	10000 G
1,2,3,4,7,8-Hexachlorodibenzofuran (ng/kg)	33	27	82	5	1300	125	18	460	1.2 U	1300	103	13	460
Benz(a)anthracene (ug/kg)	645	522	81	3 G	840000	5633	160	18000	3 G	840000	4657	124	14000
Benzo(a)pyrene (ug/kg)	643	515	80	3 G	1000000	5166	170	15000	3 G	1000000	4233	140	12000 G
Benzo(e)pyrene (ug/kg)	58	46	79	75	50000	5985	880	27000	21 U	50000	4943	660	27000
Tetrachlorodibenzofuran (ng/kg)	19	15	79	1.1	550	65	13	140	1 U	550	52	6.1	140
Benzo(k)fluoranthene (ug/kg)	543	424	78	3 G	350000	2754	100	11000	3 G	350000	2259	83	8300 G
Cyanide (mg/kg)	9	7	78	0.3 J	2.2	1.1	0.6	1.5	0.2 U	2.2	0.889	0.5	1.5
Chromium hexavalent (mg/kg)	58	45	78	0.07 G	0.99 G	0.43	0.4 G	0.85 G	0.07 G	0.99 G	0.355	0.29 G	0.85 G
C1-Naphthalene (ug/kg)	13	10	77	3.5	327	59	7.7	102	1.7 U	327	49	7.7	102
Dibenzothiophene (ug/kg)	30	23	77	3.6	3160	197	27	151	1.7 U	3160	153	21 U	151
C3-Dibenzothiophene (ug/kg)	29	22	76	5.6	1100	117	30	311	1.7 U	1100	90	20 U	311
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin (ng/kg	33	25	76	1 J	3200 J	271	10 J	180	1 J	3200 J	206	8 U	180

Table 4-3. Historical Category 1 and 2 Surface Sediment and Porewater Chemical Data Summary (1990-present).

Analyte	N	N Detected	% Detected	Detected Concentrations					Detected and Nondetected Concentrations				
				Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
Acid Volatile Sulfides (mg/kg)	85	63	74	0.8	1100 X	52	13.7	110 X	0.7 U	1100 X	39	6.1	100 X
Arsenic (mg/kg)	625	462	74	0.6 E	132	6.3	4.4	12	0.6 E	132	5.9	5 U	10.3
Mercury (mg/kg)	502	371	74	0.01	1.5	0.12	0.07	0.3	0.01	1.5	0.122	0.08	0.25
Cadmium (mg/kg)	512	377	74	0.05	6.6 G	0.62	0.4	2 G	0.0093 U	6.6 G	0.690	0.4	2 G
Beryllium (mg/kg)	250	184	74	0.22	1.1	0.64	0.66	0.83	0.22	4.8 U	0.837	0.7	1.1 U
Silver (mg/kg)	508	371	73	0.01 J	3.3	0.56	0.4	1.3	0.01 J	4.8 U	0.819	0.6	2 U
C2-Chrysene (ug/kg)	29	21	72	2	1600	153	34	200	2	1600	112	27	200
C2-Fluorene (ug/kg)	29	21	72	3.8	4400	278	22	350	1.7 U	4400	204	12	350
Indeno(1,2,3-cd)pyrene (ug/kg)	645	456	71	2 G	530000	3791	121	14000 G	2 G	530000	3004	91	10000
Benzo(g,h,i)perylene (ug/kg)	640	450	70	0.6 G	820000	4037	121	12000	0.6 G	820000	3129	95	10000
1,2,3,4,7,8,9-Heptachlorodibenzofuran (ng/kg)	33	23	70	3.1	770	84	9	160	0.88 U	770	60	6	160
2,3,4,6,7,8-Hexachlorodibenzofuran (ng/kg)	33	23	70	2.9	1100	75	9.9	75	0.41 U	1100	54	5 J	75
Tetrachlorodibenzo-p-dioxin (ng/kg)	19	13	68	1.6	310	39	11	66	0.93 U	310	27	3.1	66
Residual Range Organics (mg/kg)	19	13	68	72 Z	840	322	230 Z	640	32 U	840	291	230 Z	640
Bis(2-ethylhexyl) phthalate (ug/kg)	470	306	65	21	88000 J	1610	350	3700 B	15 U	88000 J	1421	280 G	4000 U
2,3,7,8-Tetrachlorodibenzofuran (ng/kg)	34	22	65	1.6	98	19	10	50	1 U	98	13	4.5	50
Anthracene (ug/kg)	645	413	64	0.8 G	1100000	8127	97	26000	0.8 G	1100000	5358	50 U	11000
C4-Dibenzothiophene (ug/kg)	13	8	62	4.9	232	41	6.8	33	1.7 U	232	40	6.8	141 U
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin (ng/kg	33	20	61	1.6	1400	144	13	1100	0.4 U	1400	89	4.9 U	93
Total of 3 isomers: pp-DDT,-DDD,-DDE (ug/k	274	165	60	0.2 A	84909 A	949	10.3 A	1030 A	0.2 A	84909 A	575	6.7 UA	679 A
Thallium (mg/kg)	237	140	59	0.04 J	27	10	9	23	0.04 J	48 U	8.4	7	24
Fluorene (ug/kg)	645	364	56	0.5 G	1100000 J	16916	85 G	43000	0.5 G	1100000 J	9701	37	11000
Naphthalene (ug/kg)	645	361	56	0.5 G	5100000	34890	58	30200	0.5 G	5100000	19819	31	10000 U
C3-Chrysene (ug/kg)	29	16	55	5.5	830	96	25	176	1.7 U	830	56	8.8	120
Tin (mg/kg)	29	16	55	0.89 X	14.2 G	3.695	2.05 X	7.04 G	0.89 X	14.2 G	3.9	3.9 U	6.16 G
1,2,3,7,8-Pentachlorodibenzo-p-dioxin (ng/kg)	33	18	55	1.3	590	71	8.6	480	0.44 U	590	40	4.8 U	54
2,3,4,7,8-Pentachlorodibenzofuran (ng/kg)	33	18	55	1.9	740	78	15	290	0.65 U	740	45	7.6	130
Acenaphthene (ug/kg)	645	349	54	0.9 G	1600000	22298	100	51000	0.9 G	1600000	12234	45	15000
Vanadium (mg/l)	28	15	54	0.003	0.03	0.0066	0.004	0.01	0.003 U	0.03	0.005	0.003	0.01
Dibutyltin ion (ug/kg)	120	63	53	0.6 J	2020 GH	165	17	800	0.6 J	2020 GH	89	5.8 U	692 GH
C1-Dibenzothiophene (ug/kg)	29	15	52	2.1	7400	560	10	270	1.7 U	7400	294	5 U	247
1,2,3,7,8-Pentachlorodibenzofuran (ng/kg)	33	17	52	1.6 J	320	54	13	200	0.94 U	320	30	4.9 U	100
2,3,7,8-Tetrachlorodibenzo-p-dioxin (ng/kg)	34	17	50	0.51	100	11	1.62	43	0.24 U	100	6.2	1.2	10
1-Methylnaphthalene (ug/kg)	16	8	50	1	68	28	16	47	1	68	17	5 U	47
4,4'-DDD (ug/kg)	274	136	50	0.2 J	11000	159	6.7	194	0.2 J	11000	82	3.3 U	100 J
1,2,3,7,8,9-Hexachlorodibenzofuran (ng/kg)	33	16	48	2.2	690	86	7.2	530	0.18 U	690	44	4.9 U	31
C4-Phenanthrene/anthracene (ug/kg)	29	14	48	2.7	1500	151	22	201	1.7 U	1500	81	5 U	141 U
4,4'-DDE (ug/kg)	273	131	48	0.3 J	1480	33	3.3	100	0.3 J	1480	22	2.6	96 U
Pentachlorodibenzo-p-dioxin (ng/kg)	19	9	47	5.6	2200	325	24	300	0.56 U	2200	156	4.9 U	300
Selenium (mg/kg)	281	131	47	0.47	20	12	12	17	0.31 UJ	20	6.3	5 U	15
trans-Chlordane (ug/kg)	26	12	46	1.99 JP	25.3 P	9.7	7.23	19.9 P	0.99 U	41 U	8.2	2.3 JP	25.3 P
1,2,3,6,7,8-Hexachlorodibenzofuran (ng/kg)	33	15	45	2	650	86	10	350	1.9 U	650	47	9.6 U	100
4,4'-DDT (ug/kg)	274	120	44	0.2	81000	1088	10 G	2100	0.2	81000	481	6.7 U	620

Table 4-3. Historical Category 1 and 2 Surface Sediment and Porewater Chemical Data Summary (1990-present).

Analyte	N	N Detected	% Detected	Detected Concentrations					Detected and Nondetected Concentrations				
				Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
Dibenz(a,h)anthracene (ug/kg)	645	281	44	0.7 G	98000	879	61	2500	0.7 G	98000	841	32.1	3000 U
Butyltin ion (ug/kg)	120	52	43	0.6 J	740 J	35	10 G	95.5	0.6 J	740 J	18	5.8 U	58 H
Tributyltin ion (ug/l)	150	64	43	0.006 J	11	0.68	0.14	1.79	0.006 J	11	0.309	0.05 U	1.07
Diesel fuels (mg/kg)	140	57	41	16.2 JV	2100	235	92	720	10 U	2100	131	72	480
Carbazole (ug/kg)	270	108	40	2 J	44000	1708	64	5500	2 J	44000	860	33 J	3400 U
Lead (mg/l)	28	11	39	0.001	0.04	0.007	0.002	0.01	0.001	0.04	0.003	0.001 U	0.01
trans-Nonachlor (ug/kg)	18	7	39	8.64 P	19.1	13	9.74	15.3	4.9 U	19.1	8.6	6.58 U	15.3
C4-Fluorene (ug/kg)	13	5	38	4.3	66	31	13	38	1.7 U	141 U	28	13	66
C3-Fluorene (ug/kg)	29	11	38	5.6	370	73	16	123	1.7 U	370	31	5 U	117
4-Methylphenol (ug/kg)	374	141	38	20	1400	386	330	950	16 U	90000 U	774	100 U	3000 UG
Antimony (mg/kg)	426	159	37	0.02 G	15.2	3.0	0.59 J	10 J	0.02 UG	24 U	4.2	2.78 U	10.5 U
Polychlorinated biphenyls (ug/kg)	336	122	36	4 A	9300 A	392	105 A	1240 A	4 UJ	9300 A	216	39 UA	1000 A
Dibenzofuran (ug/kg)	493	179	36	0.9 J	620000	5635	42	1900	0.9 J	620000	2308	20 U	3000 U
2-Methylnaphthalene (ug/kg)	448	161	36	1 GB	1300000	12766	30	1700 G	1 GB	1300000	4760	20 U	3000 U
Acenaphthylene (ug/kg)	645	223	35	0.7 G	190000	2071	50.8	2600	0.7 G	190000	941	20 G	3000 U
Pristane (mg/kg)	44	15	34	0.5	7	1.62	0.7	5.3	0.5 U	7	0.882	0.5 U	1.5
2,4'-DDD (ug/kg)	18	6	33	6.07 P	24	13	9.42 P	17.5 P	4.71 U	24	8.145	5.94 U	17.5 P
Acetone (ug/kg)	55	16	29	10 J	340	114	50 J	310	8 U	5100 U	391	100 U	2500 U
Copper (mg/l)	28	8	29	0.002	0.13	0.03	0.003	0.04	0.002 U	0.13	0.009	0.002 U	0.02
Aroclor 1260 (ug/kg)	326	93	29	4 J	7000 H	193	42	390	3.21 U	7000 H	104	19.5	200 U
Butylbenzyl phthalate (ug/kg)	461	120	26	3 J	6000	176	43	385	3 J	20000 U	343	25	2000 G
Lube Oil (mg/kg)	108	28	26	81	2110	496	310 E	1100 E	3.22 U	2110	188	100 U	681 J
Phytane (mg/kg)	44	11	25	0.5	6.1	1.8	0.8	5.3	0.5 U	6.1	0.855	0.5 U	1
Disulfoton (ug/kg)	4	1	25	56	56	56	56	56	50 U	56	52	50 U	50 U
Chlorobenzene (ug/kg)	75	17	23	2 J	34000	2029	5 J	250	2 J	34000	478	5 U	100 U
Aroclor 1254 (ug/kg)	326	70	21	5 J	740	118	54 J	400	1.88 U	2000 U	85	20 U	380 U
Dibutyl phthalate (ug/kg)	460	98	21	1 J	640	56	26.7	180	1 J	20000 U	373	20 U	2400 UG
Di-n-octyl phthalate (ug/kg)	461	74	16	10	30100 J	912	52	4290	10 U	30100 J	493	23	3000 U
Xylene (ug/kg)	102	16	16	13	18000	1560	68	3200	2 U	18000	306	50 U	300 U
Tetrabutyltin (ug/kg)	96	14	15	0.3 J	150	17	1 J	32	0.3 J	150	6.6	5.7 U	6 U
C4-Chrysene (ug/kg)	29	4	14	2	810	205	2.5	3.5	1.7 U	810	40	5 U	22 U
2,4-D (ug/kg)	29	4	14	9	93	37	21	24	0.23 U	250 U	20	0.28 U	93
2,4-DB (ug/kg)	29	4	14	13	130	46	19	23	0.16 U	1000 U	66	0.2 U	130
Heavy oil (mg/kg)	41	5	12	9.6	5100	1107	91	240	9.6	5100	185	25 U	125 U
2,4'-DDE (ug/kg)	18	2	11	7.77 P	8.21 P	7.99	7.77 P	7.77 P	4.58 U	8.21 P	5.8	5.21 U	7.77 P
Dibutyltin ion (ug/l)	65	7	11	0.007 J	0.1	0.028	0.01 J	0.03 J	0.007 J	0.1	0.054	0.05 U	0.06 U
Chromium (mg/l)	28	3	11	0.006	0.02	0.011	0.006	0.007	0.005 U	0.02	0.006	0.005 U	0.006
Tetrachlorophenol (ug/kg)	21	2	9.5	9	13	11	9	9	5 U	425 UJ	94	31.8 U	337 UJ
Methylene chloride (ug/kg)	65	6	9.2	5 B	16 B	9	7 B	11 B	5 U	1020 U	96	10 U	500 U
alpha-Chlordane (ug/kg)	151	13	8.6	0.2 J	18.4 P	7.5	2.39 J	17.3 P	0.2 J	110 U	9.9	2 U	48 U
Aldrin (ug/kg)	237	20	8.4	0.2 J	60	8.6	2.2	28.6 P	0.2 J	200 U	13	2 UH	50 U
Natural gasoline (mg/kg)	13	1	7.7	300	300	300	300	300	10 U	300	42	20 U	50 U
Aroclor 1248 (ug/kg)	326	25	7.7	32.6	9300	834	190	1600	2.18 U	9300	117	13 U	420

Table 4-3. Historical Category 1 and 2 Surface Sediment and Porewater Chemical Data Summary (1990-present).

Analyte	N	N Detected	% Detected	Detected Concentrations					Detected and Nondetected Concentrations				
				Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
Ethylbenzene (ug/kg)	198	15	7.6	0.06 J	10000	897	8	2000	0.009 U	10000	106	10 U	300 U
Nickel (mg/l)	28	2	7.1	0.01	0.02	0.015	0.01	0.01	0.01 U	0.02	0.010	0.01 U	0.01 U
Silver (mg/l)	28	2	7.1	0.0002	0.0003	0.0003	0.0002	0.0002	0.0002 U	0.0003	0.0002	0.0002 U	0.0002 U
Benzoic acid (ug/kg)	355	25	7.0	35 J	4110 J	809	80 J	3300 J	35 J	220000 U	2952	200 U	20000 U
gamma-Chlordane (ug/kg)	125	8	6.4	2.5	10	4.8	3	7	0.45 U	99 U	10	2 U	48 U
Diethyl phthalate (ug/kg)	461	29	6.3	2 J	26.5 J	6.7	3 J	23.5 J	2 J	20000 U	308	20 U	970 U
Endrin aldehyde (ug/kg)	229	14	6.1	0.3 J	215	16.3	0.5 J	4	0.3 J	215	12	2 UH	60 U
Phenol (ug/kg)	448	27	6.0	6 J	420 J	87	58	210 J	6 J	45000 UJ	441	50 U	3000 U
m,p-Xylene (ug/kg)	105	6	5.7	0.05 J	0.64	0.17	0.08 J	0.1 J	0.02 U	408 U	16	5 U	11 U
o-Xylene (ug/kg)	105	6	5.7	0.03 J	0.87	0.22	0.07 J	0.21	0.008 U	204 U	11	5 U	11 U
cis-Nonachlor (ug/kg)	18	1	5.6	6.88	6.88	6.88	6.88	6.88	4.58 U	7.46 U	5.6	5.21 U	6.88
Pentachlorophenol (ug/kg)	550	30	5.5	0.89	7200 J	589	88 J	1600	0.19 U	60000 U	1459	100 U	6000 U
Endosulfan sulfate (ug/kg)	229	12	5.2	0.2 J	240	22	0.7 J	12	0.2 J	240	13	2 UH	60 U
Dimethyl phthalate (ug/kg)	461	21	4.6	0.6 J	171	26	14	42	0.6 J	20000 U	306	20 U	900 U
Toluene (ug/kg)	181	8	4.4	0.08 J	4200	918	54	2400	0.02 U	4200	82	10 U	300 U
beta-Hexachlorocyclohexane (ug/kg)	229	10	4.4	0.4 J	18	4.3	2.31 JP	7.03	0.4 UJ	600 U	24	2 U	49 U
1,2,4-Trichlorobenzene (ug/kg)	323	13	4.0	2 JB	190	19	5 JB	10	2 JB	22000 UJ	304	20 U	1900 U
Dieldrin (ug/kg)	237	9	3.8	0.2 J	10	2.7	0.3 J	6	0.2 J	400 UH	14	2 UH	95 U
Benzene (ug/kg)	190	7	3.7	0.05 J	22000	3145	1.3	7.3	0.01 U	22000	151	10 U	300 U
Mercury (mg/l)	28	1	3.6	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001 U	0.0001	0.0001 U	0.0001 U
Aroclor 1242 (ug/kg)	326	11	3.4	5	350	60	12	130	2.83 U	2000 U	60	10 U	137 U
gamma-Hexachlorocyclohexane (ug/kg)	237	7	3.0	0.2 J	540	79	1.5	6	0.2 J	540	14	2 U	48 U
3- and 4-Methylphenol Coelution (ug/kg)	70	2	2.9	7.3 J	11 J	9.15	7.3 J	7.3 J	7.3 J	12000 U	400	100 U	330 U
alpha-Endosulfan (ug/kg)	216	6	2.8	0.2 J	4.95 P	1.8	0.3 J	3.91	0.2 J	99 U	8.4	2 UH	41 U
1,2-Dichlorobenzene (ug/kg)	375	10	2.7	2 JB	1700 J	175	3 JB	22	1 U	9000 UJ	82	19 U	190 U
Tetrachloroethene (ug/kg)	114	3	2.6	10	60	28	10	15	1 U	250 U	19	9.4 U	100 U
1,4-Dichlorobenzene (ug/kg)	375	9	2.4	4.8	530	127	33	230	1 U	9000 UJ	82	19 U	204 U
Methylethyl ketone (ug/kg)	49	1	2.0	44	44	44	44	44	20 U	5100 U	483	100 U	2500 U
Benzyl alcohol (ug/kg)	361	7	1.9	6 G	160	31	9	15 G	6 U	45000 U	426	25 U	3000 U
Heptachlor (ug/kg)	237	4	1.7	0.4 J	6	1.9	0.6 J	0.7 J	0.4 UJ	200 U	12	2 U	48 U
Hexachlorobenzene (ug/kg)	412	6	1.5	3.2 P	440	135	5.44 P	340	2.45 U	20000 U	497	20 U	3000 U
Aniline (ug/kg)	71	1	1.4	94.4 J	94.4 J	94	94.4 J	94.4 J	50 U	20000 U	2898	200 U	10000 U
2,3,4,6-Tetrachlorophenol (ug/kg)	71	1	1.4	24	24	24	24	24	9.63 U	11000 U	935	200 U	2200 U
Endrin ketone (ug/kg)	156	2	1.3	1.2	1.6	1.4	1.2	1.2	0.45 U	200 U	14	2 U	95 U
Hexachloroethane (ug/kg)	320	4	1.3	38	1600	474	49	210	2.45 U	45000 UJ	486	21 U	3000 U
4-Chloro-3-methylphenol (ug/kg)	342	4	1.2	29.8 J	45000	11351	68 J	306	14 U	45000	414	48 U	3000 U
2,4-Dimethylphenol (ug/kg)	453	5	1.1	7	290	71	9	31	1.4 U	12000 U	319	20 U	3000 U
Bis(2-chloroethoxy) methane (ug/kg)	277	3	1.1	29	30	30	29	30	10 U	6000 U	302	20 U	3000 U
Hexachlorobutadiene (ug/kg)	425	3	0.7	200	270	233	200	230	2.45 U	22000 UJ	767	20 U	3000 U
1,3-Dichlorobenzene (ug/kg)	375	2	0.5	14	36	25	14	14	1 U	9000 UJ	79	19 U	200 U
alpha-Hexachlorocyclohexane (ug/kg)	217	1	0.5	1.03 J	1.03 J	1.03	1.03 J	1.03 J	0.4 UJ	200 U	14	2 U	60 U
2-Methylphenol (ug/kg)	441	2	0.5	17	51	34	17	17	1.4 U	90000 U	514	20 U	3000 U
Endrin (ug/kg)	229	1	0.4	6	6	6	6	6	0.4 UJ	200 U	11	2 U	40 U

Table 4-3. Historical Category 1 and 2 Surface Sediment and Porewater Chemical Data Summary (1990-present).

Analyte	N	N Detected	% Detected	Detected Concentrations					Detected and Nondetected Concentrations				
				Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
Methoxychlor (ug/kg)	229	1	0.4	1 J	1 J	1	1 J	1 J	0.8 UJ	2000 UH	52	5 U	190 U
2,4-Dinitrotoluene (ug/kg)	277	1	0.4	260	260	260	260	260	19.9 U	45000 U	652	97 U	3000 U
2,6-Dinitrotoluene (ug/kg)	277	1	0.4	22000	22000	22000	22000	22000	10 U	22000	445	97 U	3000 U
3-Nitroaniline (ug/kg)	277	1	0.4	475 J	475 J	475	475 J	475 J	26 U	450000 U	3676	120 UJ	20000 U
Nitrobenzene (ug/kg)	277	1	0.4	300	300	300	300	300	8.9 U	22000 UJ	377	20 U	3000 U
N-Nitrosodipropylamine (ug/kg)	277	1	0.4	3 J	3 J	3	3 J	3 J	3 J	45000 U	488	39 U	3000 U
Aroclor 1016 (ug/kg)	326	1	0.3	46	46	46	46	46	5.94 U	2000 U	58	10 U	100 UH
2,4,5-Trichlorophenol (ug/kg)	394	1	0.3	190 J	190 J	190	190 J	190 J	14 U	29000 UJ	601	97 U	3000 UG
2,4,6-Trichlorophenol (ug/kg)	394	0	0						1.4 U	11000 U	392	96 U	3000 U
2,4-Dichlorophenol (ug/kg)	380	0	0						16.8 U	45000 U	1074	100 U	3000 UX
N-Nitrosodiphenylamine (ug/kg)	361	0	0						8.9 U	60000 U	482	20 U	3000 U
2-Chlorophenol (ug/kg)	342	0	0						14 U	22000 U	323	29.6 U	2900 U
4-Nitrophenol (ug/kg)	330	0	0						0.15 U	45000 U	1554	100 UG	10200 U
4,6-Dinitro-2-methylphenol (ug/kg)	328	0	0						56.5 U	90000 U	1828	190 UJ	12000 U
Aroclor 1221 (ug/kg)	325	0	0						2.26 U	4000 U	98	20 U	200 U
Aroclor 1232 (ug/kg)	325	0	0						3.84 U	2000 U	59	10 U	100 U
2-Nitrophenol (ug/kg)	317	0	0						21.4 U	22000 U	389	96 U	3000 U
2,4-Dinitrophenol (ug/kg)	304	0	0						23 U	45000 UJ	1817	250 U	20000 U
2-Chloronaphthalene (ug/kg)	277	0	0						4.58 U	6000 U	295	19 U	3000 U
2-Nitroaniline (ug/kg)	277	0	0						10 U	450000 U	3524	97 U	20000 U
4-Bromophenyl phenyl ether (ug/kg)	277	0	0						8.9 U	22000 U	376	20 U	3000 U
4-Chloroaniline (ug/kg)	277	0	0						14.2 UJ	90000 U	873	58 UJ	3000 U
4-Chlorophenyl phenyl ether (ug/kg)	277	0	0						8.9 U	9000 U	320	20 U	3000 U
4-Nitroaniline (ug/kg)	277	0	0						9.9 U	450000 U	3550	98 U	20000 U
Bis(2-chloroethyl) ether (ug/kg)	277	0	0						8.9 U	9000 UJ	334	39 U	3000 U
Isophorone (ug/kg)	277	0	0						8.9 U	6000 U	299	20 U	3000 U
3,3'-Dichlorobenzidine (ug/kg)	276	0	0						16.8 U	40000 U	1681	97 UJ	20000 U
Hexachlorocyclopentadiene (ug/kg)	260	0	0						21.5 U	12000 U	496	99 U	3000 U
beta-Endosulfan (ug/kg)	229	0	0						0.4 UJ	200 U	11	2 UH	40 U
delta-Hexachlorocyclohexane (ug/kg)	229	0	0						0.4 UJ	200 U	12	2 U	49 U
Heptachlor epoxide (ug/kg)	229	0	0						0.4 UJ	360 U	9.6	2 U	48 U
Toxaphene (ug/kg)	229	0	0						14.3 U	12000 U	598	95 U	4800 U
Bis(2-chloro-1-methylethyl) ether (ug/kg)	207	0	0						10 U	6000 U	323	20 U	3000 U
Trichloroethene (ug/kg)	149	0	0						1 U	204 U	13	5 U	50 U
Chlordane (cis & trans) (ug/kg)	111	0	0						1 U	1000 U	68	10 U	150 U
Bis(2-chloroisopropyl) ether (ug/kg)	69	0	0						8.9 U	90000 U	1721	15 U	1650 U
N-Nitrosodimethylamine (ug/kg)	65	0	0						10 U	40000 U	6086	228 UJ	20000 U
Tetrabutyltin (ug/l)	65	0	0						0.02 U	0.1 UJ	0.040	0.05 U	0.05 U
1,1,1-Trichloroethane (ug/kg)	65	0	0						1 U	250 U	27	9 U	100 U
1,1,2,2-Tetrachloroethane (ug/kg)	65	0	0						2 U	250 U	27	9 U	100 U
1,1,2-Trichloroethane (ug/kg)	65	0	0						2 U	204 U	22	5 U	100 U
1,1-Dichloroethane (ug/kg)	65	0	0						1 U	204 U	22	5 U	100 U
1,2-Dichloroethane (ug/kg)	65	0	0						2 U	204 U	22	5 U	100 U

Table 4-3. Historical Category 1 and 2 Surface Sediment and Porewater Chemical Data Summary (1990-present).

Analyte	N	N Detected	% Detected	Detected Concentrations					Detected and Nondetected Concentrations				
				Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
1,2-Dichloropropane (ug/kg)	65	0	0						2 U	204 U	22	5 U	100 U
Bromodichloromethane (ug/kg)	65	0	0						2 U	204 U	22	5 U	100 U
Bromoform (ug/kg)	65	0	0						4 U	204 U	24	9 U	100 U
Bromomethane (ug/kg)	65	0	0						5 U	2040 U	130	10 U	500 UJ
Carbon tetrachloride (ug/kg)	65	0	0						1 U	408 U	34	9 U	200 U
Chlorodibromomethane (ug/kg)	65	0	0						2 U	204 U	22	5 U	100 U
Chloroethane (ug/kg)	65	0	0						5 U	500 U	68	10 U	500 U
Chloroform (ug/kg)	65	0	0						1 U	204 U	22	5 U	100 U
Chloromethane (ug/kg)	65	0	0						5 U	1020 U	91	10 U	500 U
Vinyl chloride (ug/kg)	65	0	0						2 U	500 U	60	10 U	500 U
Vinylidene chloride (ug/kg)	65	0	0						1 U	204 U	22	5 U	100 U
2,6-Dichlorophenol (ug/kg)	64	0	0						130 U	45000 U	4900	650 U	22000 UJ
2,3,4,5-Tetrachlorophenol (ug/kg)	61	0	0						14 U	11000 U	982	200 U	2200 U
Methyl N-butyl ketone (ug/kg)	61	0	0						20 U	2040 U	179	50 U	1000 U
Styrene (ug/kg)	61	0	0						5 U	250 U	28	9 U	100 U
Trichlorofluoromethane (ug/kg)	59	0	0						5 U	500 U	49	10 U	204 U
Carbon disulfide (ug/kg)	58	0	0						5 U	2040 U	208	100 U	1000 U
Anthanthrene (ug/kg)	56	0	0						68 U	22000 U	3063	340 U	18000 U
trans-1,3-Dichloropropene (ug/kg)	56	0	0						2 U	204 U	19	5 U	100 U
Gasoline (mg/kg)	53	0	0						10 UJ	140 U	30	20 UJ	54 U
trans-1,2-Dichloroethene (ug/kg)	52	0	0						5 U	204 U	20	5 U	100 U
cis-1,3-Dichloropropene (ug/kg)	51	0	0						4 U	204 U	19	5 U	100 U
Methyl isobutyl ketone (ug/kg)	49	0	0						20 U	1020 U	164	50 U	500 U
Butyltin ion (ug/l)	48	0	0						0.05 U	0.1 U	0.056	0.05 U	0.07 U
cis-1,2-Dichloroethene (ug/kg)	47	0	0						5 U	204 U	20	5 U	100 U
Jet fuel A (mg/kg)	36	0	0						10 U	50 U	23	10 U	50 U
JP-4 jet fuel (mg/kg)	36	0	0						10 U	50 UJ	23	10 UJ	50 UJ
Kerosene (mg/kg)	36	0	0						10 U	50 U	23	10 U	50 U
Mineral spirits (mg/kg)	36	0	0						10 U	50 U	23	10 U	50 U
Naphtha distillate (mg/kg)	36	0	0						10 U	50 UJ	23	10 UJ	50 UJ
Non-petroleum hydrocarbons (mg/kg)	35	0	0						50 U	250 U	114	50 U	250 U
Dichlorodifluoromethane (ug/kg)	34	0	0						5 U	1020 U	127	10 U	500 U
Ethylene dibromide (ug/kg)	34	0	0						4 U	204 U	45	37 U	100 U
1,1,1,2-Tetrachloroethane (ug/kg)	30	0	0						5 U	204 U	29	10 U	100 U
1,1-Dichloropropene (ug/kg)	30	0	0						5 U	204 U	29	10 U	100 U
1,2,3-Trichlorobenzene (ug/kg)	30	0	0						20 U	204 U	50	40 U	100 U
1,2,3-Trichloropropane (ug/kg)	30	0	0						5 U	250 U	49	10 U	250 U
1,2-Dibromo-3-chloropropane (ug/kg)	30	0	0						20 U	250 U	70	40 U	250 U
1,3,5-Trimethylbenzene (ug/kg)	30	0	0						20 U	204 U	50	40 U	100 U
1,3-Dichloropropane (ug/kg)	30	0	0						5 U	204 U	29	10 U	100 U
2,2-Dichloropropane (ug/kg)	30	0	0						5 U	204 U	29	10 U	100 U
2-Chlorotoluene (ug/kg)	30	0	0						20 U	204 U	50	40 U	100 U
4-Chlorotoluene (ug/kg)	30	0	0						20 U	204 U	50	40 U	100 U

Table 4-3. Historical Category 1 and 2 Surface Sediment and Porewater Chemical Data Summary (1990-present).

Analyte	N	N Detected	% Detected	Detected Concentrations					Detected and Nondetected Concentrations				
				Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
Bromobenzene (ug/kg)	30	0	0						5 U	204 U	29	10 U	100 U
Bromochloromethane (ug/kg)	30	0	0						5 U	204 U	34	10 U	100 U
Isopropylbenzene (ug/kg)	30	0	0						20 U	204 U	50	40 U	100 U
Methylene bromide (ug/kg)	30	0	0						5 U	204 U	29	10 U	100 U
n-Propylbenzene (ug/kg)	30	0	0						20 U	204 U	50	40 U	100 U
Pseudocumene (ug/kg)	30	0	0						20 U	204 U	50	40 U	100 U
2,4,5-T (ug/kg)	29	0	0						0.27 U	50 U	3.9	0.33 U	5 U
2-Chloroethyl vinyl ether (ug/kg)	29	0	0						10 U	200 U	21	10 U	40 U
Dalapon (ug/kg)	29	0	0						0.13 U	1000 U	66	0.16 U	100 U
Dicamba (ug/kg)	29	0	0						0.13 U	100 U	6.7	0.16 U	10 U
Dichloroprop (ug/kg)	29	0	0						0.22 U	250 U	17	0.27 U	25 U
Dinoseb (ug/kg)	29	0	0						0.19 U	250 U	16	0.23 U	25 U
MCPA (ug/kg)	29	0	0						0.26 U	50000 U	2969	0.32 U	5000 U
MCPP (ug/kg)	29	0	0						0.11 U	50000 U	2969	0.14 U	5000 U
Silvex (ug/kg)	29	0	0						0.22 U	50 U	3.8	0.27 U	5 U
Antimony (mg/l)	28	0	0						0.05 U	0.05 U	0.05	0.05 U	0.05 U
Beryllium (mg/l)	28	0	0						0.001 U	0.001 U	0.001	0.001 U	0.001 U
Cadmium (mg/l)	28	0	0						0.002 U	0.002 U	0.002	0.002 U	0.002 U
Selenium (mg/l)	28	0	0						0.001 U	0.002 U	0.001	0.001 U	0.001 U
Thallium (mg/l)	28	0	0						0.001 U	0.001 U	0.001	0.001 U	0.001 U
Sec-butylbenzene (ug/kg)	27	0	0						20 U	204 U	50	37 UJ	100 U
tert-Butylbenzene (ug/kg)	27	0	0						20 U	204 U	50	37 U	100 U
Trichlorotrifluoroethane (ug/kg)	25	0	0						10 U	200 U	23	10 U	40 U
Vinyl acetate (ug/kg)	25	0	0						50 U	1000 U	120	50 U	200 U
n-Butylbenzene (ug/kg)	22	0	0						20 U	204 U	50	39 U	100 U
Cymene (ug/kg)	20	0	0						20 U	100 U	38	35 U	100 U
Aroclor 1262 (ug/kg)	18	0	0						3.14 U	4.62 U	3.6	3.59 U	4.46 U
Aroclor 1268 (ug/kg)	18	0	0						3.14 U	4.62 U	3.6	3.59 U	4.46 U
1,2-Dichloroethene (ug/kg)	18	0	0						1 U	250 U	42	10 U	250 U
2,4'-DDT (ug/kg)	18	0	0						4.58 U	7.46 U	5.5	5.21 U	6.59 U
Oxychlordane (ug/kg)	18	0	0						4.58 U	7.46 U	5.5	5.21 U	6.59 U
1,3-Dichloropropene (ug/kg)	14	0	0						4 U	100 U	31	10 U	100 U
Endosulfan (ug/kg)	13	0	0						0.9 U	9 U	3.4	3 U	6 U
Hexachlorocyclohexanes (ug/kg)	12	0	0						10 U	40 U	20	10 U	40 U
Benzidine (ug/kg)	10	0	0						250 U	1600 U	790	250 U	1600 U
p-Cymene (ug/kg)	10	0	0						20 U	204 U	74	40 U	100 U
Butylbenzene (ug/kg)	8	0	0						20 U	100 U	51	50 U	100 U
1,2-Diphenylhydrazine (ug/kg)	4	0	0						1600 U	1600 U	1600	1600 U	1600 U
1-Chloronaphthalene (ug/kg)	4	0	0						330 U	330 U	330	330 U	330 U
1-Naphthylamine (ug/kg)	4	0	0						330 U	330 U	330	330 U	330 U
2-Methylpyridine (ug/kg)	4	0	0						330 U	330 U	330	330 U	330 U
2-Naphthylamine (ug/kg)	4	0	0						330 U	330 U	330	330 U	330 U
3-Methylcholanthrene (ug/kg)	4	0	0						330 U	330 U	330	330 U	330 U

Table 4-3. Historical Category 1 and 2 Surface Sediment and Porewater Chemical Data Summary (1990-present).

Analyte	N	N Detected	% Detected	Detected Concentrations					Detected and Nondetected Concentrations				
				Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
4-Aminobiphenyl (ug/kg)	4	0	0						330 U	330 U	330	330 U	330 U
7,12-Dimethylbenz(a)anthracene (ug/kg)	4	0	0						330 U	330 U	330	330 U	330 U
Acetophenone (ug/kg)	4	0	0						330 U	330 U	330	330 U	330 U
alpha,alpha-Dimethylphenethylamine (ug/kg)	4	0	0						330 U	330 U	330	330 U	330 U
Diphenylamine (ug/kg)	4	0	0						330 U	330 U	330	330 U	330 U
Ethyl methanesulfonate (ug/kg)	4	0	0						330 U	330 U	330	330 U	330 U
Methyl methanesulfonate (ug/kg)	4	0	0						330 U	330 U	330	330 U	330 U
N-Nitrosodibutylamine (ug/kg)	4	0	0						330 U	330 U	330	330 U	330 U
N-Nitrosopiperidine (ug/kg)	4	0	0						330 U	330 U	330	330 U	330 U
p-Dimethylaminoazobenzene (ug/kg)	4	0	0						330 U	330 U	330	330 U	330 U
Pentachloronitrobenzene (ug/kg)	4	0	0						1600 U	1600 U	1600	1600 U	1600 U
Phenacetin (ug/kg)	4	0	0						330 U	330 U	330	330 U	330 U
Pronamide (ug/kg)	4	0	0						330 U	330 U	330	330 U	330 U
1,1,2-Trichloro-1,2,2-trifluoroethane (ug/kg)	4	0	0						10 U	10 U	10	10 U	10 U
1,2,4,5-Tetrachlorobenzene (ug/kg)	4	0	0						330 U	330 U	330	330 U	330 U
2,4-Dichloro-6-methylphenol (ug/kg)	4	0	0						200 U	570 U	300	200 U	230 U
4-Chloro-o-cresol (ug/kg)	4	0	0						81 U	230 U	121	82 U	92 U
4-Chlorophenol (ug/kg)	4	0	0						330 U	910 U	485	330 U	370 U
Azinphosmethyl (ug/kg)	4	0	0						50 U	50 U	50	50 U	50 U
Bromoxynil (ug/kg)	4	0	0						25 U	250 U	105	25 U	120 U
Chlordane (technical) (ug/kg)	4	0	0						150 U	919 U	455	150 U	600 U
Chlorpyrifos (ug/kg)	4	0	0						50 U	50 U	50	50 U	50 U
Coumaphos (ug/kg)	4	0	0						50 U	50 U	50	50 U	50 U
Cresol (ug/kg)	4	0	0						41 U	110 U	60	41 U	46 U
Demeton (ug/kg)	4	0	0						50 U	50 U	50	50 U	50 U
Diazinon (ug/kg)	4	0	0						50 U	50 U	50	50 U	50 U
Dichlorvos (ug/kg)	4	0	0						50 U	50 U	50	50 U	50 U
Ethoprop (ug/kg)	4	0	0						50 U	50 U	50	50 U	50 U
Fensulfothion (ug/kg)	4	0	0						50 U	50 U	50	50 U	50 U
Fenthion (ug/kg)	4	0	0						50 U	50 U	50	50 U	50 U
Malathion (ug/kg)	4	0	0						50 U	50 U	50	50 U	50 U
Merphos (ug/kg)	4	0	0						50 U	50 U	50	50 U	50 U
Methyl parathion (ug/kg)	4	0	0						50 U	50 U	50	50 U	50 U
Mevinphos (ug/kg)	4	0	0						50 U	50 U	50	50 U	50 U
Naled (ug/kg)	4	0	0						50 U	50 U	50	50 U	50 U
Pentachlorobenzene (ug/kg)	4	0	0						330 U	330 U	330	330 U	330 U
Perthane (ug/kg)	4	0	0						100 U	100 U	100	100 U	100 U
Phorate (ug/kg)	4	0	0						50 U	50 U	50	50 U	50 U
Prothiophos (ug/kg)	4	0	0						50 U	50 U	50	50 U	50 U
Ronnel (ug/kg)	4	0	0						50 U	50 U	50	50 U	50 U
Stirofos (ug/kg)	4	0	0						50 U	50 U	50	50 U	50 U
Sulprofos (ug/kg)	4	0	0						50 U	50 U	50	50 U	50 U
Tetraethyl pyrophosphate (ug/kg)	4	0	0						50 U	50 U	50	50 U	50 U

Table 4-3. Historical Category 1 and 2 Surface Sediment and Porewater Chemical Data Summary (1990-present).

Analyte	N	N Detected	% Detected	Detected Concentrations					Detected and Nondetected Concentrations				
				Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
Trichloronate (ug/kg)	4	0	0						50 U	50 U	50	50 U	50 U
Pyridine (ug/kg)	1	0	0						382 UJ	382 UJ	382	382 UJ	382 UJ
2,2'-Dichlorobiphenyl (ug/kg)	1	0	0						25 U	25 U	25	25 U	25 U
2,3,3',4,4'-Pentachlorobiphenyl (ug/kg)	1	0	0						5 U	5 U	5	5 U	5 U
2,3-Dichlorobiphenyl (ug/kg)	1	0	0						3 U	3 U	3	3 U	3 U
2-Chlorobiphenyl (ug/kg)	1	0	0						125 U	125 U	125	125 U	125 U
3,3',4,4',5,5'-Hexachlorobiphenyl (ug/kg)	1	0	0						5 U	5 U	5	5 U	5 U
3,3',4,4',5-Pentachlorobiphenyl (ug/kg)	1	0	0						5 U	5 U	5	5 U	5 U
3,3',4,4'-Tetrachlorobiphenyl (ug/kg)	1	0	0						5 U	5 U	5	5 U	5 U
3-Chlorobiphenyl (ug/kg)	1	0	0						5 U	5 U	5	5 U	5 U
4-Chlorobiphenyl (ug/kg)	1	0	0						25 U	25 U	25	25 U	25 U

Notes:
A - Detected quantities of analytes added together as defined in WAC 173-204-320 for LPAH and HPAH, as in DMMO 2000 for DDT, and for all Aroclors or congeners for PCB.
B - Possible method blank contamination.
E - Estimate, usually applied because the value exceeded the instrument calibration range.
G - Estimate is greater than value shown.
H - Holding time exceeded.
J - Estimate, usually applied because the value is less than the method reporting limit but greater than the method detection limit, or for QA/QC concerns.
L - Value is less than the maximum shown.
N - Presumptive evidence of presence of material.
U - Not detected at detection limit shown.
X - Recovery less than 10%.
Surface sediment is defined as any sediment sample that was exposed to the water column at the time of collection to a maximum depth of 30 cm.
No samples that have been dredged are included in the statistical summary.

Table 4-4. Historical Category 1 and 2 Subsurface Sediment and Porewater Chemical Data Summary (1990-present).

Analyte	N	N Detected	% Detected	Detected Concentrations					Detected and Nondetected Concentrations				
				Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
Total solids (%)	342	342	100	40.3	92.8	64	64.4	85.2	40.3	92.8	64	64.4	85.2
Zinc (mg/kg)	308	308	100	10.8	1500 L	148	90.1 G	469 G	10.8	1500 L	148	90.1 G	469 G
Nickel (mg/kg)	284	284	100	4.4	112	23	22	33 G	4.4	112	23	22	33 G
Chromium (mg/kg)	275	275	100	6.6	199 J	27	24.9	44	6.6	199 J	27	24.9	44
Total volatile solids (%)	106	106	100	0.7	18.3	5	5.2	8.8	0.7	18.3	5	5.2	8.8
Barium (mg/kg)	43	43	100	67.1	330	191	189	274	67.1	330	191	189	274
Iron (mg/kg)	41	41	100	34700	53900	41871	41100	46400	34700	53900	41871	41100	46400
Manganese (mg/kg)	41	41	100	344	872	622	587	836	344	872	622	587	836
Aluminum (mg/kg)	38	38	100	19000	45900	38189	38300	44100	19000	45900	38189	38300	44100
Calcium (mg/kg)	38	38	100	4310	16000	8683	8440	13800	4310	16000	8683	8440	13800
Cobalt (mg/kg)	38	38	100	16	24.6	18	17.8	20.6	16	24.6	18	17.8	20.6
Magnesium (mg/kg)	38	38	100	4900	8510	6875	7010	7670	4900	8510	6875	7010	7670
Potassium (mg/kg)	38	38	100	1000	1550	1289	1310	1470	1000	1550	1289	1310	1470
Sodium (mg/kg)	38	38	100	380	57800 J	2694	1100	2180 J	380	57800 J	2694	1100	2180 J
Vanadium (mg/kg)	38	38	100	84	136	102	103	111	84	136	102	103	111
Titanium (mg/kg)	27	27	100	1790	3490	2054	1950	2590	1790	3490	2054	1950	2590
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin (ng/k	25	25	100	13 J	25000 J	2030	220	7800 J	13 J	25000 J	2030	220	7800 J
Octachlorodibenzofuran (ng/kg)	25	25	100	6.8	7600 J	1188	130	5200	6.8	7600 J	1188	130	5200
Octachlorodibenzo-p-dioxin (ng/kg)	25	25	100	92 J	92000 J	8942	2300 B	22000 J	92 J	92000 J	8942	2300 B	22000 J
Total sulfides (mg/kg)	18	18	100	2 G	796 G	101	32	276 G	2 G	796 G	101	32	276 G
Pencil pitch (mg/kg)	16	16	100	21	2300	703	385	2000	21	2300	703	385	2000
Hexachlorodibenzofuran (ng/kg)	9	9	100	25	1200	283	52	770	25	1200	283	52	770
Pentachlorodibenzofuran (ng/kg)	9	9	100	5.9	680	136	20	240	5.9	680	136	20	240
Heptachlorodibenzofuran (ng/kg)	8	8	100	10	1300	315	77	650	10	1300	315	77	650
Heptachlorodibenzo-p-dioxin (ng/kg)	8	8	100	180	3400	951	410	1700	180	3400	951	410	1700
Hexachlorodibenzo-p-dioxin (ng/kg)	8	8	100	27	340	135	110	200	27	340	135	110	200
Tetrachlorodibenzofuran (ng/kg)	8	8	100	4.4	270	57	13	91	4.4	270	57	13	91
Tetrachlorodibenzo-p-dioxin (ng/kg)	8	8	100	1	34	8	4.3	7.2	1	34	7.6	4.3	7.2
Bromine (ug/kg)	7	7	100	5.5	15	11	10	13	5.5	15	11	10	13
Chlorine (ug/kg)	7	7	100	137	2380	843	286	1780	137	2380	843	286	1780
Tin (mg/kg)	3	3	100	2.28 G	4.46 G	3.72	2.28 G	4.42 G	2.28 G	4.46 G	3.72	2.28 G	4.42 G
Copper (mg/kg)	320	318	99	8.9	2200	79	32.7	166 G	8.9	2200	79	32.4	166 G
Total organic carbon (%)	323	316	98	0.03	37	1.6	1.21	3.7	0.03	37	1.6	1.18	3.3
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin (ng/kg)	25	24	96	0.95 J	180	23	6.3	90 J	0.95 J	180	22	5.6	90 J
1,2,3,4,6,7,8-Heptachlorodibenzofuran (ng/kg)	24	23	96	1.6	5400	554	42	2300	1.6	5400	531	42	2300
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin (ng/kg)	24	23	96	0.46	990	91	15	330	0.46	990	88	15	330
2,3,7,8-Tetrachlorodibenzofuran (ng/kg)	24	23	96	0.28	15000	676	17	84	0.28	15000	648	17	84
Ammonia (mg/kg)	28	26	93	1.4	327	133	120	239	1.4	327	129	119	239
Lead (mg/kg)	348	323	93	1.2	1080	46	22	169	1.2	1080	45	22	146
Chromium hexavalent (mg/kg)	8	7	88	0.1 G	0.6 G	0.35	0.32 GM	0.57 G	0.1 G	0.6 G	0.33	0.32 GM	0.57 G
Acid Volatile Sulfides (mg/kg)	32	27	84	0.6	53	18	13 G	42	0.6	53	15	10.2	42
Polycyclic Aromatic Hydrocarbons (ug/kg)	390	326	84	2.8 A	10096000 A	172261	2398 A	583600 A	2.8 A	10096000 A	144038	1316 A	562000 A
Residual Range Organics (mg/kg)	6	5	83	100 J	2300	858	430	730	100 J	2300	780	430	730
High Molecular Weight PAH (ug/kg)	390	321	82	2 A	2063000 A	70645	1930 A	307240 A	2 A	2063000 A	58196	957 A	247400 A

Table 4-4. Historical Category 1 and 2 Subsurface Sediment and Porewater Chemical Data Summary (1990-present).

Analyte	N	N Detected	% Detected	Detected Concentrations					Detected and Nondetected Concentrations				
				Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
Pyrene (ug/kg)	390	317	81	0.9 G	670000	20360	450 G	110000	0.9 G	670000	16598	300 U	77000
Arsenic (mg/kg)	328	264	80	0.5	140	5.2	3.2	12 G	0.2 UJ	140	5	3.16	9
2,3,4,7,8-Pentachlorodibenzofuran (ng/kg)	25	20	80	0.59	11000	588	23	230	0.39 U	11000	471	10	86
Fluoranthene (ug/kg)	390	307	79	0.7 G	910000	20203	440	96000	0.7 G	910000	15962	300 U	81600
Beryllium (mg/kg)	56	44	79	0.38	0.74	0.58	0.59	0.7	0.38	1.05 U	0.67	0.61	1 U
Cyanide (mg/kg)	18	14	78	0.2 J	5.4	1.7	1	3.7	0.2 U	5.4	1.4	0.9	3.7
1,2,3,4,7,8,9-Heptachlorodibenzofuran (ng/kg)	25	19	76	1.4	2200	252	22	1300	0.4 U	2200	192	17	360
Mercury (mg/kg)	264	200	76	0.01	2.1	0.17	0.09	0.55	0.01	2.1	0.16	0.1	0.39
Low Molecular Weight PAH (ug/kg)	390	295	76	1.4 A	8230000 A	113491	726 A	370800 A	1.4 A	8230000 A	85909	321 A	212300 A
1,2,3,4,7,8-Hexachlorodibenzofuran (ng/kg)	24	18	75	0.44	22000 J	1420	78	1000	0.44	22000 J	1074	62 U	700
Phenanthrene (ug/kg)	390	291	75	0.9 G	2000000	39530	384	140000 JM	0.9 G	2000000	29560	260	100000
Chrysene (ug/kg)	390	289	74	0.7 G	180000	6729	250	30000	0.7 G	180000	5050	200	21000
Benzo(b)fluoranthene (ug/kg)	358	262	73	2 G	160000	4393	210	18500	2 U	160000	3283	180	14000
Selenium (mg/kg)	54	39	72	0.93	14	9.3	9	13	0.45 UJ	14	7.2	8	13
Benzo(b+k)fluoranthene (ug/kg)	390	281	72	2 A	217000 A	7947	380 A	36000 A	2 A	217000 A	5790	300 UA	26000 A
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin (ng/kg)	25	18	72	0.86	50	8.8	2.4	40 J	0.5 U	50	7.1	2 U	30
1,2,3,7,8,9-Hexachlorodibenzofuran (ng/kg)	25	18	72	0.37	2700	162	11	48	0.17 U	2700	117	4.3	25
Total Petroleum Hydrocarbons (mg/kg)	67	48	72	9 J	640	168	100 J	640	9 J	640	142	100 U	312
Benz(a)anthracene (ug/kg)	390	279	72	0.7 G	150000	6150	230	26400	0.7 G	150000	4465	170	20000
Benzo(a)pyrene (ug/kg)	390	277	71	0.5 G	180000	5809	210	24000	0.5 G	180000	4200	170 G	18000
Benzo(k)fluoranthene (ug/kg)	358	252	70	1 G	92000	3633	170	17000	1 G	92000	2629	140	14000
Total of 3 isomers: pp-DDT,-DDD,-DDE (ug/kg	202	142	70	0.2 A	51000 A	1071	20 A	2646 A	0.2 A	51000 A	755	6.7 UA	1970 A
Silver (mg/kg)	264	185	70	0.03	3.4	0.51	0.3	1.4	0.004 U	3.4	0.47	0.21	1.5
Tributyltin ion (ug/kg)	109	76	70	0.2 J	90000	3242	32	17000	0.2 J	90000	2264	11 U	12000
1,2,3,6,7,8-Hexachlorodibenzofuran (ng/kg)	25	17	68	0.71 J	190	47	19	150	0.2 U	5600 UJ	259	13	150
2,3,4,6,7,8-Hexachlorodibenzofuran (ng/kg)	25	17	68	0.51	1300	113	9.5 J	210	0.26 U	1300	77	3.8 U	160
Cadmium (mg/kg)	271	182	67	0.03	5.3	0.50	0.3	1.62	0.03	5.3	0.51	0.3 U	1.62
Pentachlorodibenzo-p-dioxin (ng/kg)	9	6	67	0.46	3.8	1.5	1.2	1.4	0.46	3.8	1.5	1.3	1.6 U
Benzo(g,h,i)perylene (ug/kg)	389	259	67	0.7 G	140000	4371	166	19100	0.7 G	140000	3276	120	15000
Indeno(1,2,3-cd)pyrene (ug/kg)	390	253	65	0.8 G	90000	4545	180	20000	0.7 U	90000	3122	118	15000
1,2,3,7,8-Pentachlorodibenzofuran (ng/kg)	25	16	64	0.32	360	69	49	150	0.2 U	18000 U	764	24	150
4,4'-DDD (ug/kg)	202	129	64	0.2	29000	591	14	1900	0.2	29000	380	3.4 U	735
Bis(2-ethylhexyl) phthalate (ug/kg)	227	139	61	10 B	16000 G	561	200 J	1780	10 U	21500 U	707	200 J	3600
Anthracene (ug/kg)	390	229	59	0.6 G	430000	10085	144 GH	36000	0.6 G	430000	6054	67	22000
Tributyltin ion (ug/l)	18	10	56	0.02	27	3.194	0.13	3.4	0.02	27	1.8	0.04 U	3.4
Naphthalene (ug/kg)	393	218	55	0.4 G	3500000 J	53113	130	57700	0.4 G	3500000 J	29596	63	17000
4,4'-DDE (ug/kg)	202	112	55	0.2 J	2800	73	4	110	0.2 J	7500 U	85	3	100
Acenaphthene (ug/kg)	390	214	55	0.7 G	1200000	21544	220	68000 J	0.7 G	1200000	11952	79.4	30000
Fluorene (ug/kg)	390	211	54	0.7 G	1100000 J	16002	190	55000	0.7 G	1100000 J	8791	68 U	24000 J
Dibutyltin ion (ug/kg)	92	49	53	0.3 J	1300 J	95	6 H	320	0.3 J	1300 J	56	4	270 U
2-Methylnaphthalene (ug/kg)	274	144	53	0.6 G	51000 JM	2165	60	12000	0.6 G	51000 JM	1239	50 U	4180
Thallium (mg/kg)	49	24	49	0.06	12	5.0	5	9	0.06	12	4.8	5 U	9
Carbazole (ug/kg)	90	44	49	0.6 J	60000	2342	93 J	2900	0.6 J	60000	1262	27 U	2400 U
Polychlorinated biphenyls (ug/kg)	211	103	49	4 A	7100 A	310	73 A	1620 A	4 A	150000 UA	969	32 UA	710 A

Table 4-4. Historical Category 1 and 2 Subsurface Sediment and Porewater Chemical Data Summary (1990-present).

		N	%	Detected Concentrations					Detected and Nondetected Concentrations				
Analyte	N	Detected	Detected	Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
1,2,3,7,8-Pentachlorodibenzo-p-dioxin (ng/kg)	25	12	48	0.3 J	11	3.4	1.2	10	0.3 J	11	2.7	1.3	9
Aroclor 1260 (ug/kg)	210	88	42	4 J	7100	183	33	490	4 J	75000 U	494	16 U	232
Butyltin ion (ug/kg)	91	38	42	0.3 J	260	29	4	140	0.3 J	270 U	17	3 U	63
Dibenzofuran (ug/kg)	299	124	41	0.5 G	32000 JM	635	45 G	1500	0.5 G	32000 JM	447	50 U	1500
Dibenz(a,h)anthracene (ug/kg)	390	158	41	0.8 GB	87000	1499	77 G	5100	0.8 GB	87000	1051	55.9	4000 U
Benzo(e)pyrene (ug/kg)	31	12	39	38	15000	2246	430	3600 M	12 U	17000 U	1505	38	3600 M
4-Methylphenol (ug/kg)	111	40	36	23	450	139	97	370	19 U	6000 U	393	100 U	1400 U
Aroclor 1254 (ug/kg)	210	75	36	4	1900	188	48	1200	4	75000 U	486	15 U	290
Dibutyltin ion (ug/l)	14	5	36	0.07 J	1.1	0.376	0.19	0.32	0.02 U	1.1	0.16	0.04 U	0.32
Acenaphthylene (ug/kg)	390	131	34	0.2 G	28000	797	31 N	3220	0.2 G	28000	507	50 U	2300
2,3,7,8-Tetrachlorodibenzo-p-dioxin (ng/kg)	25	8	32	0.62	4.3	1.9	1.2	3 J	0.1 U	8.7 U	1.7	0.78 U	4.3
4,4'-DDT (ug/kg)	202	64	32	0.2	22000	1059	40	2600	0.2	22000	347	6 J	730
Antimony (mg/kg)	216	67	31	0.03 G	8.6 J	1.1	0.2 X	5.3 J	0.02 UG	170 U	8.6	0.28 J	10.5 U
Tetrabutyltin (ug/kg)	79	21	27	0.4 J	130	20	4	44	0.4 J	270 U	12	3 U	28
Methylene chloride (ug/kg)	43	10	23	2 J	59	14	2 J	55	2 J	500 U	26	10 U	55
Acetone (ug/kg)	31	7	23	12 J	200	47	20 J	39 J	12 J	1000 U	96	50 U	200 U
Butyltin ion (ug/l)	14	3	21	0.04	0.2	0.10	0.04	0.05 J	0.02 U	0.2	0.05	0.04 U	0.05 J
Tetrabutyltin (ug/l)	14	3	21	0.05	0.2	0.13	0.05	0.15	0.02 U	0.2	0.06	0.04 U	0.15
Butylbenzyl phthalate (ug/kg)	227	45	20	2 J	260	41	19	140	2 J	6000 U	253	35 U	660 U
Dibutyl phthalate (ug/kg)	227	45	20	4.4 JB	1500	66	16	130	4.4 JB	10800 U	320	35	1000 U
3- and 4-Methylphenol Coelution (ug/kg)	107	19	18	4.8 J	360	93	33	300	4.8 J	12000 U	534	200 U	360
Diesel fuels (mg/kg)	95	16	17	40 J	12400	4053	703	11600	10 U	12400	702	25 U	6850
alpha-Hexachlorocyclohexane (ug/kg)	152	25	16	0.9 J	30	5.3	3 J	10	0.9 J	3800 U	31	2 U	10
Methylethyl ketone (ug/kg)	31	5	16	2 J	5 J	3.6	3 J	4 J	2 J	1000 U	74	20 U	200 U
o-Xylene (ug/kg)	101	15	15	0.02 J	513	35	0.09 J	4	0.008 U	513	10	5 U	10 U
Xylene (ug/kg)	14	2	14	1300	6000	3650	1300	1300	10 U	6000	696	300 U	1300
Benzoic acid (ug/kg)	178	25	14	8.7 J	2600	438	380	860	8.7 J	45000 U	2019	250 U	10800 U
Ethylbenzene (ug/kg)	115	14	12	0.05 J	6200	555	0.36	1300	0.009 U	6200	93	5 U	300 U
m,p-Xylene (ug/kg)	101	12	12	0.03 J	740	63	0.1 J	5.1	0.02 U	740	12	5 U	10 U
gamma-Hexachlorocyclohexane (ug/kg)	168	19	11	0.2 J	360	70	10	300	0.2 J	3800 U	39	2 U	45.9
Aldrin (ug/kg)	168	15	8.9	0.2 J	9 J	4.9	5 J	9 J	0.2 J	3800 U	52	2 U	40 U
Natural gasoline (mg/kg)	25	2	8.0	44	110	77	44	44	10 U	110	17	10 U	20 U
p-Cymene (ug/kg)	27	2	7.4	6 J	253	130	6 J	6 J	6 J	253	30	20 U	28 U
Benzene (ug/kg)	115	8	7.0	0.03 J	1800	226	0.04 J	6.4	0.01 U	1800	45	5 U	300 U
Heavy oil (mg/kg)	87	6	6.9	100 G	910	353	280	380	25 U	910	104	100 U	300 U
Phenol (ug/kg)	224	15	6.7	4.9 J	300	36	9 J	52	4.9 J	6000 U	296	50 U	1000 U
Endrin (ug/kg)	164	9	5.5	0.5 J	10	3.8	0.8 J	9 J	0.5 J	7500 U	60	2 U	43.3 U
Endrin aldehyde (ug/kg)	164	9	5.5	0.5 J	6	2.4	0.9 J	5.6	0.5 J	7500 U	61	2 U	60 U
Pentachlorophenol (ug/kg)	274	15	5.5	3.2 J	1700	158	19	200 J	2.4 U	45000 U	1374	142 U	7080 U
Toluene (ug/kg)	115	6	5.2	0.03 J	66	15	0.07 J	21	0.01 U	300 U	32	5 U	300 U
1,3,5-Trimethylbenzene (ug/kg)	39	2	5.1	5 J	630	318	5 J	5 J	5 J	630	44	20 U	45 U
n-Butylbenzene (ug/kg)	39	2	5.1	5 J	3190	1598	5 J	5 J	5 J	3190	109	20 U	45 U
Pseudocumene (ug/kg)	39	2	5.1	14 J	2210	1112	14 J	14 J	14 J	2210	84	20 U	45 U
Sec-butylbenzene (ug/kg)	39	2	5.1	3 J	1640	822	3 J	3 J	3 J	1640	70	20 U	45 U

Table 4-4. Historical Category 1 and 2 Subsurface Sediment and Porewater Chemical Data Summary (1990-present).

		N	%	Detected Concentrations					Detected and Nondetected Concentrations				
Analyte	N	Detected	Detected	Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
Heptachlor epoxide (ug/kg)	164	8	4.9	2 J	10	6.6	7 J	10	0.94 U	3800 U	34	2 U	40 U
Chlorobenzene (ug/kg)	43	2	4.7	1900	18000	9950	1900	1900	5 U	18000	471	5 U	11 U
delta-Hexachlorocyclohexane (ug/kg)	164	7	4.3	0.14 J	8 J	3.7	2 J	6 J	0.14 J	3800 UJ	32	2 U	25 U
Dieldrin (ug/kg)	168	7	4.2	0.4	13	3.7	2	3.8	0.4	7500 U	58	2 U	48 U
Di-n-octyl phthalate (ug/kg)	227	9	4.0	11	3180	480	18	851	10 U	12000 U	327	45.4	1000 U
Lube Oil (mg/kg)	76	3	3.9	79	200	140	79	140	25 U	200	68	100 U	100 U
Benzyl alcohol (ug/kg)	182	7	3.8	5.5 JN	9.4 JN	7.6	7.3 J	9 J	5.5 JN	6000 U	246	30 UG	1200 U
Hexachloroethane (ug/kg)	158	6	3.8	31	20000	3407	95	160	10 U	20000	439	50 U	1000 U
Diethyl phthalate (ug/kg)	227	8	3.5	3 J	16.3 J	8.7	5 J	16 J	3 J	6000 U	252	20 U	910 U
Dimethyl phthalate (ug/kg)	227	8	3.5	0.5 J	99 G	24	10 G	59 N	0.5 J	6000 U	250	20 U	660 U
Tetrachloroethene (ug/kg)	61	2	3.3	8	19	14	8	8	5 U	100 U	8.7	5 U	11 U
2,3,4,6-Tetrachlorophenol (ug/kg)	32	1	3.1	26	26	26	26	26	2.4 U	6100 U	364	66 UJ	700 U
beta-Endosulfan (ug/kg)	164	5	3.0	1 J	30	9.2	2 J	7 J	1 U	7500 U	60	2 U	50 U
Heptachlor (ug/kg)	168	5	3.0	0.34 J	6 J	3.7	2 J	5 J	0.34 J	3800 U	31	2 U	25 U
Aroclor 1242 (ug/kg)	210	6	2.9	7	69 J	33	26	43	7	75000 U	424	10 U	100 U
Gasoline (mg/kg)	37	1	2.7	40 J	40 J	40	40 J	40 J	10 U	100 U	22	10 UJ	69 U
Isopropylbenzene (ug/kg)	39	1	2.6	588	588	588	588	588	20 U	588	43	20 U	45 U
n-Propylbenzene (ug/kg)	39	1	2.6	1840	1840	1840	1840	1840	20 U	1840	75	20 U	45 U
tert-Butylbenzene (ug/kg)	39	1	2.6	128	128	128	128	128	20 U	200 U	31	20 U	45 U
1,2,4-Trichlorobenzene (ug/kg)	157	4	2.5	12	530	156	40 G	41	5 U	6000 U	132	20 U	300 U
Hexachlorobenzene (ug/kg)	213	4	1.9	25	14000	3897	61	1500	9.7 U	35000 U	571	24 U	2400 U
Hexachlorobutadiene (ug/kg)	216	4	1.9	19	34000	15019	57	26000	9.7 U	87000 UJ	1175	39 U	4000 U
alpha-Endosulfan (ug/kg)	164	3	1.8	0.5 J	6 J	2.5	0.5 J	1 J	0.5 J	3800 U	33	2 U	40 U
Methoxychlor (ug/kg)	164	3	1.8	1 J	2	1.3	1 J	1 J	1 J	38000 U	281	5 U	200 U
1,4-Dichlorobenzene (ug/kg)	173	3	1.7	5.8 J	23	12	5.8 J	6	1 U	910 U	65	15 U	300 U
Non-petroleum hydrocarbons (mg/kg)	67	1	1.5	8 J	8 J	8	8 J	8 J	8 J	100 U	73	50 U	100 U
gamma-Chlordane (ug/kg)	72	1	1.4	0.2 J	0.2 J	0.2	0.2 J	0.2 J	0.2 J	3800 U	69	2 U	40 U
2-Chlorophenol (ug/kg)	158	2	1.3	51	93	72	51	51	12 U	6000 U	211	50 U	330 U
Endosulfan sulfate (ug/kg)	164	2	1.2	0.2 J	0.5 J	0.35	0.2 J	0.2 J	0.2 J	7500 UJ	60	2 U	50 U
Chlordane (cis & trans) (ug/kg)	92	1	1.1	47	47	47	47	47	10 U	1000 U	105	17 U	500 U
2,4,5-Trichlorophenol (ug/kg)	189	2	1.1	35	73	54	35	35	2.4 U	12000 U	342	98 U	970 U
2,4,6-Trichlorophenol (ug/kg)	189	2	1.1	57	100	79	57	57	2.4 U	6100 U	275	88 U	650 U
4-Chloroaniline (ug/kg)	116	1	0.86	4 J	4 J	4	4 J	4 J	4 J	21500 U	584	74 U	2000 U
Isophorone (ug/kg)	116	1	0.86	43	43	43	43	43	9.7 U	6000 U	239	35 U	500 U
2,4-Dinitrophenol (ug/kg)	149	1	0.67	18 J	18 J	18	18 J	18 J	12 U	45000 U	1264	300 U	2000 U
4-Nitrophenol (ug/kg)	156	1	0.64	600 J	600 J	600	600 J	600 J	12 U	45000 U	1049	100 UG	2000 U
beta-Hexachlorocyclohexane (ug/kg)	164	1	0.61	1 J	1 J	1	1 J	1 J	0.94 U	3800 U	33	2 U	30 U
N-Nitrosodiphenylamine (ug/kg)	182	1	0.55	3800 M	3800 M	3800	3800 M	3800 M	9.7 U	6000 U	262	20 U	660 U
2,4-Dichlorophenol (ug/kg)	187	1	0.53	140	140	140	140	140	12 U	26000 UJ	592	100 UG	1400 U
Aroclor 1232 (ug/kg)	210	1	0.48	10	10	10	10	10	10 U	75000 U	423	10 U	100 U
Aroclor 1248 (ug/kg)	210	1	0.48	1420	1420	1420	1420	1420	10 U	75000 U	430	10 U	144 U
2,4-Dimethylphenol (ug/kg)	224	0	0						6 U	12000 U	377	20 U	1000 U
2-Methylphenol (ug/kg)	224	0	0						6 U	12000 U	292	100 U	910 U
Aroclor 1016 (ug/kg)	210	0	0						10 U	75000 U	423	10 U	100 U

Table 4-4. Historical Category 1 and 2 Subsurface Sediment and Porewater Chemical Data Summary (1990-present).

		N	%	Detected Concentrations					Detected and Nondetected Concentrations				
Analyte	N	Detected	Detected	Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
Aroclor 1221 (ug/kg)	210	0	0						10 U	150000 U	834	20 U	200 U
1,2-Dichlorobenzene (ug/kg)	173	0	0						1 U	910 U	65	15 U	300 U
1,3-Dichlorobenzene (ug/kg)	173	0	0						1 U	910 U	65	15 U	300 U
Toxaphene (ug/kg)	164	0	0						30 U	380000 U	3608	98 UJ	4000 U
4,6-Dinitro-2-methylphenol (ug/kg)	158	0	0						12 U	45000 U	1186	190 UJ	2000 U
4-Chloro-3-methylphenol (ug/kg)	158	0	0						12 U	6000 U	226	50 U	390 U
2-Nitrophenol (ug/kg)	146	0	0						12 U	6000 U	279	97 U	530 U
2,4-Dinitrotoluene (ug/kg)	116	0	0						12 U	21500 U	612	99 U	2000 U
2,6-Dinitrotoluene (ug/kg)	116	0	0						10 U	6000 U	347	99 U	970 U
2-Chloronaphthalene (ug/kg)	116	0	0						2.8 U	6000 U	237	35 U	500 U
2-Nitroaniline (ug/kg)	116	0	0						10 U	45000 U	1313	170 U	2000 U
3,3'-Dichlorobenzidine (ug/kg)	116	0	0						12 U	45000 U	1395	200 U	2000 U
3-Nitroaniline (ug/kg)	116	0	0						12 U	45000 U	1568	280 U	3000 U
4-Bromophenyl phenyl ether (ug/kg)	116	0	0						9.7 U	6000 U	241	35 U	500 U
4-Chlorophenyl phenyl ether (ug/kg)	116	0	0						9.7 U	6000 U	239	35 U	500 U
4-Nitroaniline (ug/kg)	116	0	0						10 U	45000 U	1360	170 U	2000 U
Bis(2-chloroethoxy) methane (ug/kg)	116	0	0						10 U	6000 U	245	35 U	500 U
Bis(2-chloroethyl) ether (ug/kg)	116	0	0						9.7 U	6000 U	257	50 U	500 U
Nitrobenzene (ug/kg)	116	0	0						9.7 U	6000 U	241	35 U	500 U
N-Nitrosodipropylamine (ug/kg)	116	0	0						9.7 U	6000 U	262	50 U	590 U
Hexachlorocyclopentadiene (ug/kg)	107	0	0						12 U	12000 U	583	300 U	1000 U
Endrin ketone (ug/kg)	91	0	0						1.9 U	7500 UJ	103	2.8 U	40 U
Trichloroethene (ug/kg)	87	0	0						4 U	100 U	7.5	5 U	10 U
alpha-Chlordane (ug/kg)	76	0	0						0.94 U	3800 UJ	67	2 U	43.3 U
Jet fuel A (mg/kg)	68	0	0						10 U	25 U	17	10 UJ	25 U
Kerosene (mg/kg)	68	0	0						10 U	25 U	17	10 U	25 U
Mineral spirits (mg/kg)	68	0	0						10 U	25 U	17	10 U	25 U
Bis(2-chloro-1-methylethyl) ether (ug/kg)	67	0	0						10 U	6000 U	144	19 U	300 U
Bis(2-chloroisopropyl) ether (ug/kg)	49	0	0						9.7 U	3550 U	395	300 U	660 U
Aniline (ug/kg)	44	0	0						50 U	20000 U	1390	1000 U	1000 U
1,1,1-Trichloroethane (ug/kg)	43	0	0						5 U	100 U	9.6	5 U	11 U
1,1,2,2-Tetrachloroethane (ug/kg)	43	0	0						5 U	100 U	9.6	5 U	11 U
1,1,2-Trichloroethane (ug/kg)	43	0	0						5 U	100 U	9.6	5 U	11 U
1,1-Dichloroethane (ug/kg)	43	0	0						5 U	100 U	9.6	5 U	11 U
1,2-Dichloroethane (ug/kg)	43	0	0						5 U	100 U	9.6	5 U	11 U
1,2-Dichloropropane (ug/kg)	43	0	0						5 U	100 U	9.6	5 U	11 U
Bromodichloromethane (ug/kg)	43	0	0						5 U	100 U	9.6	5 U	11 U
Bromoform (ug/kg)	43	0	0						5 U	100 U	9.6	5 U	11 U
Bromomethane (ug/kg)	43	0	0						5 U	500 U	20	5 UJ	20 U
Carbon disulfide (ug/kg)	43	0	0						5 U	1000 U	48.2	5 U	200 U
Carbon tetrachloride (ug/kg)	43	0	0						5 U	100 U	9.6	5 U	11 U
Chlorodibromomethane (ug/kg)	43	0	0						5 U	100 U	9.6	5 U	11 U
Chloroethane (ug/kg)	43	0	0						5 U	100 U	11	5 U	20 U
Chloroform (ug/kg)	43	0	0						5 U	100 U	9.6	5 U	11 U

Table 4-4. Historical Category 1 and 2 Subsurface Sediment and Porewater Chemical Data Summary (1990-present).

		N	%	Detected Concentrations					Detected and Nondetected Concentrations				
Analyte	N	Detected	Detected	Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
Chloromethane (ug/kg)	43	0	0						5 U	500 U	20	5 UJ	20 U
cis-1,2-Dichloroethene (ug/kg)	43	0	0						5 U	100 U	9.6	5 U	11 U
cis-1,3-Dichloropropene (ug/kg)	43	0	0						5 U	100 U	9.6	5 U	11 U
Methyl N-butyl ketone (ug/kg)	43	0	0						20 U	1000 U	58	20 U	100 U
Styrene (ug/kg)	43	0	0						5 U	100 U	9.6	5 U	11 U
trans-1,2-Dichloroethene (ug/kg)	43	0	0						5 U	100 U	9.6	5 U	11 U
trans-1,3-Dichloropropene (ug/kg)	43	0	0						5 U	100 U	9.6	5 U	11 U
Trichlorofluoromethane (ug/kg)	43	0	0						5 U	100 U	11	5 UJ	20 U
Vinyl chloride (ug/kg)	43	0	0						5 U	100 U	11	5 U	20 U
Vinylidene chloride (ug/kg)	43	0	0						5 U	100 U	9.6	5 U	11 U
N-Nitrosodimethylamine (ug/kg)	41	0	0						2000 U	45000 U	3073	2000 U	2000 U
1,1,1,2-Tetrachloroethane (ug/kg)	39	0	0						5 U	100 U	9.6	5 U	11 U
1,1-Dichloropropene (ug/kg)	39	0	0						5 U	100 U	9.6	5 U	11 U
1,2,3-Trichlorobenzene (ug/kg)	39	0	0						20 U	200 U	30	20 U	45 U
1,2,3-Trichloropropane (ug/kg)	39	0	0						5 U	100 U	9.6	5 U	11 U
1,2-Dibromo-3-chloropropane (ug/kg)	39	0	0						20 U	500 U	41	20 U	45 U
1,3-Dichloropropane (ug/kg)	39	0	0						5 U	100 U	9.6	5 U	11 U
2,2-Dichloropropane (ug/kg)	39	0	0						5 U	100 U	9.6	5 U	11 U
2-Chlorotoluene (ug/kg)	39	0	0						20 U	200 U	30	20 U	45 U
4-Chlorotoluene (ug/kg)	39	0	0						20 U	200 U	30	20 U	45 U
Bromobenzene (ug/kg)	39	0	0						5 U	100 U	9.6	5 U	11 U
Bromochloromethane (ug/kg)	39	0	0						5 U	100 U	9.6	5 U	11 U
Dichlorodifluoromethane (ug/kg)	39	0	0						5 U	500 U	20	5 UJ	11 UG
Ethylene dibromide (ug/kg)	39	0	0						20 U	200 U	30	20 U	45 U
Methylene bromide (ug/kg)	39	0	0						5 U	100 U	9.6	5 U	11 U
JP-4 jet fuel (mg/kg)	35	0	0						10 U	10 UJ	10	10 U	10 UJ
Naphtha distillate (mg/kg)	35	0	0						10 U	10 UJ	10	10 UJ	10 UJ
Anthanthrene (ug/kg)	31	0	0						59 U	87000 U	4027	88 U	8600 U
2,3,4,5-Tetrachlorophenol (ug/kg)	31	0	0						2.4 U	6100 U	375	66 UJ	700 U
Methyl isobutyl ketone (ug/kg)	31	0	0						20 U	500 U	47	20 U	100 U
2,6-Dichlorophenol (ug/kg)	30	0	0						120 U	26000 U	2252	140 U	12000 U
Cymene (ug/kg)	12	0	0						20 U	200 U	43	20 U	45 U
Hexachlorocyclohexanes (ug/kg)	12	0	0						10 U	400 U	51	10 U	40 U
2,4,5-T (ug/kg)	11	0	0						14 U	21 U	17	17 U	19 U
2,4-D (ug/kg)	11	0	0						14 U	21 U	17	17 U	19 U
2,4-DB (ug/kg)	11	0	0						14 U	21 U	17	17 U	19 U
Dalapon (ug/kg)	11	0	0						69 U	110 U	88	86 U	96 U
Dicamba (ug/kg)	11	0	0						27 U	42 U	35	34 U	38 U
Dichloroprop (ug/kg)	11	0	0						14 U	21 U	17	17 U	19 U
Dinoseb (ug/kg)	11	0	0						14 U	21 U	17	17 U	19 U
MCPA (ug/kg)	11	0	0						14 U	21 U	17	17 U	19 U
MCPP (ug/kg)	11	0	0						14 U	21 U	17	17 U	19 U
Silvex (ug/kg)	11	0	0						14 U	21 U	17	17 U	19 U
2-Chloroethyl vinyl ether (ug/kg)	4	0	0						20 U	20 U	20	20 U	20 U

Table 4-4. Historical Category 1 and 2 Subsurface Sediment and Porewater Chemical Data Summary (1990-present).

		N	%	Detected Concentrations					Detected and Nondetected Concentrations				
Analyte	N	Detected	Detected	Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
Chlordane (technical) (ug/kg)	4	0	0						150 U	968 U	430	150 U	450 U
trans-Chlordane (ug/kg)	4	0	0						6.7 U	43.3 U	19	6.7 U	20.1 U
Trichlorotrifluoroethane (ug/kg)	4	0	0						20 U	20 U	20	20 U	20 U
Vinyl acetate (ug/kg)	4	0	0						100 U	100 U	100	100 U	100 U
Benzidine (ug/kg)	3	0	0						250 U	250 UG	250	250 U	250 U
Phytane (mg/kg)	3	0	0						0.5 U	0.5 U	0.5	0.5 U	0.5 U
Pristane (mg/kg)	3	0	0						0.5 U	0.5 U	0.5	0.5 U	0.5 U
Methyl tert-butyl ether (ug/kg)	1	0	0						100 U	100 U	100	100 U	100 U

Notes:
A - Detected quantities of analytes added together as defined in WAC 173-204-320 for LPAH and HPAH, as in DMMO 2000 for DDT, and for all Aroclors or congeners for PCB.
B - Possible method blank contamination.
E - Estimate, usually applied because the value exceeded the instrument calibration range.
G - Estimate is greater than value shown.
H - Holding time exceeded.
J - Estimate, usually applied because the value is less than the method reporting limit but greater than the method detection limit, or for QA/QC concerns.
L - Value is less than the maximum shown.
N - Presumptive evidence of presence of material.
U - Not detected at detection limit shown.
X - Recovery less than 10%.
No samples that have been dredged are included in the statistical summary.

Table 4-5. Historical Surface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detected	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
1	2-Methylnaphthalene (ug/kg)	2	2	100	1 GB	2 GB	1.5	1 GB	1 GB	1 GB	2 GB	1.5	1 GB	1 GB
1	Acenaphthene (ug/kg)	2	2	100	0.9 G	1 G	0.95	0.9 G	0.9 G	0.9 G	1 G	0.95	0.9 G	0.9 G
1	Acenaphthylene (ug/kg)	2	2	100	1 G	2 G	1.5	1 G	1 G	1 G	2 G	1.5	1 G	1 G
1	Anthracene (ug/kg)	2	2	100	1 G	1 G	1	1 G	1 G	1 G	1 G	1	1 G	1 G
1	Arsenic (mg/kg)	2	2	100	1 E	1.2 E	1.1	1 E	1 E	1 E	1.2 E	1.1	1 E	1 E
1	Benz(a)anthracene (ug/kg)	2	2	100	3 G	4 G	3.5	3 G	3 G	3 G	4 G	3.5	3 G	3 G
1	Benzo(a)pyrene (ug/kg)	2	2	100	9 G	11 G	10	9 G	9 G	9 G	11 G	10	9 G	9 G
1	Benzo(b)fluoranthene (ug/kg)	2	2	100	7 G	7 G	7	7 G	7 G	7 G	7 G	7	7 G	7 G
1	Benzo(b+k)fluoranthene (ug/kg)	2	2	100	13 A	14 A	13.5	13 A	13 A	13 A	14 A	13.5	13 A	13 A
1	Benzo(g,h,i)perylene (ug/kg)	2	2	100	9 GB	12 GB	10.5	9 GB	9 GB	9 GB	12 GB	10.5	9 GB	9 GB
1	Benzo(k)fluoranthene (ug/kg)	2	2	100	6 G	7 G	6.5	6 G	6 G	6 G	7 G	6.5	6 G	6 G
1	Cadmium (mg/kg)	2	2	100	0.19	0.21	0.2	0.19	0.19	0.19	0.21	0.2	0.19	0.19
1	Chromium (mg/kg)	2	2	100	10.5	11.9	11.2	10.5	10.5	10.5	11.9	11.2	10.5	10.5
1	Chrysene (ug/kg)	2	2	100	3 G	5 G	4	3 G	3 G	3 G	5 G	4	3 G	3 G
1	Copper (mg/kg)	2	2	100	8	8.8	8.4	8	8	8	8.8	8.4	8	8
1	Dibenz(a,h)anthracene (ug/kg)	2	2	100	3 GB	3 GB	3	3 GB	3 GB	3 GB	3 GB	3	3 GB	3 GB
1	Fines (%)	2	2	100	5.2	7.4	6.3	5.2	5.2	5.2	7.4	6.3	5.2	5.2
1	Fluoranthene (ug/kg)	2	2	100	4 G	10 G	7	4 G	4 G	4 G	10 G	7	4 G	4 G
1	Fluorene (ug/kg)	2	2	100	0.7 G	1 G	0.85	0.7 G	0.7 G	0.7 G	1 G	0.85	0.7 G	0.7 G
1	Gravel (%)	2	2	100	9.3	13.7	11.5	9.3	9.3	9.3	13.7	11.5	9.3	9.3
1	High Molecular Weight PAH (ug/kg)	2	2	100	66 A	71 A	68.5	66 A	66 A	66 A	71 A	68.5	66 A	66 A
1	Indeno(1,2,3-cd)pyrene (ug/kg)	2	2	100	8 GB	12 GB	10	8 GB	8 GB	8 GB	12 GB	10	8 GB	8 GB
1	Lead (mg/kg)	2	2	100	5	5.3	5.15	5	5	5	5.3	5.15	5	5
1	Low Molecular Weight PAH (ug/kg)	2	2	100	10.9 A	11.7 A	11.3	10.9 A	10.9 A	10.9 A	11.7 A	11.3	10.9 A	10.9 A
1	Mean grain size (mm)	2	2	100	0.47	0.64	0.555	0.47	0.47	0.47	0.64	0.555	0.47	0.47
1	Median grain size (mm)	2	2	100	0.28	0.3	0.29	0.28	0.28	0.28	0.3	0.29	0.28	0.28
1	Mercury (mg/kg)	2	2	100	0.02	0.03	0.025	0.02	0.02	0.02	0.03	0.025	0.02	0.02
1	Naphthalene (ug/kg)	2	2	100	1 GB	1 GB	1	1 GB	1 GB	1 GB	1 GB	1	1 GB	1 GB
1	Nickel (mg/kg)	2	2	100	9	9.4	9.2	9	9	9	9.4	9.2	9	9
1	Phenanthrene (ug/kg)	2	2	100	4 GB	5 G	4.5	4 GB	4 GB	4 GB	5 G	4.5	4 GB	4 GB
1	Polycyclic Aromatic Hydrocarbons (ug/kg)	2	2	100	76.9 A	82.7 A	79.8	76.9 A	76.9 A	76.9 A	82.7 A	79.8	76.9 A	76.9 A
1	Pyrene (ug/kg)	2	2	100	5 G	9 G	7	5 G	5 G	5 G	9 G	7	5 G	5 G
1	Sand (%)	2	2	100	79.8	85.5	82.65	79.8	79.8	79.8	85.5	82.65	79.8	79.8
1	Silt (%)	2	2	100	5.2	7.4	6.3	5.2	5.2	5.2	7.4	6.3	5.2	5.2
1	Silver (mg/kg)	2	2	100	0.04	0.05	0.045	0.04	0.04	0.04	0.05	0.045	0.04	0.04
1	Total organic carbon (%)	2	2	100	0.13	0.16	0.145	0.13	0.13	0.13	0.16	0.145	0.13	0.13
1	Total solids (%)	2	2	100	73	75.1	74.05	73	73	73	75.1	74.05	73	73
1	Total volatile solids (%)	2	2	100	0.8	0.9	0.85	0.8	0.8	0.8	0.9	0.85	0.8	0.8
1	Zinc (mg/kg)	2	2	100	51	52.6	51.8	51	51	51	52.6	51.8	51	51
1	4,4'-DDD (ug/kg)	2	1	50	0.2	0.2	0.2	0.2	0.2	0.2	2 U	1.1	0.2	0.2
1	Total of 3 isomers: pp-DDT,-DDD,-DDE (ug/k	2	1	50	0.2 A	0.2 A	0.2	0.2 A	0.2 A	0.2 A	2 UA	1.1	0.2 A	0.2 A
1	4,4'-DDE (ug/kg)	2	0	0						2 U	2 U	2	2 U	2 U
1	4,4'-DDT (ug/kg)	2	0	0						2 U	2 U	2	2 U	2 U
1	Acid Volatile Sulfides (mg/kg)	2	0	0						0.7 U	0.7 U	0.7	0.7 U	0.7 U
1	Aroclor 1016 (ug/kg)	2	0	0						10 U	10 UG	10	10 U	10 U
1	Aroclor 1221 (ug/kg)	2	0	0						10 U	10 UG	10	10 U	10 U
1	Aroclor 1232 (ug/kg)	2	0	0						10 U	10 UG	10	10 U	10 U
1	Aroclor 1242 (ug/kg)	2	0	0						10 U	10 U	10	10 U	10 U

Table 4-5. Historical Surface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detected	Detected Concentrations Minimum	Maximum	Mean	Median	95th	Detected and Nondetected Concentrations Minimum	Maximum	Mean	Median	95th
1	Aroclor 1248 (ug/kg)	2	0	0						10 U	10 UG	10	10 U	10 U
1	Aroclor 1254 (ug/kg)	2	0	0						10 U	10 U	10	10 U	10 U
1	Aroclor 1260 (ug/kg)	2	0	0						10 U	10 U	10	10 U	10 U
1	Clay (%)	2	0	0						0.1 U	0.1 U	0.1	0.1 U	0.1 U
1	Dibenzofuran (ug/kg)	2	0	0						5 UG	5 UG	5	5 UG	5 UG
1	Polychlorinated biphenyls (ug/kg)	2	0	0						10 UA	10 UA	10	10 UA	10 UA
1	Tributyltin ion (ug/l)	2	0	0						0.05 U	0.05 U	0.05	0.05 U	0.05 U
1	Aldrin (ug/kg)	2	0	0						2 UG	2 U	2	2 UG	2 UG
1	alpha-Endosulfan (ug/kg)	2	0	0						2 UG	2 U	2	2 UG	2 UG
1	alpha-Hexachlorocyclohexane (ug/kg)	2	0	0						2 UG	2 U	2	2 UG	2 UG
1	beta-Endosulfan (ug/kg)	2	0	0						2 UG	2 U	2	2 UG	2 UG
1	beta-Hexachlorocyclohexane (ug/kg)	2	0	0						2 UG	2 U	2	2 UG	2 UG
1	Chlordane (cis & trans) (ug/kg)	2	0	0						10 U	10 U	10	10 U	10 U
1	delta-Hexachlorocyclohexane (ug/kg)	2	0	0						2 U	2 UG	2	2 U	2 U
1	Dieldrin (ug/kg)	2	0	0						2 U	2 U	2	2 U	2 U
1	Endosulfan sulfate (ug/kg)	2	0	0						2 U	2 UG	2	2 U	2 U
1	Endrin (ug/kg)	2	0	0						2 U	2 UG	2	2 U	2 U
1	Endrin aldehyde (ug/kg)	2	0	0						2 U	2 UG	2	2 U	2 U
1	gamma-Hexachlorocyclohexane (ug/kg)	2	0	0						2 U	2 UG	2	2 U	2 U
1	Heptachlor (ug/kg)	2	0	0						2 U	2 UG	2	2 U	2 U
1	Heptachlor epoxide (ug/kg)	2	0	0						2 U	2 UG	2	2 U	2 U
1	Methoxychlor (ug/kg)	2	0	0						4 U	4 UG	4	4 U	4 U
1	Toxaphene (ug/kg)	2	0	0						30 U	30 UG	30	30 U	30 U
2	Arsenic (mg/kg)	3	3	100	0.6 E	2.5 E	1.8	0.6 E	2.2	0.6 E	2.5 E	1.8	0.6 E	2.2
2	Chromium (mg/kg)	3	3	100	21.7 J	28.9	26.1	21.7 J	27.6	21.7 J	28.9	26.1	21.7 J	27.6
2	Clay (%)	3	3	100	0.25	4.7	2.8	0.25	3.4	0.25	4.7	2.8	0.25	3.4
2	Copper (mg/kg)	3	3	100	12.8	30.4	23.8	12.8	28.2	12.8	30.4	23.8	12.8	28.2
2	Nickel (mg/kg)	3	3	100	12.5	20.9	17.7	12.5	19.7	12.5	20.9	17.7	12.5	19.7
2	Polychlorinated biphenyls (ug/kg)	3	3	100	5 A	140 A	50.7	5 A	7 A	5 A	140 A	50.7	5 A	7 A
2	Silt (%)	3	3	100	7.15	70.6	48.75	7.15	68.5	7.15	70.6	48.75	7.15	68.5
2	Total organic carbon (%)	3	3	100	0.16	1.33	0.90	0.16	1.2	0.16	1.33	0.90	0.16	1.2
2	Total solids (%)	3	3	100	51.5	95.2	67.0	51.5	54.2	51.5	95.2	67.0	51.5	54.2
2	Zinc (mg/kg)	3	3	100	68.9	139	107.6	68.9	115	68.9	139	108	68.9	115
2	4,4'-DDD (ug/kg)	2	2	100	1	1	1	1	1	1	1	1	1	1
2	4,4'-DDE (ug/kg)	2	2	100	2	2	2	2	2	2	2	2	2	2
2	Acid Volatile Sulfides (mg/kg)	2	2	100	14.8	65	39.9	14.8	14.8	14.8	65	39.9	14.8	14.8
2	Fines (%)	2	2	100	71.9	75.3	73.6	71.9	71.9	71.9	75.3	73.6	71.9	71.9
2	Gravel (%)	2	2	100	0.1	35.4	17.75	0.1	0.1	0.1	35.4	17.75	0.1	0.1
2	Mean grain size (mm)	2	2	100	0.04	0.07	0.055	0.04	0.04	0.04	0.07	0.055	0.04	0.04
2	Median grain size (mm)	2	2	100	0.03	0.04	0.035	0.03	0.03	0.03	0.04	0.035	0.03	0.03
2	Total of 3 isomers: pp-DDT,-DDD,-DDE (ug/k	2	2	100	3 A	3 A	3	3 A	3 A	3 A	3 A	3	3 A	3 A
2	Total volatile solids (%)	2	2	100	3.6	4.2	3.9	3.6	3.6	3.6	4.2	3.9	3.6	3.6
2	Aldrin (ug/kg)	2	2	100	0.4 J	0.4 J	0.4	0.4 J	0.4 J	0.4 J	0.4 J	0.4	0.4 J	0.4 J
2	Coarse sand (%)	1	1	100	15.5	15.5	15.5	15.5	15.5	15.5	15.5	15.5	15.5	15.5
2	Fine sand (%)	1	1	100	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43
2	Medium sand (%)	1	1	100	41.9	41.9	41.9	41.9	41.9	41.9	41.9	41.9	41.9	41.9
2	Sand (%)	1	1	100	24.6	24.6	24.6	24.6	24.6	24.6	24.6	24.6	24.6	24.6
2	Very coarse sand (%)	1	1	100	6.47	6.47	6.47	6.47	6.47	6.47	6.47	6.47	6.47	6.47

Table 4-5. Historical Surface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detected	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
2	Very fine sand (%)	1	1	100	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
2	2-Methylnaphthalene (ug/kg)	3	2	67	3 GB	6 GB	4.5	3 GB	3 GB	3 GB	9.9 U	6.3	3 GB	6 GB
2	Acenaphthene (ug/kg)	3	2	67	2 G	6 G	4	2 G	2 G	2 G	9.9 U	6.0	2 G	6 G
2	Acenaphthylene (ug/kg)	3	2	67	3 G	5 G	4	3 G	3 G	3 G	9.9 U	6.0	3 G	5 G
2	Anthracene (ug/kg)	3	2	67	6 G	11 G	8.5	6 G	6 G	6 G	11 G	9.0	6 G	9.9 U
2	Aroclor 1260 (ug/kg)	3	2	67	5	7	6	5	5	5	100 U	37.3	5	7
2	Benz(a)anthracene (ug/kg)	3	2	67	14 G	42 G	28	14 G	14 G	9.9 U	42 G	22.0	9.9 U	14 G
2	Benzo(a)pyrene (ug/kg)	3	2	67	36 G	109 G	72.5	36 G	36 G	9.9 U	109 G	51.6	9.9 U	36 G
2	Benzo(b)fluoranthene (ug/kg)	3	2	67	25 G	84 G	54.5	25 G	25 G	9.9 U	84 G	39.6	9.9 U	25 G
2	Benzo(b+k)fluoranthene (ug/kg)	3	2	67	50 A	163 A	106.5	50 A	50 A	9.9 UA	163 A	74.3	9.9 UA	50 A
2	Benzo(g,h,i)perylene (ug/kg)	3	2	67	33 G	91 G	62	33 G	33 G	20 U	91 G	48	20 U	33 G
2	Benzo(k)fluoranthene (ug/kg)	3	2	67	25 G	79 G	52	25 G	25 G	9.9 U	79 G	38.0	9.9 U	25 G
2	Cadmium (mg/kg)	3	2	67	0.65	0.93	0.79	0.65	0.65	0.65	1.02 U	0.87	0.65	0.93
2	Chrysene (ug/kg)	3	2	67	17 G	49 G	33	17 G	17 G	9.9 U	49 G	25.3	9.9 U	17 G
2	Dibenz(a,h)anthracene (ug/kg)	3	2	67	8 GB	22 G	15	8 GB	8 GB	8 GB	22 G	16.7	8 GB	20 U
2	Dibenzofuran (ug/kg)	3	2	67	0.9 G	3 G	1.95	0.9 G	0.9 G	0.9 G	9.9 U	4.6	0.9 G	3 G
2	Fluoranthene (ug/kg)	3	2	67	23 G	73 G	48	23 G	23 G	9.9 U	73 G	35.3	9.9 U	23 G
2	Fluorene (ug/kg)	3	2	67	3 G	6 G	4.5	3 G	3 G	3 G	9.9 U	6.3	3 G	6 G
2	High Molecular Weight PAH (ug/kg)	3	2	67	240 A	713 A	476.5	240 A	240 A	20 UA	713 A	324	20 UA	240 A
2	Indeno(1,2,3-cd)pyrene (ug/kg)	3	2	67	33 G	97 G	65	33 G	33 G	20 U	97 G	50	20 U	33 G
2	Lead (mg/kg)	3	2	67	15.9	19.6	17.75	15.9	15.9	15.9	20.4 U	18.6	15.9	19.6
2	Low Molecular Weight PAH (ug/kg)	3	2	67	33 A	80 A	56.5	33 A	33 A	9.9 UA	80 A	41.0	9.9 UA	33 A
2	Mercury (mg/kg)	3	2	67	0.06	0.08	0.07	0.06	0.06	0.02 U	0.08	0.05	0.02 U	0.06
2	Naphthalene (ug/kg)	3	2	67	2 GB	8 GB	5	2 GB	2 GB	2 GB	9.9 U	6.6	2 GB	8 GB
2	Phenanthrene (ug/kg)	3	2	67	14 G	38 G	26	14 G	14 G	9.9 U	38 G	20.6	9.9 U	14 G
2	Polycyclic Aromatic Hydrocarbons (ug/kg)	3	2	67	273 A	793 A	533	273 A	273 A	20 UA	793 A	362	20 UA	273 A
2	Pyrene (ug/kg)	3	2	67	26 G	67 G	46.5	26 G	26 G	9.9 U	67 G	34.3	9.9 U	26 G
2	Silver (mg/kg)	3	2	67	0.16	0.21	0.185	0.16	0.16	0.16	2.04 U	0.80	0.16	0.21
2	beta-Hexachlorocyclohexane (ug/kg)	2	1	50	0.4 J	0.4 J	0.4	0.4 J	0.4 J	0.4 J	2 U	1.2	0.4 J	0.4 J
2	Aroclor 1248 (ug/kg)	3	1	33	140	140	140	140	140	10 U	140	53	10 U	10 U
2	Aroclor 1016 (ug/kg)	3	0	0						10 U	100 U	40	10 U	10 U
2	Aroclor 1221 (ug/kg)	3	0	0						10 U	200 U	73	10 U	10 U
2	Aroclor 1232 (ug/kg)	3	0	0						10 U	100 U	40	10 U	10 U
2	Aroclor 1242 (ug/kg)	3	0	0						10 U	100 U	40	10 U	10 U
2	Aroclor 1254 (ug/kg)	3	0	0						10 U	100 U	40	10 U	10 U
2	4,4'-DDT (ug/kg)	2	0	0						2 U	2 U	2	2 U	2 U
2	Tributyltin ion (ug/l)	2	0	0						0.05 U	0.05 U	0.05	0.05 U	0.05 U
2	alpha-Endosulfan (ug/kg)	2	0	0						2 U	2 U	2	2 U	2 U
2	alpha-Hexachlorocyclohexane (ug/kg)	2	0	0						2 U	2 U	2	2 U	2 U
2	beta-Endosulfan (ug/kg)	2	0	0						2 U	2 U	2	2 U	2 U
2	Chlordane (cis & trans) (ug/kg)	2	0	0						10 U	10 U	10	10 U	10 U
2	delta-Hexachlorocyclohexane (ug/kg)	2	0	0						2 U	2 U	2	2 U	2 U
2	Dieldrin (ug/kg)	2	0	0						2 U	2 U	2	2 U	2 U
2	Endosulfan sulfate (ug/kg)	2	0	0						2 U	2 U	2	2 U	2 U
2	Endrin (ug/kg)	2	0	0						2 U	2 U	2	2 U	2 U
2	Endrin aldehyde (ug/kg)	2	0	0						2 U	2 U	2	2 U	2 U
2	gamma-Hexachlorocyclohexane (ug/kg)	2	0	0						2 U	2 U	2	2 U	2 U
2	Heptachlor (ug/kg)	2	0	0						2 U	2 U	2	2 U	2 U

Table 4-5. Historical Surface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detected	Detected Concentrations Minimum	Maximum	Mean	Median	95th	Detected and Nondetected Concentrations Minimum	Maximum	Mean	Median	95th
2	Heptachlor epoxide (ug/kg)	2	0	0						2 U	2 U	2	2 U	2 U
2	Methoxychlor (ug/kg)	2	0	0						4 U	4 U	4	4 U	4 U
2	Toxaphene (ug/kg)	2	0	0						30 U	30 U	30	30 U	30 U
2	2,4-Dinitrotoluene (ug/kg)	1	0	0						50 U	50 U	50	50 U	50 U
2	2,6-Dinitrotoluene (ug/kg)	1	0	0						20 U	20 U	20	20 U	20 U
2	2-Chloronaphthalene (ug/kg)	1	0	0						9.9 U	9.9 U	9.9	9.9 U	9.9 U
2	2-Nitroaniline (ug/kg)	1	0	0						20 U	20 U	20	20 U	20 U
2	3,3'-Dichlorobenzidine (ug/kg)	1	0	0						70 UJ	70 UJ	70	70 UJ	70 UJ
2	3-Nitroaniline (ug/kg)	1	0	0						200 U	200 U	200	200 U	200 U
2	4-Bromophenyl phenyl ether (ug/kg)	1	0	0						9.9 U	9.9 U	9.9	9.9 U	9.9 U
2	4-Chloroaniline (ug/kg)	1	0	0						50 UJ	50 UJ	50	50 UJ	50 UJ
2	4-Chlorophenyl phenyl ether (ug/kg)	1	0	0						9.9 U	9.9 U	9.9	9.9 U	9.9 U
2	4-Nitroaniline (ug/kg)	1	0	0						99 U	99 U	99	99 U	99 U
2	Antimony (mg/kg)	1	0	0						10.2 U	10.2 U	10.2	10.2 U	10.2 U
2	Benzoic acid (ug/kg)	1	0	0						400 U	400 U	400	400 U	400 U
2	Benzyl alcohol (ug/kg)	1	0	0						50 U	50 U	50	50 U	50 U
2	Beryllium (mg/kg)	1	0	0						1.02 U	1.02 U	1.02	1.02 U	1.02 U
2	Bis(2-chloroethoxy) methane (ug/kg)	1	0	0						20 U	20 U	20	20 U	20 U
2	Bis(2-chloroethyl) ether (ug/kg)	1	0	0						9.9 U	9.9 U	9.9	9.9 U	9.9 U
2	Bis(2-chloroisopropyl) ether (ug/kg)	1	0	0						9.9 U	9.9 U	9.9	9.9 U	9.9 U
2	Hexachlorobutadiene (ug/kg)	1	0	0						9.9 U	9.9 U	9.9	9.9 U	9.9 U
2	Hexachlorocyclopentadiene (ug/kg)	1	0	0						200 U	200 U	200	200 U	200 U
2	Hexachloroethane (ug/kg)	1	0	0						40 U	40 U	40	40 U	40 U
2	Isophorone (ug/kg)	1	0	0						9.9 U	9.9 U	9.9	9.9 U	9.9 U
2	Nitrobenzene (ug/kg)	1	0	0						9.9 U	9.9 U	9.9	9.9 U	9.9 U
2	N-Nitrosodiphenylamine (ug/kg)	1	0	0						9.9 U	9.9 U	9.9	9.9 U	9.9 U
2	N-Nitrosodipropylamine (ug/kg)	1	0	0						9.9 U	9.9 U	9.9	9.9 U	9.9 U
2	Selenium (mg/kg)	1	0	0						1.04 U	1.04 U	1.04	1.04 U	1.04 U
2	Thallium (mg/kg)	1	0	0						1.04 U	1.04 U	1.04	1.04 U	1.04 U
2	1,2,4-Trichlorobenzene (ug/kg)	1	0	0						9.9 U	9.9 U	9.9	9.9 U	9.9 U
2	1,2-Dichlorobenzene (ug/kg)	1	0	0						9.9 U	9.9 U	9.9	9.9 U	9.9 U
2	1,3-Dichlorobenzene (ug/kg)	1	0	0						9.9 U	9.9 U	9.9	9.9 U	9.9 U
2	1,4-Dichlorobenzene (ug/kg)	1	0	0						9.9 U	9.9 U	9.9	9.9 U	9.9 U
2	2,4,5-Trichlorophenol (ug/kg)	1	0	0						50 U	50 U	50	50 U	50 U
2	2,4,6-Trichlorophenol (ug/kg)	1	0	0						50 U	50 U	50	50 U	50 U
2	2,4-Dichlorophenol (ug/kg)	1	0	0						99 U	99 U	99	99 U	99 U
2	2,4-Dimethylphenol (ug/kg)	1	0	0						200 U	200 U	200	200 U	200 U
2	2,4-Dinitrophenol (ug/kg)	1	0	0						300 U	300 U	300	300 U	300 U
2	2-Chlorophenol (ug/kg)	1	0	0						50 U	50 U	50	50 U	50 U
2	2-Methylphenol (ug/kg)	1	0	0						200 U	200 U	200	200 U	200 U
2	2-Nitrophenol (ug/kg)	1	0	0						50 U	50 U	50	50 U	50 U
2	3- and 4-Methylphenol Coelution (ug/kg)	1	0	0						200 U	200 U	200	200 U	200 U
2	4,6-Dinitro-2-methylphenol (ug/kg)	1	0	0						200 U	200 U	200	200 U	200 U
2	4-Chloro-3-methylphenol (ug/kg)	1	0	0						50 U	50 U	50	50 U	50 U
2	4-Nitrophenol (ug/kg)	1	0	0						99 U	99 U	99	99 U	99 U
2	Bis(2-ethylhexyl) phthalate (ug/kg)	1	0	0						200 U	200 U	200	200 U	200 U
2	Butylbenzyl phthalate (ug/kg)	1	0	0						20 U	20 U	20	20 U	20 U
2	Carbazole (ug/kg)	1	0	0						9.9 U	9.9 U	9.9	9.9 U	9.9 U

Table 4-5. Historical Surface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detected	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
2	Dibutyl phthalate (ug/kg)	1	0	0						20 U	20 U	20	20 U	20 U
2	Diethyl phthalate (ug/kg)	1	0	0						9.9 U	9.9 U	9.9	9.9 U	9.9 U
2	Dimethyl phthalate (ug/kg)	1	0	0						9.9 U	9.9 U	9.9	9.9 U	9.9 U
2	Di-n-octyl phthalate (ug/kg)	1	0	0						200 U	200 U	200	200 U	200 U
2	Hexachlorobenzene (ug/kg)	1	0	0						9.9 U	9.9 U	9.9	9.9 U	9.9 U
2	Pentachlorophenol (ug/kg)	1	0	0						300 U	300 U	300	300 U	300 U
2	Phenol (ug/kg)	1	0	0						50 U	50 U	50	50 U	50 U
3	Chromium (mg/kg)	17	17	100	13.1 J	819 J	269	223 J	693 J	13.1 J	819 J	269	223 J	693 J
3	Copper (mg/kg)	17	17	100	11.1	148	56	36.7	145	11.1	148	56	36.7	145
3	Nickel (mg/kg)	17	17	100	12.4	60.8	27	19.7	58.4	12.4	60.8	27	19.7	58.4
3	Total solids (%)	17	17	100	24.2	97.2	80	89.2	95.6	24.2	97.2	80	89.2	95.6
3	Zinc (mg/kg)	17	17	100	43.1	823	264	137	698	43.1	823	264	137	698
3	Clay (%)	16	16	100	0	5.7	1.2	0.05	5.5	0	5.7	1.2	0.05	5.5
3	Silt (%)	16	16	100	2.67	67.3	18	7.08	65.2	2.67	67.3	18	7.08	65.2
3	Coarse sand (%)	13	13	100	3.29	24.6	15	13.9	19.7	3.29	24.6	15	13.9	19.7
3	Fine sand (%)	13	13	100	0.53	11.5	4.24	2.53	11.46	0.53	11.5	4.24	2.53	11.46
3	Gravel (%)	13	13	100	0.41	84.6	46	47.6	79.1	0.41	84.6	46	47.6	79.1
3	Medium sand (%)	13	13	100	4.48	71.8	28	17.9	70	4.48	71.8	28	17.9	70
3	Very coarse sand (%)	13	13	100	0.53	15.5	7.69	6	13.1	0.53	15.5	7.7	6	13.1
3	Very fine sand (%)	13	13	100	0.04	2.17	0.53	0.13	1.44	0.04	2.17	0.53	0.13	1.44
3	4,4'-DDD (ug/kg)	3	3	100	1	2	1.7	1	2	1	2	1.7	1	2
3	4,4'-DDE (ug/kg)	3	3	100	1	2	1.7	1	2	1	2	1.7	1	2
3	Acid Volatile Sulfides (mg/kg)	3	3	100	2.9	47	32.3	2.9	47	2.9	47	32	2.9	47
3	Fines (%)	3	3	100	69.1	72.2	71	69.1	70.9	69.1	72.2	71	69.1	70.9
3	Mean grain size (mm)	3	3	100	0.06	0.13	0.09	0.06	0.07	0.06	0.13	0.09	0.06	0.07
3	Median grain size (mm)	3	3	100	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
3	Total of 3 isomers: pp-DDT,-DDD,-DDE (ug/k	3	3	100	2.3 A	4.3 A	3.5	2.3 A	4 A	2.3 A	4.3 A	3.5	2.3 A	4 A
3	Total volatile solids (%)	3	3	100	3.9	5	4.6	3.9	4.9	3.9	5	4.6	3.9	4.9
3	Aldrin (ug/kg)	3	3	100	0.3 J	0.4 J	0.37	0.3 J	0.4 J	0.3 J	0.4 J	0.37	0.3 J	0.4 J
3	Sand (%)	1	1	100	30.9	30.9	30.9	30.9	30.9	30.9	30.9	30.9	30.9	30.9
3	Lube Oil (mg/kg)	1	1	100	81	81	81	81	81	81	81	81	81	81
3	Arsenic (mg/kg)	17	16	94	1.8	132	12	3	9.3	1.8	132	11	2.8	9.3
3	Total organic carbon (%)	16	15	94	0.11	1.91	0.70	0.42	1.84	0.05 U	1.91	0.66	0.42	1.84
3	Polychlorinated biphenyls (ug/kg)	17	15	88	4 A	9300 A	1371	550 A	2790 A	4 A	9300 A	1233	290 A	2790 A
3	High Molecular Weight PAH (ug/kg)	17	13	76	24 A	39000 A	3562	196 A	2643 A	19 UA	39000 A	2729	132 A	2643 A
3	Polycyclic Aromatic Hydrocarbons (ug/kg)	17	13	76	24 A	53093 A	4704	196 A	2899 A	19 UA	53093 A	3602	132 A	2899 A
3	Pyrene (ug/kg)	17	13	76	10	5700	510	22	265 G	9.7 U	5700	392	16	265 G
3	Aroclor 1248 (ug/kg)	17	12	71	180	9300	1579	770	2500	10 U	9300	1128	290	2500
3	Benzo(b+k)fluoranthene (ug/kg)	17	12	71	11 A	7100 A	720	42 A	539 A	9.7 UA	7100 A	511	30 A	539 A
3	Chrysene (ug/kg)	17	12	71	11	3800	370	26	180 G	9.7 U	3800	264	18	180 G
3	Lead (mg/kg)	17	12	71	14.8	166	75.55	75.6	110	14.8	166	59	21 U	110
3	Mercury (mg/kg)	17	12	71	0.02	0.09	0.05	0.05	0.08	0.02	0.09	0.04	0.03	0.08
3	4,4'-DDT (ug/kg)	3	2	67	0.3	0.3	0.3	0.3	0.3	0.3	2 U	0.87	0.3	0.3
3	Tributyltin ion (ug/l)	3	2	67	0.1	0.1	0.1	0.1	0.1	0.05 U	0.1	0.08	0.05 U	0.1
3	Endrin aldehyde (ug/kg)	3	2	67	0.3 J	0.4 J	0.35	0.3 J	0.3 J	0.3 J	2 U	0.9	0.3 J	0.4 J
3	Aroclor 1260 (ug/kg)	17	11	65	4	390	147	140	290	4	1000 U	183	100 U	390
3	Benzo(a)pyrene (ug/kg)	17	11	65	18	4300	500	28	459 G	9.6 U	4300	327	19	459 G
3	Benzo(b)fluoranthene (ug/kg)	17	11	65	11	3500	388	22	270 G	9.7 U	3500	255.2	19 U	270 G

Table 4-5. Historical Surface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detected	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
3	Benzo(k)fluoranthene (ug/kg)	17	11	65	13	3600	397	20	269 G	9.6 U	3600	260	17	269 G
3	Fluoranthene (ug/kg)	17	11	65	12	7600	757	34	208 G	9.6 U	7600	494	12	208 G
3	Benzo(g,h,i)perylene (ug/kg)	17	9	53	20	2900	418	26	385 G	19 U	2900	241	20	385 G
3	Benz(a)anthracene (ug/kg)	17	8	47	15	4000	557	58 G	158 G	8.9 U	4000	267	9.9 U	158 G
3	Indeno(1,2,3-cd)pyrene (ug/kg)	17	7	41	23	3600	631	31	383 G	18 U	3600	282	20 U	383 G
3	Anthracene (ug/kg)	17	6	35	12	1900	335	17 G	36 G	8.9 U	1900	124	9.9 U	36 G
3	Cadmium (mg/kg)	17	6	35	0.54	2.1	1.17	0.71	1.5	0.54	2.1	1.1	1.04 U	1.5
3	Low Molecular Weight PAH (ug/kg)	17	6	35	54 A	14093 A	2475	147 A	256 A	8.9 UA	14093 A	880	9.9 UA	256 A
3	Phenanthrene (ug/kg)	17	6	35	40	7700	1347	66 G	120 G	8.9 U	7700	482	9.9 U	120 G
3	gamma-Hexachlorocyclohexane (ug/kg)	3	1	33	0.3 J	0.3 J	0.3	0.3 J	0.3 J	0.3 J	2 U	1.4	0.3 J	2 U
3	Acenaphthylene (ug/kg)	17	5	29	10 G	25 G	16.8	12	23	8.9 U	25 G	12	9.9 U	23
3	Dibenzofuran (ug/kg)	17	5	29	3 G	1000	206	6 G	14	3 G	1000	67	9.7 U	14
3	Naphthalene (ug/kg)	17	5	29	10	3100	635	19 G	23 G	8.9 U	3100	194	9.9 U	23 G
3	Silver (mg/kg)	17	5	29	0.16	2.3	1.038	0.25	2.2	0.16	2.48 U	1.8	2.08 U	2.35 U
3	2-Methylnaphthalene (ug/kg)	17	4	24	13 G	440	124	21 G	22 G	8.9 U	440	37	9.9 U	22 G
3	Acenaphthene (ug/kg)	17	4	24	9 G	270	76	11 G	14 G	8.9 U	270	26	9.9 U	20 U
3	Fluorene (ug/kg)	17	4	24	9 G	1100	285	14 G	16 G	8.9 U	1100	74	9.9 U	16 G
3	Dibenz(a,h)anthracene (ug/kg)	17	3	18	26 G	66 G	44	26 G	39 G	18 U	970 U	90	20 U	200 U
3	Butylbenzyl phthalate (ug/kg)	14	1	7	34	34	34	34	34	18 U	34	20	19 U	20 U
3	Carbazole (ug/kg)	14	1	7	1500	1500	1500	1500	1500	8.9 U	1500	116	9.9 U	10 U
3	Phenol (ug/kg)	14	1	7	72	72	72	72	72	44 U	72	50.5	49 U	50 U
3	Aroclor 1016 (ug/kg)	17	0	0						10 U	1000 U	137	100 U	100 U
3	Aroclor 1221 (ug/kg)	17	0	0						10 U	2000 U	272	200 U	200 U
3	Aroclor 1232 (ug/kg)	17	0	0						10 U	1000 U	137	100 U	100 U
3	Aroclor 1242 (ug/kg)	17	0	0						10 U	1000 U	137	100 U	100 U
3	Aroclor 1254 (ug/kg)	17	0	0						10 U	1000 U	137	100 U	100 U
3	2,4-Dinitrotoluene (ug/kg)	14	0	0						44 U	50 U	49	49 U	50 U
3	2,6-Dinitrotoluene (ug/kg)	14	0	0						18 U	20 U	19	19 U	20 U
3	2-Chloronaphthalene (ug/kg)	14	0	0						8.9 U	10 U	9.7	9.7 U	10 U
3	2-Nitroaniline (ug/kg)	14	0	0						18 U	20 U	19	19 U	20 U
3	3,3'-Dichlorobenzidine (ug/kg)	14	0	0						70 UJ	300 UJ	89	70 UJ	80 UJ
3	3-Nitroaniline (ug/kg)	14	0	0						180 U	200 U	194	190 U	200 U
3	4-Bromophenyl phenyl ether (ug/kg)	14	0	0						8.9 U	10 U	9.7	9.7 U	10 U
3	4-Chloroaniline (ug/kg)	14	0	0						44 UJ	50 UJ	49	49 UJ	50 UJ
3	4-Chlorophenyl phenyl ether (ug/kg)	14	0	0						8.9 U	10 U	9.7	9.7 U	10 U
3	4-Nitroaniline (ug/kg)	14	0	0						9.9 U	100 U	91	97 U	100 U
3	Antimony (mg/kg)	14	0	0						9.89 U	12.4 U	11	10.5 U	11.8 U
3	Benzoic acid (ug/kg)	14	0	0						360 U	400 U	392	390 U	400 U
3	Benzyl alcohol (ug/kg)	14	0	0						44 U	50 U	49	49 U	50 U
3	Beryllium (mg/kg)	14	0	0						1 U	1.24 U	1.1	1.05 U	1.18 U
3	Bis(2-chloroethoxy) methane (ug/kg)	14	0	0						18 U	20 U	19	19 U	20 U
3	Bis(2-chloroethyl) ether (ug/kg)	14	0	0						8.9 U	10 U	9.7	9.7 U	10 U
3	Bis(2-chloroisopropyl) ether (ug/kg)	14	0	0						8.9 U	10 U	9.7	9.7 U	10 U
3	Hexachlorobutadiene (ug/kg)	14	0	0						8.9 U	10 U	9.7	9.7 U	10 U
3	Hexachlorocyclopentadiene (ug/kg)	14	0	0						180 U	200 U	194	190 U	200 U
3	Hexachloroethane (ug/kg)	14	0	0						36 U	40 U	39	39 U	40 U
3	Isophorone (ug/kg)	14	0	0						8.9 U	10 U	9.7	9.7 U	10 U
3	Nitrobenzene (ug/kg)	14	0	0						8.9 U	10 U	9.7	9.7 U	10 U

Table 4-5. Historical Surface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detected	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
3	N-Nitrosodiphenylamine (ug/kg)	14	0	0						8.9 U	10 U	9.7	9.7 U	10 U
3	N-Nitrosodipropylamine (ug/kg)	14	0	0						8.9 U	10 U	9.7	9.7 U	10 U
3	Selenium (mg/kg)	14	0	0						1 U	1.2 U	1.1	1.05 U	1.19 U
3	Thallium (mg/kg)	14	0	0						1 U	1.2 U	1.1	1.05 U	1.19 U
3	1,2,4-Trichlorobenzene (ug/kg)	14	0	0						8.9 U	20 U	10	9.7 U	10 U
3	1,2-Dichlorobenzene (ug/kg)	14	0	0						8.9 U	20 U	10	9.7 U	10 U
3	1,3-Dichlorobenzene (ug/kg)	14	0	0						8.9 U	20 U	10	9.7 U	10 U
3	1,4-Dichlorobenzene (ug/kg)	14	0	0						8.9 U	10 U	9.7	9.7 U	10 U
3	2,4,5-Trichlorophenol (ug/kg)	14	0	0						44 U	500 U	81	49 U	50 U
3	2,4,6-Trichlorophenol (ug/kg)	14	0	0						44 U	50 U	49	49 U	50 U
3	2,4-Dichlorophenol (ug/kg)	14	0	0						89 U	100 U	97	97 U	100 U
3	2,4-Dimethylphenol (ug/kg)	14	0	0						180 U	200 U	194	190 U	200 U
3	2,4-Dinitrophenol (ug/kg)	14	0	0						270 U	300 U	294	290 U	300 U
3	2-Chlorophenol (ug/kg)	14	0	0						44 U	50 U	49	49 U	50 U
3	2-Methylphenol (ug/kg)	14	0	0						180 U	200 U	194	190 U	200 U
3	2-Nitrophenol (ug/kg)	14	0	0						44 U	50 U	49	49 U	50 U
3	3- and 4-Methylphenol Coelution (ug/kg)	14	0	0						180 U	200 U	194	190 U	200 U
3	4,6-Dinitro-2-methylphenol (ug/kg)	14	0	0						180 U	200 U	194	190 U	200 U
3	4-Chloro-3-methylphenol (ug/kg)	14	0	0						44 U	90 U	52	49 U	50 U
3	4-Nitrophenol (ug/kg)	14	0	0						89 U	100 U	97	97 U	100 U
3	Bis(2-ethylhexyl) phthalate (ug/kg)	14	0	0						180 U	2000 U	323	190 U	200 U
3	Dibutyl phthalate (ug/kg)	14	0	0						18 U	20 U	19	19 U	20 U
3	Diethyl phthalate (ug/kg)	14	0	0						8.9 U	10 U	9.7	9.7 U	10 U
3	Dimethyl phthalate (ug/kg)	14	0	0						8.9 U	10 U	9.7	9.7 U	10 U
3	Di-n-octyl phthalate (ug/kg)	14	0	0						180 U	200 U	194	190 U	200 U
3	Hexachlorobenzene (ug/kg)	14	0	0						8.9 U	10 U	9.7	9.7 U	10 U
3	Pentachlorophenol (ug/kg)	14	0	0						270 U	300 U	294	290 U	300 U
3	alpha-Endosulfan (ug/kg)	3	0	0						2 U	2 U	2	2 U	2 U
3	alpha-Hexachlorocyclohexane (ug/kg)	3	0	0						2 U	2 U	2	2 U	2 U
3	beta-Endosulfan (ug/kg)	3	0	0						2 U	2 U	2	2 U	2 U
3	beta-Hexachlorocyclohexane (ug/kg)	3	0	0						2 U	2 U	2	2 U	2 U
3	Chlordane (cis & trans) (ug/kg)	3	0	0						10 U	10 U	10	10 U	10 U
3	delta-Hexachlorocyclohexane (ug/kg)	3	0	0						2 U	2 U	2	2 U	2 U
3	Dieldrin (ug/kg)	3	0	0						2 U	2 U	2	2 U	2 U
3	Endosulfan sulfate (ug/kg)	3	0	0						2 U	2 U	2	2 U	2 U
3	Endrin (ug/kg)	3	0	0						2 U	2 U	2	2 U	2 U
3	Heptachlor (ug/kg)	3	0	0						2 U	2 U	2	2 U	2 U
3	Heptachlor epoxide (ug/kg)	3	0	0						2 U	2 U	2	2 U	2 U
3	Methoxychlor (ug/kg)	3	0	0						4 U	4 U	4	4 U	4 U
3	Toxaphene (ug/kg)	3	0	0						30 U	30 U	30	30 U	30 U
3	Diesel fuels (mg/kg)	1	0	0						10 U	10 U	10	10 U	10 U
3	Gasoline (mg/kg)	1	0	0						10 U	10 U	10	10 U	10 U
3	Heavy oil (mg/kg)	1	0	0						25 U	25 U	25	25 U	25 U
3	Jet fuel A (mg/kg)	1	0	0						10 U	10 U	10	10 U	10 U
3	JP-4 jet fuel (mg/kg)	1	0	0						10 U	10 U	10	10 U	10 U
3	Kerosene (mg/kg)	1	0	0						10 U	10 U	10	10 U	10 U
3	Mineral spirits (mg/kg)	1	0	0						10 U	10 U	10	10 U	10 U
3	Naphtha distillate (mg/kg)	1	0	0						10 U	10 U	10	10 U	10 U

Table 4-5. Historical Surface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detected	Detected Concentrations Minimum	Maximum	Mean	Median	95th	Detected and Nondetected Concentrations Minimum	Maximum	Mean	Median	95th
4	Chromium (mg/kg)	30	30	100	17.6	44.7	33	35.5	39.1	17.6	44.7	33.3	35.5	39.1
4	Copper (mg/kg)	30	30	100	15.3	64.8	39	39.3	47.9	15.3	64.8	39	39.3	47.9
4	Fluoranthene (ug/kg)	30	30	100	22	3850	636	226 E	2200	22	3850	636	226 E	2200
4	High Molecular Weight PAH (ug/kg)	30	30	100	62 A	18489 A	3332	1294 A	9598 A	62 A	18489 A	3332	1294 A	9598 A
4	Lead (mg/kg)	30	30	100	5	28.7	13	12.3	20	5	28.7	13	12.3	20
4	Nickel (mg/kg)	30	30	100	17.4	34.5	27	27.9	30.4	17.4	34.5	26.97	27.9	30.4
4	Polycyclic Aromatic Hydrocarbons (ug/kg)	30	30	100	62 A	23274 A	4025	1501 A	11593 A	62 A	23274 A	4025	1501 A	11593 A
4	Pyrene (ug/kg)	30	30	100	20	4600	660	236 E	1740	20	4600	659.9	236 E	1740
4	Total organic carbon (%)	30	30	100	0.37	12	2.1	1.73	3.02	0.37	12	2.1	1.73	3.02
4	Zinc (mg/kg)	30	30	100	66	226	112	102	151	66	226	112.33	102	151
4	Aluminum (mg/kg)	28	28	100	16600	42700	32889	32200	42100	16600	42700	32889	32200	42100
4	Barium (mg/kg)	28	28	100	115	322	174	176	196	115	322	174	176	196
4	Beryllium (mg/kg)	28	28	100	0.37	1.1	0.7	0.7	0.88	0.37	1.1	0.69	0.7	0.88
4	Cobalt (mg/kg)	28	28	100	12.7	26.2	18	17.9 J	20.4	12.7	26.2	18	17.9 J	20.4
4	Iron (mg/kg)	28	28	100	27600	47600	36186	35400	43500	27600	47600	36186	35400	43500
4	Magnesium (mg/kg)	28	28	100	3830	7480	6232	6440	7240	3830	7480	6232	6440	7240
4	Manganese (mg/kg)	28	28	100	385	815	593	592	725	385	815	593	592	725
4	Vanadium (mg/kg)	28	28	100	69.6	112	91	88	107	69.6	112	91	88	107
4	Clay (%)	17	17	100	1.15	19.32	8.27	8.71	12.36	1.15	19.32	8.27	8.71	12.36
4	Fines (%)	17	17	100	4.32	79	52	59.5	72.43	4.32	79	52	59.5	72.43
4	Silt (%)	17	17	100	3.17	72.1	44	42.71	67.31	3.17	72.1	44	42.71	67.31
4	Titanium (mg/kg)	17	17	100	608	1960	1182	1030	1880	608	1960	1182	1030	1880
4	Sand (%)	16	16	100	21.19	94.98	49	40.05	82.29	21.19	94.98	49	40.05	82.29
4	Calcium (mg/kg)	15	15	100	5770	9850	7992	8060	9820	5770	9850	7992	8060	9820
4	Potassium (mg/kg)	15	15	100	790	1670	1226	1270	1520	790	1670	1226	1270	1520
4	Sodium (mg/kg)	15	15	100	870	1330	1136	1140	1290	870	1330	1136	1140	1290
4	Thallium (mg/kg)	15	15	100	5	23	12	9	23	5	23	12	9	23
4	< 0_075 mm (%)	13	13	100	59.5	95.6	82	85.9	92	59.5	95.6	82	85.9	92
4	0_075 to 0_85 mm (%)	13	13	100	4.3	39.5	18	12.9	34.4	4.3	39.5	18	12.9	34.4
4	C1-Chrysene (ug/kg)	13	13	100	3.9	779	124	56	174	3.9	779	124	56	174
4	C1-Fluoranthene/pyrene (ug/kg)	13	13	100	7.9	1850	306	95	655	7.9	1850	306	95	655
4	C1-Phenanthrene/anthracene (ug/kg)	13	13	100	6.7	1820	276	55	517	6.7	1820	276	55	517
4	C2-Chrysene (ug/kg)	13	13	100	2	393	67	31	128	2	393	67	31	128
4	C2-Phenanthrene/anthracene (ug/kg)	13	13	100	5.3	1530	252	50	467	5.3	1530	252	50	467
4	C3-Phenanthrene/anthracene (ug/kg)	13	13	100	3.2	631	164	43	448	3.2	631	164	43	448
4	Gravel (%)	13	13	100	0.04	2.87	0.52	0.15	0.98	0.04	2.87	0.522	0.15	0.98
4	Diesel fuels (mg/kg)	13	13	100	21	262	97	69	160	21	262	97	69	160
4	4,4'-DDD (ug/kg)	6	6	100	1	7.3 J	3.1	1.4 J	5.8 J	1	7.3 J	3.1	1.4 J	5.8 J
4	Total of 3 isomers: pp-DDT,-DDD,-DDE (ug/k	6	6	100	1.4 A	25 A	7.11	2.94 A	7.4 A	1.4 A	25 A	7.1	2.94 A	7.4 A
4	Tributyltin ion (ug/kg)	4	4	100	16	47000	11779	18 J	81	16	47000	11779	18 J	81
4	Aluminum (mg/l)	3	3	100	0.3	9.01	3.27	0.3	0.51	0.3	9.01	3.3	0.3	0.51
4	Barium (mg/l)	3	3	100	0.05	0.09	0.07	0.05	0.07	0.05	0.09	0.07	0.05	0.07
4	Calcium (mg/l)	3	3	100	10.2	61.2	41	10.2	52.2	10.2	61.2	41.2	10.2	52.2
4	Iron (mg/l)	3	3	100	0.69	8.17	5.12	0.69	6.49	0.69	8.17	5.12	0.69	6.49
4	Magnesium (mg/l)	3	3	100	3.77	20	14	3.77	18.1	3.77	20	14	3.77	18.1
4	Manganese (mg/l)	3	3	100	0.88	5.94	3.80	0.88	4.59	0.88	5.94	3.80	0.88	4.59
4	Potassium (mg/l)	3	3	100	1.9	3.4	2.7	1.9	2.9	1.9	3.4	2.7	1.9	2.9
4	Sodium (mg/l)	3	3	100	11	16.3	14	11	14.7	11	16.3	14	11	14.7

Table 4-5. Historical Surface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detected	Detected Concentrations Minimum	Maximum	Mean	Median	95th	Detected and Nondetected Concentrations Minimum	Maximum	Mean	Median	95th
4	Acid Volatile Sulfides (mg/kg)	2	2	100	4.6	17.5	11.1	4.6	4.6	4.6	17.5	11.1	4.6	4.6
4	Mean grain size (mm)	2	2	100	0.07	0.18	0.13	0.07	0.07	0.07	0.18	0.13	0.07	0.07
4	Median grain size (mm)	2	2	100	0.04	0.13	0.09	0.04	0.04	0.04	0.13	0.09	0.04	0.04
4	Total solids (%)	2	2	100	46.2	70.1	58	46.2	46.2	46.2	70.1	58	46.2	46.2
4	Total volatile solids (%)	2	2	100	3.5	5.3	4.4	3.5	3.5	3.5	5.3	4.4	3.5	3.5
4	Benz(a)anthracene (ug/kg)	30	29	97	9.2	1680	293	122	940	9.2	1680	284	122	940
4	Benzo(a)pyrene (ug/kg)	30	29	97	10	1890	374	160	1100	10	1890	363	160	1100
4	Benzo(b)fluoranthene (ug/kg)	30	29	97	13	1960	383	180	1100	13	1960	371	180	1100
4	Benzo(b+k)fluoranthene (ug/kg)	30	29	97	16.3 A	2419 A	585	250 A	1730 A	16.3 A	2419 A	567	250 A	1730 A
4	Benzo(g,h,i)perylene (ug/kg)	30	29	97	7.1	1610	279	133	860 G	7.1	1610	270	133	860 G
4	Benzo(k)fluoranthene (ug/kg)	30	29	97	3.3	967 G	202	100	600	3.3	967 G	196	100	600
4	Chrysene (ug/kg)	30	29	97	8.5	1360	311	120	1100	8.5	1360	301	120	1100
4	Indeno(1,2,3-cd)pyrene (ug/kg)	30	29	97	5.3	1080	224	96	806	5.3	1080	217	96	806
4	Low Molecular Weight PAH (ug/kg)	30	29	97	25.2 A	4785 A	717	222 A	1992 A	20 UA	4785 A	693	222 A	1992 A
4	Mercury (mg/kg)	30	29	97	0.02	0.36	0.09	0.08	0.18	0.01 U	0.36	0.09	0.08	0.18
4	Phenanthrene (ug/kg)	30	29	97	12	3040	416	136 G	1120	12	3040	403	136 G	1120
4	C2-Dibenzothiophene (ug/kg)	13	11	85	5.5	515	123	14	409	1.7 U	515	106	14	409
4	C2-Naphthalene (ug/kg)	13	11	85	2.4	1080	154	15	242	2.4	1080	134	16	242
4	C3-Chrysene (ug/kg)	13	11	85	5.5	176	38	13	84	1.7 U	176	34	13	84
4	C3-Dibenzothiophene (ug/kg)	13	11	85	5.6	404	94	11	311	1.7 U	404	81	11	311
4	C3-Fluorene (ug/kg)	13	11	85	5.6	370	73	16	123	1.7 U	370	64	16	123
4	4,4'-DDE (ug/kg)	6	5	83	0.7	2.7	1.4	0.84 J	1.6 J	0.7	2.7	1.5	1	1.9 U
4	Anthracene (ug/kg)	30	24	80	2.4	613	97	35	200	2.4	613	81.2	31 G	200
4	C1-Fluorene (ug/kg)	13	10	77	3.3	287	54	9.4	90	1.7 U	287	45	9.4	90
4	C1-Naphthalene (ug/kg)	13	10	77	3.5	327	59	7.7	102	1.7 U	327	49	7.7	102
4	C2-Fluorene (ug/kg)	13	10	77	3.8	366	74	12	113	1.7 U	366	60	12	113
4	C3-Naphthalene (ug/kg)	13	10	77	4.9	1240	198	14	285	1.7 U	1240	155	14	285
4	C4-Naphthalene (ug/kg)	13	10	77	4.3	835	139	11	174	1.7 U	835	110	11	174
4	C4-Phenanthrene/anthracene (ug/kg)	13	10	77	2.7	201	52	11	106	1.7 U	201	52	11	141 U
4	Dibenz(a,h)anthracene (ug/kg)	30	23	77	5.4	207 G	51	27	140	1.7 U	207 G	47	23 G	141 U
4	Acenaphthene (ug/kg)	30	22	73	2.9	411	79	50	150	2.9	411	63.4	21	150
4	Arsenic (mg/kg)	30	22	73	2.6 E	21.6	8.6	8.9	13	2.6 E	21.6	7.6	5 U	13
4	Fluorene (ug/kg)	30	22	73	2.5	265	59	40	110	2.5	265	49	21 U	110
4	Naphthalene (ug/kg)	30	22	73	5.4	358	106	35 G	270	5.4	358	83.2	24	270
4	C1-Dibenzothiophene (ug/kg)	13	9	69	2.1	247	64	5.8	126	1.7 U	247	50	5.8	126
4	Dibenzothiophene (ug/kg)	13	9	69	3.6	340	78	8.3	151	1.7 U	340	59	9.4	151
4	Carbazole (ug/kg)	15	10	67	19 J	220 J	52.4	31 J	67 J	19 U	220 J	41	24 J	67 J
4	4,4'-DDT (ug/kg)	6	4	67	0.2	15	4.3	1 J	1	0.2	15	3.5	1	2 U
4	Arsenic (mg/l)	3	2	67	0.001	0.002	0.0015	0.001	0.001	0.001 U	0.002	0.001	0.001 U	0.001
4	Cobalt (mg/l)	3	2	67	0.004	0.006	0.005	0.004	0.004	0.003 U	0.006	0.004	0.003 U	0.004
4	Zinc (mg/l)	3	2	67	0.004	0.02	0.012	0.004	0.004	0.004 U	0.02	0.01	0.004 U	0.004
4	Acenaphthylene (ug/kg)	30	19	63	6.1	153	49	25	132	1.7 U	153	37	20 U	107 G
4	Cadmium (mg/kg)	30	19	63	0.2	1.3	0.4	0.3	0.84	0.2	1.3	0.57	0.4	0.98 U
4	C4-Dibenzothiophene (ug/kg)	13	8	62	4.9	232	41	6.8	33	1.7 U	232	40	6.8	141 U
4	Silver (mg/kg)	30	16	53	0.1	0.7	0.5	0.4	0.7	0.1	2 U	1.0	0.7	1.9 U
4	2-Methylnaphthalene (ug/kg)	17	9	53	22 G	140	64	38	100	19 U	140	43	20 U	100
4	Dibenzofuran (ug/kg)	17	8	47	6 G	53	30	27	48	6 G	53	24	20 U	48
4	Tributyltin ion (ug/l)	5	2	40	0.03	0.14	0.09	0.03	0.03	0.02 U	0.14	0.05	0.02 U	0.05 U

Table 4-5. Historical Surface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detected	Detected Concentrations Minimum	Maximum	Mean	Median	95th	Detected and Nondetected Concentrations Minimum	Maximum	Mean	Median	95th
4	C4-Fluorene (ug/kg)	13	5	38	4.3	66	31	13	38	1.7 U	141 U	28	13	66
4	Antimony (mg/kg)	28	10	36	4 J	11 J	8.7	9 J	11 J	0.72 U	11 J	4.3	4 UJ	10 J
4	Aroclor 1260 (ug/kg)	6	2	33	5	9	7	5	5	5	20 U	15	19 UJ	20 U
4	Polychlorinated biphenyls (ug/kg)	6	2	33	5 A	9 A	7	5 A	5 A	5 A	40 UA	28	37 UA	39 UA
4	Chromium (mg/l)	3	1	33	0.007	0.007	0.007	0.007	0.007	0.005 U	0.007	0.006	0.005 U	0.005 U
4	Copper (mg/l)	3	1	33	0.006	0.006	0.006	0.006	0.006	0.002 U	0.006	0.003	0.002 U	0.002 U
4	Lead (mg/l)	3	1	33	0.004	0.004	0.004	0.004	0.004	0.001 U	0.004	0.002	0.001 U	0.001 U
4	Vanadium (mg/l)	3	1	33	0.01	0.01	0.01	0.01	0.01	0.003 U	0.01	0.01	0.003 U	0.003 U
4	Phenol (ug/kg)	28	9	32	28	152	89	81	108	17 U	152	42	20 U	103
4	4-Methylphenol (ug/kg)	28	8	29	23	76	39	25	71	16 U	76	25	20 U	37
4	Selenium (mg/kg)	28	7	25	0.9	12	8.3	11	11	0.66 U	12	4.0	3 U	11
4	Butyltin ion (ug/kg)	4	1	25	740 J	740 J	740	740 J	740 J	5.6 UJ	740 J	189	5.9 UJ	6 U
4	Dibutyltin ion (ug/kg)	4	1	25	800	800	800	800	800	5.6 U	800	204	5.9 UJ	6 U
4	Tetrabutyltin (ug/kg)	4	1	25	150	150	150	150	150	0.59 UJ	150	41	5.6 U	6 U
4	C4-Chrysene (ug/kg)	13	3	23	2	3.5	2.7	2	2.5	1.7 U	141 U	21	3.5	22 U
4	Aldrin (ug/kg)	6	1	17	0.3 J	0.3 J	0.3	0.3 J	0.3 J	0.3 J	2 UG	1.03	0.97 U	0.99 U
4	Bis(2-ethylhexyl) phthalate (ug/kg)	15	2	13	210	320	265	210	210	35 UJ	1200 UJ	192	110 UJ	320
4	Di-n-octyl phthalate (ug/kg)	15	1	7	21	21	21	21	21	19 U	21	19	19 U	20 U
4	Pentachlorophenol (ug/kg)	28	1	4	110 J	110 J	110	110 J	110 J	14 U	110 J	61	94 UJ	99 UJ
4	2,4,5-Trichlorophenol (ug/kg)	28	0	0						14 U	99 U	60	94 U	99 U
4	2,4,6-Trichlorophenol (ug/kg)	28	0	0						1.4 U	99 U	53	94 U	99 U
4	2,4-Dimethylphenol (ug/kg)	28	0	0						1.4 U	20 U	11	19 U	20 U
4	2-Chlorophenol (ug/kg)	28	0	0						14 U	22 U	19	19 U	21 U
4	2-Methylphenol (ug/kg)	28	0	0						1.4 U	20 U	11	19 U	20 U
4	4-Chloro-3-methylphenol (ug/kg)	28	0	0						14 U	40 U	29	37 U	40 U
4	2,4-Dinitrotoluene (ug/kg)	15	0	0						94 U	99 U	97	96 U	99 U
4	2,6-Dinitrotoluene (ug/kg)	15	0	0						94 U	99 U	97	96 U	99 U
4	2-Chloronaphthalene (ug/kg)	15	0	0						19 U	20 U	19	19 U	20 U
4	2-Nitroaniline (ug/kg)	15	0	0						94 U	99 U	97	96 U	99 U
4	3,3'-Dichlorobenzidine (ug/kg)	15	0	0						94 U	99 UJ	97	96 U	99 U
4	3-Nitroaniline (ug/kg)	15	0	0						110 U	120 UJ	117	120 U	120 UJ
4	4-Bromophenyl phenyl ether (ug/kg)	15	0	0						19 U	20 U	19	19 U	20 U
4	4-Chloroaniline (ug/kg)	15	0	0						56 U	60 UJ	58	58 U	60 U
4	4-Chlorophenyl phenyl ether (ug/kg)	15	0	0						19 U	20 U	19	19 U	20 U
4	4-Nitroaniline (ug/kg)	15	0	0						94 UJ	99 UJ	97	96 UJ	99 UJ
4	Benzoic acid (ug/kg)	15	0	0						190 U	200 U	193	190 U	200 U
4	Benzyl alcohol (ug/kg)	15	0	0						19 UJ	20 UJ	19	19 UJ	20 UJ
4	Bis(2-chloro-1-methylethyl) ether (ug/kg)	15	0	0						19 UJ	20 U	19	19 U	20 U
4	Bis(2-chloroethoxy) methane (ug/kg)	15	0	0						19 U	20 U	19	19 U	20 U
4	Bis(2-chloroethyl) ether (ug/kg)	15	0	0						37 U	40 U	39	38 U	40 U
4	Hexachlorobutadiene (ug/kg)	15	0	0						19 U	20 U	19	19 U	20 U
4	Hexachlorocyclopentadiene (ug/kg)	15	0	0						94 UJ	99 UJ	97	96 UJ	99 UJ
4	Hexachloroethane (ug/kg)	15	0	0						19 U	20 U	19	19 U	20 U
4	Isophorone (ug/kg)	15	0	0						19 U	20 U	19	19 U	20 U
4	Nitrobenzene (ug/kg)	15	0	0						19 U	20 U	19	19 U	20 U
4	N-Nitrosodiphenylamine (ug/kg)	15	0	0						19 U	20 U	19	19 U	20 U
4	N-Nitrosodipropylamine (ug/kg)	15	0	0						37 U	40 UJ	39	38 UJ	40 U
4	1,2,4-Trichlorobenzene (ug/kg)	15	0	0						19 U	20 U	19	19 U	20 U

Table 4-5. Historical Surface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detected	Detected Concentrations Minimum	Maximum	Mean	Median	95th	Detected and Nondetected Concentrations Minimum	Maximum	Mean	Median	95th
4	1,2-Dichlorobenzene (ug/kg)	15	0	0						19 U	20 U	19	19 U	20 U
4	1,3-Dichlorobenzene (ug/kg)	15	0	0						19 U	20 U	19	19 U	20 U
4	1,4-Dichlorobenzene (ug/kg)	15	0	0						19 U	20 U	19	19 U	20 U
4	2,4-Dichlorophenol (ug/kg)	15	0	0						56 U	60 U	58	58 U	60 U
4	2,4-Dinitrophenol (ug/kg)	15	0	0						190 UJ	200 UJ	193	190 UJ	200 UJ
4	2-Nitrophenol (ug/kg)	15	0	0						94 U	99 U	97	96 U	99 U
4	4,6-Dinitro-2-methylphenol (ug/kg)	15	0	0						190 U	200 UJ	193	190 UJ	200 UJ
4	4-Nitrophenol (ug/kg)	15	0	0						94 U	99 U	97	96 U	99 U
4	Butylbenzyl phthalate (ug/kg)	15	0	0						19 U	20 U	19	19 U	20 U
4	Dibutyl phthalate (ug/kg)	15	0	0						19 UJ	20 UJ	19	19 UJ	20 UJ
4	Diethyl phthalate (ug/kg)	15	0	0						19 U	20 U	19	19 U	20 U
4	Dimethyl phthalate (ug/kg)	15	0	0						19 U	20 U	19	19 U	20 U
4	Hexachlorobenzene (ug/kg)	15	0	0						19 U	20 U	19	19 U	20 U
4	Tin (mg/kg)	13	0	0						3.6 U	5 U	4.2	4.1 U	4.9 U
4	Aroclor 1016 (ug/kg)	6	0	0						10 U	20 U	16	19 U	20 U
4	Aroclor 1221 (ug/kg)	6	0	0						10 U	40 U	29	37 UJ	39 U
4	Aroclor 1232 (ug/kg)	6	0	0						10 U	20 U	16	19 UJ	20 U
4	Aroclor 1242 (ug/kg)	6	0	0						10 U	20 U	16	19 UJ	20 U
4	Aroclor 1248 (ug/kg)	6	0	0						10 U	20 U	16	19 UJ	20 U
4	Aroclor 1254 (ug/kg)	6	0	0						10 U	20 U	16	19 UJ	20 U
4	alpha-Endosulfan (ug/kg)	6	0	0						0.94 UJ	2 U	1.31	0.98 U	2 UG
4	alpha-Hexachlorocyclohexane (ug/kg)	6	0	0						0.94 UJ	2 U	1.31	0.98 UJ	2 UG
4	beta-Endosulfan (ug/kg)	6	0	0						1.9 UJ	2 U	2.0	2 UG	2 U
4	beta-Hexachlorocyclohexane (ug/kg)	6	0	0						0.94 UJ	2 U	1.31	0.98 U	2 UG
4	delta-Hexachlorocyclohexane (ug/kg)	6	0	0						0.94 UJ	2.5 UIJ	1.84	2 U	2 UIJ
4	Dieldrin (ug/kg)	6	0	0						1.9 UJ	2 U	2.0	2 U	2 U
4	Endosulfan sulfate (ug/kg)	6	0	0						1.9 U	2 UG	2.0	2 U	2 U
4	Endrin (ug/kg)	6	0	0						1.9 U	2 UG	2.0	2 U	2 U
4	Endrin aldehyde (ug/kg)	6	0	0						0.5 UG	2 U	1.7	1.9 UJ	2 U
4	gamma-Hexachlorocyclohexane (ug/kg)	6	0	0						0.94 UJ	2 U	1.31	0.98 U	2 UG
4	Heptachlor (ug/kg)	6	0	0						0.94 UJ	2 U	1.31	0.98 U	2 UG
4	Heptachlor epoxide (ug/kg)	6	0	0						0.94 UJ	2 U	1.31	0.98 U	2 UG
4	Methoxychlor (ug/kg)	6	0	0						4 UG	9.9 U	7.8	9.4 UJ	9.8 U
4	Toxaphene (ug/kg)	6	0	0						30 U	99 U	75.5	94 UJ	98 U
4	alpha-Chlordane (ug/kg)	4	0	0						0.94 UJ	0.99 U	0.97	0.97 U	0.98 U
4	Endrin ketone (ug/kg)	4	0	0						1.9 U	2 U	2.0	1.9 UJ	2 U
4	gamma-Chlordane (ug/kg)	4	0	0						0.94 UJ	0.99 U	0.97	0.97 U	0.98 U
4	Antimony (mg/l)	3	0	0						0.05 U	0.05 U	0.05	0.05 U	0.05 U
4	Beryllium (mg/l)	3	0	0						0.001 U	0.001 U	0.001	0.001 U	0.001 U
4	Butyltin ion (ug/l)	3	0	0						0.06 U	0.06 U	0.06	0.06 U	0.06 U
4	Cadmium (mg/l)	3	0	0						0.002 U	0.002 U	0.002	0.002 U	0.002 U
4	Dibutyltin ion (ug/l)	3	0	0						0.06 U	0.06 U	0.06	0.06 U	0.06 U
4	Mercury (mg/l)	3	0	0						0.0001 U	0.0001 U	0.0001	0.0001 U	0.0001 U
4	Nickel (mg/l)	3	0	0						0.01 U	0.01 U	0.01	0.01 U	0.01 U
4	Selenium (mg/l)	3	0	0						0.001 U	0.001 U	0.001	0.001 U	0.001 U
4	Silver (mg/l)	3	0	0						0.0002 U	0.0002 U	0.0002	0.0002 U	0.0002 U
4	Tetrabutyltin (ug/l)	3	0	0						0.02 U	0.02 U	0.02	0.02 U	0.02 U
4	Thallium (mg/l)	3	0	0						0.001 U	0.001 U	0.001	0.001 U	0.001 U

Table 4-5. Historical Surface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detected	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
4	Chlordane (cis & trans) (ug/kg)	2	0	0						10 U	10 U	10	10 U	10 U
5	Total organic carbon (%)	90	90	100	0.15	4.72	1.7	1.7	2.74 J	0.15	4.72	1.7	1.7	2.74 J
5	Chromium (mg/kg)	87	87	100	8	165	34	29	49.4	8	165	34	29	49.4
5	Copper (mg/kg)	87	87	100	15	151	45	41.2	71	15	151	45	41.2	71
5	Zinc (mg/kg)	87	87	100	66	1330 G	210	109 G	563 G	66	1330 G	210	109 G	563 G
5	Nickel (mg/kg)	83	83	100	12 G	56 G	25	24	31	12 G	56 G	25	24	31
5	Total solids (%)	82	82	100	27.2	94.3	51	47	73.8	27.2	94.3	51	47	73.8
5	Clay (%)	62	62	100	0.03	20.7	11	10.42	17.6	0.03	20.7	11	10.42	17.6
5	Silt (%)	62	62	100	0.12	81	53	59.92	74.71	0.12	81	53	59.92	74.71
5	Fines (%)	47	47	100	19.1	94.5	70	74.74	91.03	19.1	94.5	70	74.74	91.03
5	Sand (%)	47	47	100	5.5	80.7	29	24.82	64.4	5.5	80.7	29	24.82	64.4
5	Gravel (%)	43	43	100	0	60.3	5.1	0.21	27.4	0	60.3	5.1	0.21	27.4
5	Ammonia (mg/kg)	38	38	100	12.2	224	95	85.9	171	12.2	224	95	85.9	171
5	Total volatile solids (%)	36	36	100	1.4	12.9	6.6	6.37	9	1.4	12.9	6.6	6.37	9
5	Total sulfides (mg/kg)	34	34	100	1.6 E	1830 G	136	17.5 G	590 G	1.6 E	1830 G	136	17.5 G	590 G
5	Barium (mg/kg)	28	28	100	97.5	201	178	183	194	97.5	201	178	183	194
5	Aluminum (mg/kg)	24	24	100	36300	44000	39725	39700	41700	36300	44000	39725	39700	41700
5	Calcium (mg/kg)	24	24	100	7740 J	9190	8271	8220	8540	7740 J	9190	8271	8220	8540
5	Cobalt (mg/kg)	24	24	100	17.4	19.9	19	18.7	19.4	17.4	19.9	19	18.7	19.4
5	Iron (mg/kg)	24	24	100	38900	48000	42454	42300	44200	38900	48000	42454	42300	44200
5	Magnesium (mg/kg)	24	24	100	6560	7780	7027	7040	7280	6560	7780	7027	7040	7280
5	Manganese (mg/kg)	24	24	100	571	854	723	723	792	571	854	723	723	792
5	Potassium (mg/kg)	24	24	100	1230	1580	1359	1340	1500	1230	1580	1359	1340	1500
5	Sodium (mg/kg)	24	24	100	978	1490	1134	1120	1220	978	1490	1134	1120	1220
5	Vanadium (mg/kg)	24	24	100	97.5	114	105	105	110	97.5	114	105	105	110
5	< 0_075 mm (%)	19	19	100	6.2	96.3	67	83.2	95.8	6.2	96.3	67	83.2	95.8
5	> 0_075 mm (%)	19	19	100	3.7	93.8	33	16.2	90.2	3.7	93.8	33	16.2	90.2
5	Coarse sand (%)	15	15	100	0.18	33.5	9.24	1.82	31	0.18	33.5	9.24	1.82	31
5	Fine sand (%)	15	15	100	1.71	30.8	10	8.3	22.3	1.71	30.8	10	8.3	22.3
5	Medium sand (%)	15	15	100	0.08	55.5	11	5.1	32.7	0.08	55.5	11	5.1	32.7
5	Very coarse sand (%)	15	15	100	0.14	28.8	5.64	0.84	12.9	0.14	28.8	5.64	0.84	12.9
5	Very fine sand (%)	15	15	100	0.02	18.7	6.16	3.89	15.7	0.02	18.7	6.16	3.89	15.7
5	>10 Phi clay (%)	4	4	100	0	4.5	1.1	0	0	0	4.5	1.1	0	0
5	8-9 Phi clay (%)	4	4	100	0	12.9	4.35	0	4.5	0	12.9	4.35	0	4.5
5	9-10 Phi clay (%)	4	4	100	4.3	12	8.0	6.7	9.1	4.3	12	8.0	6.7	9.1
5	Aluminum (mg/l)	4	4	100	0.06	0.9	0.38	0.12	0.42	0.06	0.9	0.38	0.12	0.42
5	Arsenic (mg/l)	4	4	100	0.002	0.008	0.004	0.002	0.004	0.002	0.008	0.004	0.002	0.004
5	Barium (mg/l)	4	4	100	0.12	0.17	0.14	0.12	0.13	0.12	0.17	0.14	0.12	0.13
5	Calcium (mg/l)	4	4	100	76.9	163	114.5	96.1	122	76.9	163	115	96.1	122
5	Coarse silt (%)	4	4	100	20.6	51.3	34	24.3	41.6	20.6	51.3	34	24.3	41.6
5	Cobalt (mg/l)	4	4	100	0.01	0.02	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01
5	Fine silt (%)	4	4	100	3	12.9	6.8	4.5	6.7	3	12.9	6.8	4.5	6.7
5	Iron (mg/l)	4	4	100	8.95	26.9	19	18.5	21.6	8.95	26.9	19	18.5	21.6
5	Magnesium (mg/l)	4	4	100	24.3	55.3	38	31.8	41.8	24.3	55.3	38	31.8	41.8
5	Manganese (mg/l)	4	4	100	8.9	20.5	14	11.7	14.2	8.9	20.5	14	11.7	14.2
5	Medium silt (%)	4	4	100	6.7	9.1	8.4	8.6	9	6.7	9.1	8.4	8.6	9
5	Potassium (mg/l)	4	4	100	3.9	5.1	4.2	3.9	4	3.9	5.1	4.2	3.9	4
5	Sieve 10 (%)	4	4	100	0.3	7.5	2.2	0.4	0.7	0.3	7.5	2.2	0.4	0.7

Table 4-5. Historical Surface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detected	Detected Concentrations Minimum	Maximum	Mean	Median	95th	Detected and Nondetected Concentrations Minimum	Maximum	Mean	Median	95th
5	Sieve 140 (%)	4	4	100	2.4	7.8	5.5	5.2	6.7	2.4	7.8	5.5	5.2	6.7
5	Sieve 20 (%)	4	4	100	0.5	5.3	1.8	0.6	0.6	0.5	5.3	1.8	0.6	0.6
5	Sieve 200 (%)	4	4	100	0.3	4.4	2.1	1.3	2.2	0.3	4.4	2.1	1.3	2.2
5	Sieve 230 (%)	4	4	100	2.6	6.7	5.1	5.3	5.9	2.6	6.7	5.1	5.3	5.9
5	Sieve 4 (%)	4	4	100	0	8.3	2.3	0	0.9	0	8.3	2.3	0	0.9
5	Sieve 40 (%)	4	4	100	1	2	1.5	1.3	1.5	1	2	1.5	1.3	1.5
5	Sieve 60 (%)	4	4	100	1.1	3.1	2	1.6	2.2	1.1	3.1	2	1.6	2.2
5	Sodium (mg/l)	4	4	100	15	17.8	16	15.1	15.5	15	17.8	16	15.1	15.5
5	Titanium (mg/kg)	4	4	100	1850	2040	1930	1870	1960	1850	2040	1930	1870	1960
5	Tributyltin ion (ug/kg)	4	4	100	8.2	72	37.3	14	55	8.2	72	37.3	14	55
5	Vanadium (mg/l)	4	4	100	0.003	0.004	0.004	0.004	0.004	0.003	0.004	0.004	0.004	0.004
5	Very fine silt (%)	4	4	100	3	9.1	5.775	4.3	6.7	3	9.1	5.775	4.3	6.7
5	1,2,3,4,6,7,8-Heptachlorodibenzofuran (ng/kg)	1	1	100	19	19	19	19	19	19	19	19	19	19
5	1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin (ng/	1	1	100	98	98	98	98	98	98	98	98	98	98
5	1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin (ng/kg	1	1	100	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9
5	1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin (ng/kg	1	1	100	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1
5	2,3,4,6,7,8-Hexachlorodibenzofuran (ng/kg)	1	1	100	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
5	2,3,7,8-Tetrachlorodibenzofuran (ng/kg)	1	1	100	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
5	Acid Volatile Sulfides (mg/kg)	1	1	100	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2
5	Heptachlorodibenzofuran (ng/kg)	1	1	100	65	65	65	65	65	65	65	65	65	65
5	Heptachlorodibenzo-p-dioxin (ng/kg)	1	1	100	180	180	180	180	180	180	180	180	180	180
5	Hexachlorodibenzofuran (ng/kg)	1	1	100	23	23	23	23	23	23	23	23	23	23
5	Hexachlorodibenzo-p-dioxin (ng/kg)	1	1	100	29	29	29	29	29	29	29	29	29	29
5	Mean grain size (mm)	1	1	100	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26
5	Median grain size (mm)	1	1	100	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
5	Moisture (%)	1	1	100	54	54	54	54	54	54	54	54	54	54
5	Octachlorodibenzofuran (ng/kg)	1	1	100	49	49	49	49	49	49	49	49	49	49
5	Octachlorodibenzo-p-dioxin (ng/kg)	1	1	100	890	890	890	890	890	890	890	890	890	890
5	Tetrachlorodibenzofuran (ng/kg)	1	1	100	13	13	13	13	13	13	13	13	13	13
5	Tetrachlorodibenzo-p-dioxin (ng/kg)	1	1	100	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1
5	Lead (mg/kg)	87	86	99	9	1160 E	96	26	322	9	1160 E	95	24	322
5	High Molecular Weight PAH (ug/kg)	95	92	97	186 A	765000 A	68368	9910 A	333200 A	186 A	765000 A	66251	8790 A	333200 A
5	Polycyclic Aromatic Hydrocarbons (ug/kg)	95	92	97	193 A	868000 A	74097	10774 A	364840 A	193 A	868000 A	71799	10641 A	364840 A
5	Pyrene (ug/kg)	95	92	97	14	110000	9897	1600	40000	14	110000	9626	1600 G	40000
5	Fluoranthene (ug/kg)	106	102	96	16	130000	10234	2300	28000	16	130000	9917	2300	28000
5	Benz(a)anthracene (ug/kg)	95	90	95	13	81000	5935	940	28000	13	81000	5718	940	28000
5	Benzo(a)pyrene (ug/kg)	95	90	95	18	86000	6866	1200	31000	18	86000	6599	1200	31000
5	Benzo(k)fluoranthene (ug/kg)	95	90	95	17	63000	4668	670	21000	17	63000	4517	670	21000
5	Chrysene (ug/kg)	95	90	95	21	78000	6096	1100	30000	21	78000	5870	1100	30000
5	Indeno(1,2,3-cd)pyrene (ug/kg)	95	90	95	31	110000	7848	1000	40000	31	110000	7530	1000	40000
5	C1-Fluoranthene/pyrene (ug/kg)	16	15	94	30	3300	447	200	750	5 U	3300	419	200	750
5	C1-Phenanthrene/anthracene (ug/kg)	16	15	94	14	1700	271	130	440	5 U	1700	255	130	440
5	C2-Phenanthrene/anthracene (ug/kg)	16	15	94	11	6000	519	96	430	5 U	6000	487	96	430
5	Benzo(b)fluoranthene (ug/kg)	95	89	94	18	83000	5994	920	23000	5 U	83000	5710	920	23000
5	Benzo(g,h,i)perylene (ug/kg)	95	89	94	32	55000	4673	740	22000	32	55000	4490	740	22000
5	Low Molecular Weight PAH (ug/kg)	95	89	94	7 A	114000 A	5923	1225 A	26950 A	7 A	114000 A	5629	1070 A	26950 A
5	Phenanthrene (ug/kg)	95	89	94	7	74000	4078	820	16000	7	74000	3901	730 G	16000
5	Benzo(b+k)fluoranthene (ug/kg)	79	74	94	124 A	144000 A	12696	2200 A	55000 A	124 A	144000 A	12006	2190 A	55000 A

Table 4-5. Historical Surface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detected	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
5	C1-Chrysene (ug/kg)	16	14	88	25	1900	349	200	660	5 U	1900	306	180	660
5	C1-Fluorene (ug/kg)	16	14	88	7	1300	140	23	290	5 U	1300	123	17	290
5	C2-Naphthalene (ug/kg)	16	14	88	8	840	132	37	520	5 U	840	116	26	520
5	C3-Naphthalene (ug/kg)	16	14	88	9	9000	781	36	1100	5 U	9000	684	34	1100
5	C3-Phenanthrene/anthracene (ug/kg)	16	14	88	17	4200	380	59	400	5 U	4200	333	35	400
5	C4-Naphthalene (ug/kg)	16	14	88	10	18000	1382	35	740	5 U	18000	1210	27	740
5	Anthracene (ug/kg)	95	81	85	5	12000	776	140	2000	5 U	20000 U	1163	210 G	5000 U
5	Pencil pitch (mg/kg)	44	37	84	310	14000	2274	1500	5200	100 U	14000	1938	1100 E	4500
5	C2-Dibenzothiophene (ug/kg)	16	13	81	9	1600	168	31	190	5 U	1600	137	23	190
5	Dibenzothiophene (ug/kg)	16	13	81	8	150	51	27	97	5 U	150	42	22	97
5	Acenaphthene (ug/kg)	95	77	81	6	14000	644	120	1600	5 U	20000 U	1024	120 G	5000 U
5	Arsenic (mg/kg)	87	68	78	1.8	14 G	4.8	4	9 G	1.8	14 G	4.9	5 U	7
5	Dibenz(a,h)anthracene (ug/kg)	95	73	77	6	11000	874	173 G	3600	6	20000 U	1280	220	5000 U
5	Fluorene (ug/kg)	95	72	76	8	14000	463	95	730 G	5 U	20000 U	854	85 G	3000 U
5	Zinc (mg/l)	4	3	75	0.005	0.01	0.007	0.005	0.005	0.004 U	0.01	0.006	0.005	0.005
5	Total of 3 isomers: pp-DDT,-DDD,-DDE (ug/k	31	23	74	1.2 A	39 A	15	10.4 A	28.4 A	1.2 A	41 UA	15	10 UA	29.2 A
5	Silver (mg/kg)	87	64	74	0.1	2	0.6	0.4	1.15	0.1	2.04 U	0.9	0.7	2 U
5	Mercury (mg/kg)	77	56	73	0.02 E	0.5	0.10	0.07	0.2	0.02 E	0.5	0.1	0.09 E	0.2 U
5	Carbazole (ug/kg)	24	17	71	25	2800 J	290	42	420	19 U	2800 J	211	37 J	390
5	C2-Fluorene (ug/kg)	16	11	69	8	4400	464	30	350	5 U	4400	321	10	350
5	C3-Dibenzothiophene (ug/kg)	16	11	69	7	1100	139	30	130	5 U	1100	97	20	130
5	Cadmium (mg/kg)	87	59	68	0.16	6.6 G	1.1	0.4	4	0.16	6.6 G	1.0	0.6	2.6 G
5	4,4'-DDE (ug/kg)	31	21	68	1	15	4.8	3.3	10	1	41 U	8.1	5 G	20 UG
5	Naphthalene (ug/kg)	95	64	67	6	2200	171	57	450	5 U	20000 U	731	50	3000 U
5	4,4'-DDD (ug/kg)	31	19	61	1 G	18.3	5.6	3.4	12	1 G	41 U	8.1	6.7 U	18.3
5	4,4'-DDT (ug/kg)	31	18	58	1	26 G	7.2	6.2	13	1	41 U	10	10 G	26 G
5	Bis(2-ethylhexyl) phthalate (ug/kg)	78	45	58	50	38000	1479	350	3200	50	38000	1948	300	10000 U
5	Beryllium (mg/kg)	45	25	56	0.6	1	0.7	0.7	0.7	0.6	1 U	0.83	0.7	1 U
5	Thallium (mg/kg)	45	23	51	6	25	15	11	24	1 U	25	8.1	6	23
5	1-Methylnaphthalene (ug/kg)	16	8	50	1	68	28	16	47	1	68	16.5	5 U	47
5	C2-Chrysene (ug/kg)	16	8	50	14	1600	292	110	200	5 U	1600	149	5 U	200
5	Dibenzofuran (ug/kg)	95	46	48	4 G	860	118	52	270	4 G	20000 U	687	31 G	3000 U
5	Tributyltin ion (ug/l)	7	3	43	0.03	0.05 G	0.04	0.03	0.05 G	0.02 U	0.05 G	0.03	0.02 U	0.05 U
5	Acenaphthylene (ug/kg)	95	40	42	11	3600	186	58	460 G	5 U	20000 U	707	31	3370 U
5	Antimony (mg/kg)	82	32	39	0.02 G	13 J	4.09	0.8 G	11	0.02 UG	13 J	5.11	5 UJ	10 J
5	Aroclor 1260 (ug/kg)	26	10	38	4	110	39	21	77	4	500 U	67	26	110
5	Polychlorinated biphenyls (ug/kg)	26	10	38	4 A	135 A	52	21 A	119 A	4 A	500 UA	89	40 UA	137 UA
5	C1-Dibenzothiophene (ug/kg)	16	6	38	7	7400	1305	20	270	5 U	7400	492	5 U	270
5	Pristane (mg/kg)	44	15	34	0.5	7	1.62	0.7	5.3	0.5 U	7	0.9	0.5 U	1.5
5	2-Methylnaphthalene (ug/kg)	60	20	33	6	420	75	30	410	5 U	5000 U	329	20 U	3000 U
5	C3-Chrysene (ug/kg)	16	5	31	52	830	224	52	120	5 U	830	73	5 U	120
5	Phytane (mg/kg)	44	11	25	0.5	6.1	1.8	0.8	5.3	0.5 U	6.1	0.9	0.5 U	1
5	C4-Phenanthrene/anthracene (ug/kg)	16	4	25	19	1500	400	24	56	5 U	1500	104	5 U	56
5	Diesel fuels (mg/kg)	44	10	23	230	2100	657	440	960	25 U	2100	227	100 U	550 E
5	Selenium (mg/kg)	49	11	22	7	12	11	11	12	0.5 U	12	4.4	1 U	12
5	4-Methylphenol (ug/kg)	64	14	22	20	640	271	130	620	19 U	20000 U	907	20 UG	3000 UG
5	Aroclor 1242 (ug/kg)	26	5	19	12	42	25	12	35	10 U	137 U	43	19 UJ	100 U
5	gamma-Chlordane (ug/kg)	21	4	19	2.5	5.8	3.4	2.6	2.7	0.95 U	20 UG	6.9	1.7 U	20 UG

Table 4-5. Historical Surface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detected	Detected Concentrations Minimum	Maximum	Mean	Median	95th	Detected and Nondetected Concentrations Minimum	Maximum	Mean	Median	95th
5	Lube Oil (mg/kg)	44	7	16	160 E	1100 E	479	340 E	650 E	100 U	1100 E	160	100 U	390 E
5	Butylbenzyl phthalate (ug/kg)	78	12	15	20	3000	312	36 G	340	10 U	20000 U	823	20 U	3370 U
5	Methylene chloride (ug/kg)	9	1	11	11 B	11 B	11	11 B	11 B	5 U	1020 U	295	11 B	500 U
5	alpha-Chlordane (ug/kg)	25	2	8	1.1	2.1	1.6	1.1	1.1	0.95 U	41 U	8.7	1.7 U	20 UG
5	C4-Chrysene (ug/kg)	16	1	6	810	810	810	810	810	5 U	810	55	5 U	5 U
5	Di-n-octyl phthalate (ug/kg)	78	4	5	40	190	105	91	100	10 U	20000 U	820	20 U	3370 U
5	Xylene (ug/kg)	21	1	5	190	190	190	190	190	5 U	200 U	105	100 U	200 U
5	2,4-Dimethylphenol (ug/kg)	68	3	4	7	31	16	7	9	6 U	10200 U	634	19 U	3000 U
5	beta-Hexachlorocyclohexane (ug/kg)	29	1	3	2.1	2.1	2.1	2.1	2.1	0.95 U	41 U	13	6.7 U	30 U
5	Endosulfan sulfate (ug/kg)	29	1	3	12	12	12	12	12	1 U	41 U	9.8	6.7 U	20 UG
5	Aldrin (ug/kg)	31	1	3	0.3 J	0.3 J	0.3	0.3 J	0.3 J	0.3 J	41 U	8.6	2 U	20 UG
5	gamma-Hexachlorocyclohexane (ug/kg)	31	1	3	0.2 J	0.2 J	0.2	0.2 J	0.2 J	0.2 J	41 U	8.6	2 U	20 UG
5	2-Methylphenol (ug/kg)	68	2	3	17	51	34	17	17	6 U	6000 U	456	19 U	3000 U
5	Phenol (ug/kg)	68	2	3	55	110	83	55	55	19 U	20000 U	892	20 UG	3370 U
5	Toluene (ug/kg)	57	1	2	600	600	600	600	600	5 U	600	60	10 U	200 U
5	Benzoic acid (ug/kg)	68	1	1	110	110	110	110	110	100 U	100000 U	4633	190 U	20000 U
5	Benzyl alcohol (ug/kg)	68	1	1	12 G	12 G	12	12 G	12 G	6 U	6000 U	455	19 UJ	3000 U
5	Dibutyl phthalate (ug/kg)	78	1	1	43	43	43	43	43	10 U	20000 U	934	20 U	5000 U
5	Diethyl phthalate (ug/kg)	78	1	1	25	25	25	25	25	10 U	20000 U	778	20 U	3370 U
5	Dimethyl phthalate (ug/kg)	78	0	0						10 U	20000 U	778	20 U	3370 U
5	Hexachlorobutadiene (ug/kg)	68	0	0						19 U	20000 U	1070	20 UG	5000 U
5	N-Nitrosodiphenylamine (ug/kg)	68	0	0						12 U	12000 U	642	19 U	3370 U
5	Hexachlorobenzene (ug/kg)	68	0	0						19 U	20000 U	890	20 U	3370 U
5	Pentachlorophenol (ug/kg)	68	0	0						60 U	60000 U	3342	97 U	20000 UG
5	1,2-Dichlorobenzene (ug/kg)	67	0	0						1 U	204 U	23	10 U	100 U
5	1,3-Dichlorobenzene (ug/kg)	67	0	0						1 U	204 U	23	10 U	100 U
5	1,4-Dichlorobenzene (ug/kg)	67	0	0						1 U	204 U	23	10 U	100 U
5	Benzene (ug/kg)	57	0	0						5 U	204 U	34	10 U	100 U
5	Ethylbenzene (ug/kg)	57	0	0						5 U	204 U	51	10 U	200 U
5	Tetrachloroethene (ug/kg)	41	0	0						5 U	204 U	23	10 U	100 U
5	Trichloroethene (ug/kg)	41	0	0						5 U	204 U	23	10 U	100 U
5	m,p-Xylene (ug/kg)	36	0	0						5 U	408 U	36	10 U	200 U
5	o-Xylene (ug/kg)	36	0	0						5 U	204 U	22	10 U	100 U
5	2,4-Dinitrotoluene (ug/kg)	33	0	0						95 U	20400 U	1549	98 U	5000 U
5	2,6-Dinitrotoluene (ug/kg)	33	0	0						95 U	5100 U	722	98 U	3000 U
5	2-Chloronaphthalene (ug/kg)	33	0	0						19 U	5000 U	552	20 U	3000 U
5	2-Nitroaniline (ug/kg)	33	0	0						95 U	35000 U	2670	98 U	20000 U
5	3,3'-Dichlorobenzidine (ug/kg)	33	0	0						95 U	35000 U	3040	98 U	20000 U
5	3-Nitroaniline (ug/kg)	33	0	0						110 U	35000 U	3060	120 U	20000 U
5	4-Bromophenyl phenyl ether (ug/kg)	33	0	0						19 U	5000 U	552	20 U	3000 U
5	4-Chloroaniline (ug/kg)	33	0	0						57 U	20400 U	1511	59 U	5000 U
5	4-Chlorophenyl phenyl ether (ug/kg)	33	0	0						19 U	5000 U	552	20 U	3000 U
5	4-Nitroaniline (ug/kg)	33	0	0						95 U	35000 U	2670	98 U	20000 U
5	Bis(2-chloroethoxy) methane (ug/kg)	33	0	0						19 U	5000 U	552	20 U	3000 U
5	Bis(2-chloroethyl) ether (ug/kg)	33	0	0						38 U	5000 U	571	39 U	3000 U
5	Hexachlorocyclopentadiene (ug/kg)	33	0	0						95 U	10200 U	997	98 U	5000 U
5	Hexachloroethane (ug/kg)	33	0	0						19 U	10200 U	922	20 U	5000 U
5	Isophorone (ug/kg)	33	0	0						19 U	5000 U	552	20 U	3000 U

Table 4-5. Historical Surface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detected	Detected Concentrations Minimum	Maximum	Mean	Median	95th	Detected and Nondetected Concentrations Minimum	Maximum	Mean	Median	95th
5	Nitrobenzene (ug/kg)	33	0	0						19 U	5000 U	552	20 U	3000 U
5	N-Nitrosodipropylamine (ug/kg)	33	0	0						38 U	5000 U	571	39 U	3000 U
5	1,2,4-Trichlorobenzene (ug/kg)	33	0	0						19 U	5000 U	386	20 U	3000 U
5	2,4,5-Trichlorophenol (ug/kg)	33	0	0						95 U	5000 U	628	98 U	3000 UG
5	2,4,6-Trichlorophenol (ug/kg)	33	0	0						95 U	5000 U	628	98 U	3000 UG
5	2,4-Dichlorophenol (ug/kg)	33	0	0						57 U	5000 U	590	59 U	3000 UG
5	2-Chlorophenol (ug/kg)	33	0	0						19 U	5000 U	552	20 U	3000 UG
5	2-Nitrophenol (ug/kg)	33	0	0						95 U	5000 U	628	98 U	3000 UG
5	4-Chloro-3-methylphenol (ug/kg)	33	0	0						38 U	5000 U	571	39 U	3000 UG
5	4-Nitrophenol (ug/kg)	33	0	0						95 U	35000 U	3040	98 U	20000 UX
5	4,6-Dinitro-2-methylphenol (ug/kg)	32	0	0						190 U	35000 U	3225	200 U	20000 UX
5	Dieldrin (ug/kg)	31	0	0						1 U	41 U	9.2	2.3 U	20 UG
5	Heptachlor (ug/kg)	31	0	0						0.95 U	41 U	8.69	2 U	20 UG
5	Bis(2-chloro-1-methylethyl) ether (ug/kg)	29	0	0						19 U	5000 U	421	19 UJ	3000 U
5	alpha-Endosulfan (ug/kg)	29	0	0						0.95 U	41 U	9.17	6.7 U	20 UG
5	alpha-Hexachlorocyclohexane (ug/kg)	29	0	0						0.95 U	41 U	9.17	6.7 U	20 UG
5	beta-Endosulfan (ug/kg)	29	0	0						1 U	41 U	10	6.7 U	20 UG
5	delta-Hexachlorocyclohexane (ug/kg)	29	0	0						0.96 U	41 U	9.27	6.7 U	20 UG
5	Endrin (ug/kg)	29	0	0						1 U	41 U	9.3	6.7 U	20 UG
5	Endrin aldehyde (ug/kg)	29	0	0						1 U	41 U	9.8	6.7 U	20 UG
5	Heptachlor epoxide (ug/kg)	29	0	0						0.95 U	41 U	9.17	6.7 U	20 UG
5	Methoxychlor (ug/kg)	29	0	0						1 U	70 U	17	9.7 UJ	40 UG
5	Toxaphene (ug/kg)	29	0	0						30 U	2000 UI	381	250 UI	1200 UI
5	2,4-Dinitrophenol (ug/kg)	28	0	0						190 UJ	35000 U	3223	200 UJ	20000 UX
5	Aroclor 1016 (ug/kg)	26	0	0						10 U	137 U	41	15 U	100 U
5	Aroclor 1221 (ug/kg)	26	0	0						10 U	274 U	61	30 U	134 U
5	Aroclor 1232 (ug/kg)	26	0	0						10 U	137 U	41	15 U	100 U
5	Aroclor 1248 (ug/kg)	26	0	0						10 U	500 U	56	15 U	100 UH
5	Aroclor 1254 (ug/kg)	26	0	0						10 U	500 U	56	15 U	100 UH
5	Endrin ketone (ug/kg)	23	0	0						1 U	52 UI	13	5.8 UI	26.8 U
5	C3-Fluorene (ug/kg)	16	0	0						5 U	5 U	5	5 U	5 U
5	1,1,1-Trichloroethane (ug/kg)	9	0	0						5 U	204 U	70	10 U	100 U
5	1,1,2,2-Tetrachloroethane (ug/kg)	9	0	0						5 U	204 U	70	10 U	100 U
5	1,1,2-Trichloroethane (ug/kg)	9	0	0						5 U	204 U	70	10 U	100 U
5	1,1-Dichloroethane (ug/kg)	9	0	0						5 U	204 U	70	10 U	100 U
5	1,2-Dichloroethane (ug/kg)	9	0	0						5 U	204 U	70	10 U	100 U
5	1,2-Dichloropropane (ug/kg)	9	0	0						5 U	204 U	70	10 U	100 U
5	Acetone (ug/kg)	9	0	0						100 U	5100 U	1678	200 U	2500 U
5	Bromodichloromethane (ug/kg)	9	0	0						5 U	204 U	70	10 U	100 U
5	Bromoform (ug/kg)	9	0	0						5 U	204 U	70	10 U	100 U
5	Bromomethane (ug/kg)	9	0	0						10 U	2040 U	588	20 U	1000 U
5	Carbon disulfide (ug/kg)	9	0	0						100 U	2040 U	838	200 U	2000 U
5	Carbon tetrachloride (ug/kg)	9	0	0						5 U	408 U	126	10 U	200 U
5	Chlorobenzene (ug/kg)	9	0	0						5 U	204 U	70	10 U	100 U
5	Chlorodibromomethane (ug/kg)	9	0	0						5 U	204 U	70	10 U	100 U
5	Chloroethane (ug/kg)	9	0	0						10 U	408 U	140	20 U	200 U
5	Chloroform (ug/kg)	9	0	0						5 U	204 U	70	10 U	100 U
5	Chloromethane (ug/kg)	9	0	0						10 U	1020 U	308	20 U	500 U

Table 4-5. Historical Surface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detected	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
5	cis-1,2-Dichloroethene (ug/kg)	9	0	0						5 U	204 U	70	10 U	100 U
5	cis-1,3-Dichloropropene (ug/kg)	9	0	0						5 U	204 U	70	10 U	100 U
5	Methyl isobutyl ketone (ug/kg)	9	0	0						50 U	1020 U	419	100 U	1000 U
5	Methyl N-butyl ketone (ug/kg)	9	0	0						50 U	2040 U	699	100 U	1000 U
5	Methylethyl ketone (ug/kg)	9	0	0						100 U	5100 U	1678	200 U	2500 U
5	Styrene (ug/kg)	9	0	0						5 U	204 U	70	10 U	100 U
5	trans-1,2-Dichloroethene (ug/kg)	9	0	0						5 U	204 U	70	10 U	100 U
5	trans-1,3-Dichloropropene (ug/kg)	9	0	0						5 U	204 U	70	10 U	100 U
5	Trichlorofluoromethane (ug/kg)	9	0	0						10 U	204 U	84	20 U	200 U
5	Vinyl chloride (ug/kg)	9	0	0						10 U	204 U	84	20 U	200 U
5	Vinylidene chloride (ug/kg)	9	0	0						5 U	204 U	70	10 U	100 U
5	Chlordane (cis & trans) (ug/kg)	6	0	0						10 U	100 UH	85	100 U	100 U
5	Aniline (ug/kg)	5	0	0						1000 U	15000 U	7400	1000 U	10000 U
5	N-Nitrosodimethylamine (ug/kg)	5	0	0						2000 U	35000 U	15800	2000 U	20000 U
5	2-Chloroethyl vinyl ether (ug/kg)	5	0	0						10 U	200 U	50	10 U	20 U
5	Trichlorotrifluoroethane (ug/kg)	5	0	0						10 U	200 U	50	10 U	20 U
5	Vinyl acetate (ug/kg)	5	0	0						50 U	1000 U	250	50 U	100 U
5	Antimony (mg/l)	4	0	0						0.05 U	0.05 U	0.05	0.05 U	0.05 U
5	Beryllium (mg/l)	4	0	0						0.001 U	0.001 U	0.001	0.001 U	0.001 U
5	Bis(2-chloroisopropyl) ether (ug/kg)	4	0	0						330 U	3370 U	1503	660 U	1650 U
5	Butyltin ion (ug/kg)	4	0	0						5.7 U	5.9 U	5.8	5.8 U	5.8 U
5	Cadmium (mg/l)	4	0	0						0.002 U	0.002 U	0.002	0.002 U	0.002 U
5	Chromium (mg/l)	4	0	0						0.005 U	0.005 U	0.005	0.005 U	0.005 U
5	Copper (mg/l)	4	0	0						0.002 U	0.002 U	0.002	0.002 U	0.002 U
5	Dibutyltin ion (ug/kg)	4	0	0						5.7 U	5.9 U	5.8	5.8 U	5.8 U
5	Dibutyltin ion (ug/l)	4	0	0						0.06 U	0.06 U	0.06	0.06 U	0.06 U
5	Lead (mg/l)	4	0	0						0.001 U	0.001 U	0.001	0.001 U	0.001 U
5	Mercury (mg/l)	4	0	0						0.0001 U	0.0001 U	0.0001	0.0001 U	0.0001 U
5	Nickel (mg/l)	4	0	0						0.01 U	0.01 U	0.01	0.01 U	0.01 U
5	Selenium (mg/l)	4	0	0						0.001 U	0.001 U	0.001	0.001 U	0.001 U
5	Silver (mg/l)	4	0	0						0.0002 U	0.0002 U	0.0002	0.0002 U	0.0002 U
5	Tetrabutyltin (ug/kg)	4	0	0						5.7 U	5.9 U	5.8	5.8 U	5.8 U
5	Tetrabutyltin (ug/l)	4	0	0						0.02 U	0.02 U	0.02	0.02 U	0.02 U
5	Thallium (mg/l)	4	0	0						0.001 U	0.001 U	0.001	0.001 U	0.001 U
5	1,1,1,2-Tetrachloroethane (ug/kg)	4	0	0						100 U	204 U	126	100 U	100 U
5	1,1-Dichloropropene (ug/kg)	4	0	0						100 U	204 U	126	100 U	100 U
5	1,2,3-Trichlorobenzene (ug/kg)	4	0	0						100 U	204 U	126	100 U	100 U
5	1,2,3-Trichloropropane (ug/kg)	4	0	0						100 U	204 U	126	100 U	100 U
5	1,2-Dibromo-3-chloropropane (ug/kg)	4	0	0						100 U	204 U	126	100 U	100 U
5	1,3,5-Trimethylbenzene (ug/kg)	4	0	0						100 U	204 U	126	100 U	100 U
5	1,3-Dichloropropane (ug/kg)	4	0	0						100 U	204 U	126	100 U	100 U
5	2,2-Dichloropropane (ug/kg)	4	0	0						100 U	204 U	126	100 U	100 U
5	2-Chlorotoluene (ug/kg)	4	0	0						100 U	204 U	126	100 U	100 U
5	3- and 4-Methylphenol Coelution (ug/kg)	4	0	0						330 U	3370 U	1502.5	660 U	1650 U
5	4-Chlorotoluene (ug/kg)	4	0	0						100 U	204 U	126	100 U	100 U
5	Bromobenzene (ug/kg)	4	0	0						100 U	204 U	126	100 U	100 U
5	Bromochloromethane (ug/kg)	4	0	0						100 U	204 U	126	100 U	100 U
5	Chlordane (technical) (ug/kg)	4	0	0						150 U	919 U	454.75	150 U	600 U

Table 4-5. Historical Surface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detected	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
5	Dichlorodifluoromethane (ug/kg)	4	0	0						500 U	1020 U	630	500 U	500 U
5	Ethylene dibromide (ug/kg)	4	0	0						100 U	204 U	126	100 U	100 U
5	Isopropylbenzene (ug/kg)	4	0	0						100 U	204 U	126	100 U	100 U
5	Methylene bromide (ug/kg)	4	0	0						100 U	204 U	126	100 U	100 U
5	n-Butylbenzene (ug/kg)	4	0	0						100 U	204 U	126	100 U	100 U
5	n-Propylbenzene (ug/kg)	4	0	0						100 U	204 U	126	100 U	100 U
5	p-Cymene (ug/kg)	4	0	0						100 U	204 U	126	100 U	100 U
5	Pseudocumene (ug/kg)	4	0	0						100 U	204 U	126	100 U	100 U
5	Sec-butylbenzene (ug/kg)	4	0	0						100 U	204 U	126	100 U	100 U
5	tert-Butylbenzene (ug/kg)	4	0	0						100 U	204 U	126	100 U	100 U
5	trans-Chlordane (ug/kg)	4	0	0						6.7 U	41 U	20.3	6.7 U	26.8 U
5	Butyltin ion (ug/l)	3	0	0						0.06 U	0.06 U	0.06	0.06 U	0.06 U
5	1,2,3,4,7,8,9-Heptachlorodibenzofuran (ng/kg)	1	0	0						0.88 U	0.88 U	0.88	0.88 U	0.88 U
5	1,2,3,4,7,8-Hexachlorodibenzofuran (ng/kg)	1	0	0						2.2 U	2.2 U	2.2	2.2 U	2.2 U
5	1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin (ng/kg	1	0	0						2.1 U	2.1 U	2.1	2.1 U	2.1 U
5	1,2,3,6,7,8-Hexachlorodibenzofuran (ng/kg)	1	0	0						2.2 U	2.2 U	2.2	2.2 U	2.2 U
5	1,2,3,7,8,9-Hexachlorodibenzofuran (ng/kg)	1	0	0						2.2 U	2.2 U	2.2	2.2 U	2.2 U
5	1,2,3,7,8-Pentachlorodibenzofuran (ng/kg)	1	0	0						0.94 U	0.94 U	0.94	0.94 U	0.94 U
5	1,2,3,7,8-Pentachlorodibenzo-p-dioxin (ng/kg)	1	0	0						2.2 U	2.2 U	2.2	2.2 U	2.2 U
5	2,3,4,7,8-Pentachlorodibenzofuran (ng/kg)	1	0	0						0.94 U	0.94 U	0.94	0.94 U	0.94 U
5	2,3,7,8-Tetrachlorodibenzo-p-dioxin (ng/kg)	1	0	0						0.85 U	0.85 U	0.85	0.85 U	0.85 U
5	Pentachlorodibenzofuran (ng/kg)	1	0	0						0.94 U	0.94 U	0.94	0.94 U	0.94 U
5	Pentachlorodibenzo-p-dioxin (ng/kg)	1	0	0						2.2 U	2.2 U	2.2	2.2 U	2.2 U
6	Chromium (mg/kg)	37	37	100	14.3	220	42	33.6	109	14.3	220	42	33.6	109
6	Copper (mg/kg)	37	37	100	15.2	1150	90	37.8	140	15.2	1150	90	37.8	140
6	Lead (mg/kg)	37	37	100	4.5	577	60	16	232	4.5	577	60	16	232
6	Nickel (mg/kg)	37	37	100	14	167	31	26	50	14	167	31	26	50
6	Zinc (mg/kg)	37	37	100	52.3	2010	184	98.6	388	52.3	2010	184	98.6	388
6	Benz(a)anthracene (ug/kg)	29	29	100	64	6100	630	140	2100	64	6100	630	140	2100
6	Benzo(a)pyrene (ug/kg)	29	29	100	56	6800	759	150	2000	56	6800	759	150	2000
6	Benzo(b)fluoranthene (ug/kg)	29	29	100	54 G	6400	588	170	2200	54 G	6400	588	170	2200
6	Benzo(k)fluoranthene (ug/kg)	29	29	100	38	3800 G	403	140	1000	38	3800 G	403	140	1000
6	Chrysene (ug/kg)	29	29	100	94	7200	767	180	2300	94	7200	767	180	2300
6	Fluoranthene (ug/kg)	29	29	100	140	17000	1781	380	4100	140	17000	1781	380	4100
6	High Molecular Weight PAH (ug/kg)	29	29	100	798 A	78600 A	8049	2085 A	20407 A	798 A	78600 A	8049	2085 A	20407 A
6	Indeno(1,2,3-cd)pyrene (ug/kg)	29	29	100	41	5600	552	100	1600	41	5600	552	100	1600
6	Low Molecular Weight PAH (ug/kg)	29	29	100	115 A	19320 A	2026	444 A	4420 A	115 A	19320 A	2026	444 A	4420 A
6	Phenanthrene (ug/kg)	29	29	100	79	15000	1247	254	2200	79	15000	1247	254	2200
6	Polycyclic Aromatic Hydrocarbons (ug/kg)	29	29	100	913 A	97920 A	10074	2483 A	23617 A	913 A	97920 A	10074	2483 A	23617 A
6	Pyrene (ug/kg)	29	29	100	140	21000	1924	380	4100	140	21000	1924	380	4100
6	Benzo(b+k)fluoranthene (ug/kg)	26	26	100	113 A	8800 A	1016	260 A	2410 A	113 A	8800 A	1016	260 A	2410 A
6	Total organic carbon (%)	26	26	100	0.38	2.79	1.445	1.3	2.49	0.38	2.79	1.445	1.3	2.49
6	Aluminum (mg/kg)	20	20	100	8470	40900	30954	33200	40900	8470	40900	30954	33200	40900
6	Barium (mg/kg)	20	20	100	111	426	183	173	232	111	426	183	173	232
6	Calcium (mg/kg)	20	20	100	5360 J	53800	12547	8230 J	52700	5360 J	53800	12547	8230 J	52700
6	Cobalt (mg/kg)	20	20	100	12.9	55.5	21	17.7	36.7	12.9	55.5	21	17.7	36.7
6	Iron (mg/kg)	20	20	100	19100	84900	40650	39700	50100	19100	84900	40650	39700	50100
6	Magnesium (mg/kg)	20	20	100	3710	14500	6881	6460	11900	3710	14500	6881	6460	11900

Table 4-5. Historical Surface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detected	Detected Concentrations Minimum	Maximum	Mean	Median	95th	Detected and Nondetected Concentrations Minimum	Maximum	Mean	Median	95th
6	Manganese (mg/kg)	20	20	100	322	1440	699	637	1330	322	1440	699	637	1330
6	Potassium (mg/kg)	20	20	100	760	50000	4276	1230	10200	760	50000	4276	1230	10200
6	Sodium (mg/kg)	20	20	100	753	49000	4165	1110	10700	753	49000	4165	1110	10700
6	Vanadium (mg/kg)	20	20	100	71.9	147	99	99	112	71.9	147	99	99	112
6	Fines (%)	19	19	100	1.9	74.34	48	47.73	72.09	1.9	74.34	48	47.73	72.09
6	Silt (%)	19	19	100	1.9	72.04	41	39.61	62.42	1.9	72.04	41	39.61	62.42
6	Sand (%)	18	18	100	25.5	96.8	49	42.7	84.69	25.5	96.8	49	42.7	84.69
6	Gravel (%)	17	17	100	0.01	14.18	1.20	0.11	1.77	0.01	14.18	1.20	0.11	1.77
6	Total solids (%)	17	17	100	41.9	78.4	55	47.6	76.6	41.9	78.4	55	47.6	76.6
6	Titanium (mg/kg)	9	9	100	1520	1980	1807	1760	1970	1520	1980	1807	1760	1970
6	Aluminum (mg/l)	6	6	100	0.05	0.61	0.20	0.08	0.24	0.05	0.61	0.20	0.08	0.24
6	Arsenic (mg/l)	6	6	100	0.001	0.008	0.003	0.002	0.002	0.001	0.008	0.003	0.002	0.002
6	Barium (mg/l)	6	6	100	0.04	0.13	0.08	0.08	0.1	0.04	0.13	0.08	0.08	0.1
6	Calcium (mg/l)	6	6	100	25.8	108	74	71.4	103	25.8	108	74	71.4	103
6	Iron (mg/l)	6	6	100	0.49	24	6.65	2.21	5.83	0.49	24	6.65	2.21	5.83
6	Magnesium (mg/l)	6	6	100	15	37.9	27	24.1	35.2	15	37.9	27	24.1	35.2
6	Manganese (mg/l)	6	6	100	2.66	12.9	7.69	7.27	10.5	2.66	12.9	7.69	7.27	10.5
6	Potassium (mg/l)	6	6	100	2.1	4.7	3.2	2.8	3.9	2.1	4.7	3.2	2.8	3.9
6	Sodium (mg/l)	6	6	100	10.1	17.6	15	15.5	16.4	10.1	17.6	15	15.5	16.4
6	Total volatile solids (%)	3	3	100	1.4	4.97	2.86	1.4	2.2	1.4	4.97	2.86	1.4	2.2
6	Mean grain size (mm)	2	2	100	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47
6	Median grain size (mm)	2	2	100	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42
6	Ammonia (mg/kg)	1	1	100	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5
6	Total sulfides (mg/kg)	1	1	100	52	52	52	52	52	52	52	52	52	52
6	Anthracene (ug/kg)	29	28	97	25	4400 G	287	62	680	20 U	4400 G	277	55	680
6	Tributyltin ion (ug/kg)	18	17	94	0.7 J	819	133	43.7	480 J	0.7 J	819	126	43.7	480 J
6	Fluorene (ug/kg)	29	27	93	16	1600	173	50	410	16	1600	162	46	410
6	Carbazole (ug/kg)	23	21	91	9 J	650 J	120	48 J	210 J	9 J	650 J	112	41 J	210 J
6	Dibenz(a,h)anthracene (ug/kg)	29	26	90	10 G	690 G	93	45	300	10 G	690 G	85	40	300
6	Clay (%)	19	17	89	2.23	11.23	7.49	7.99	9.98	0.1 U	11.23	6.71	7.82	9.98
6	4,4'-DDD (ug/kg)	8	7	88	1.6 J	4.1	2.6	2	3.3	1.6 J	4.1	2.7	2.6	3.3
6	4,4'-DDT (ug/kg)	8	7	88	1.7 J	14	6.0	2.4	11	1.7 J	14	6.1	3.9	11
6	Total of 3 isomers: pp-DDT,-DDD,-DDE (ug/k	8	7	88	3.3 A	17.5 A	9.1	4.7 A	17.3 A	3.3 A	17.5 A	8.8	6.5 A	17.3 A
6	Acenaphthene (ug/kg)	29	25	86	28	1700 G	231	66	760	20 U	1700 G	203	56	760
6	Benzo(g,h,i)perylene (ug/kg)	29	25	86	44	5700	660	170	1700	19 UJ	5700	571	110	1700
6	Naphthalene (ug/kg)	29	25	86	4 J	680	113	50	300 J	4 J	680	101	37	300 J
6	4-Methylphenol (ug/kg)	18	15	83	21	1000	372	300	680	19 U	1000	313	280	680
6	Cobalt (mg/l)	6	5	83	0.007	0.01	0.008	0.008	0.008	0.003 U	0.01	0.007	0.008	0.008
6	Zinc (mg/l)	6	5	83	0.005	0.01	0.008	0.006	0.01	0.004 U	0.01	0.007	0.006	0.01
6	2-Methylnaphthalene (ug/kg)	25	20	80	2 J	530	73	32	240	2 J	530	62	27	135 G
6	Beryllium (mg/kg)	34	26	76	0.39	0.86	0.57	0.57	0.7	0.39	4.8 U	1.39	0.6	4.5 U
6	Silver (mg/kg)	37	28	76	0.05	1.16	0.5975	0.7	0.9	0.05	4.8 U	1.35	0.7	4.5 U
6	Dibenzofuran (ug/kg)	26	19	73	6 J	290	67	31	220	6 J	290	54	25	200 J
6	Mercury (mg/kg)	37	27	73	0.02	0.12	0.06	0.05	0.11	0.02	0.2 U	0.09	0.07	0.2 U
6	Cadmium (mg/kg)	37	25	68	0.06	0.5	0.30	0.3	0.4	0.06	4.8 U	1.12	0.3	4.5 U
6	Diesel fuels (mg/kg)	6	4	67	92	720	280	99	210	92	720	222	99	210
6	Arsenic (mg/kg)	37	22	59	1.8	105	13	4.3	30.6	1.8	105	9.53	5 U	30.6
6	Thallium (mg/kg)	34	20	59	0.07	27	12	20	25	0.07	48 U	17	20	45 U

Table 4-5. Historical Surface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detected	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
6	Selenium (mg/kg)	34	19	56	0.47	15	10	11	14	0.47	15	6.40	2.38 U	14
6	Bis(2-ethylhexyl) phthalate (ug/kg)	24	12	50	50 J	430	184	170	300 J	50 J	12000 U	648	130 U	300 J
6	Dibutyltin ion (ug/kg)	18	9	50	0.8 J	253	40	7	45	0.8 J	253	22	5.8 U	45
6	Lead (mg/l)	6	3	50	0.001	0.002	0.002	0.001	0.002	0.001	0.002	0.001	0.001 U	0.002
6	Residual Range Organics (mg/kg)	6	3	50	410	840	630	410	640	380 U	840	520	410	640
6	Acid Volatile Sulfides (mg/kg)	2	1	50	0.9	0.9	0.9	0.9	0.9	0.7 U	0.9	0.8	0.7 U	0.7 U
6	Acenaphthylene (ug/kg)	29	14	48	6 J	406 G	82.3	33 J	280 J	6 J	406 G	50	20	110
6	Butyltin ion (ug/kg)	18	8	44	2	95.5	18	3	24 J	1 U	95.5	11	5.7 U	24 J
6	Aroclor 1260 (ug/kg)	14	5	36	4	19	11	8 J	13	4	20 U	14	13	20 U
6	Polychlorinated biphenyls (ug/kg)	14	5	36	4 A	19 A	11	8 A	13 A	4 A	40 UA	24	20 UA	39 UA
6	Butylbenzyl phthalate (ug/kg)	24	7	29	3 J	37	19	6 J	30	3 J	1200 U	69.5	20 U	30 U
6	4,4'-DDE (ug/kg)	8	2	25	0.7	2.4	1.55	0.7	0.7	0.7	2.4	1.9	2 U	2.3 U
6	Antimony (mg/kg)	35	8	23	0.14	15.2	3.62	0.62	10.1	0.02 UG	24 U	7.78	5 UJ	23 U
6	Tetrabutyltin (ug/kg)	18	4	22	0.5 J	7.14	2.41	1 J	1 J	0.5 J	7.14	4.13	5.6 U	5.9 U
6	Tributyltin ion (ug/l)	9	2	22	0.03	0.25	0.14	0.03	0.03	0.02 U	0.25	0.05	0.02 U	0.05 U
6	Benzoic acid (ug/kg)	24	5	21	50 J	80 J	68	50 J	80 J	50 J	23000 U	1115	190 U	200 U
6	Diethyl phthalate (ug/kg)	24	5	21	2 J	10 J	4.4	3 J	4 J	2 J	970 U	56	19 U	20 U
6	Dimethyl phthalate (ug/kg)	24	4	17	0.6 J	36	9.65	1 J	1 J	0.6 J	580 U	41	19 U	20 U
6	Phenol (ug/kg)	24	4	17	6 J	7 J	6.25	6 J	6 J	6 J	2900 U	140	19 U	20 U
6	Copper (mg/l)	6	1	17	0.003	0.003	0.003	0.003	0.003	0.002 U	0.003	0.002	0.002 U	0.002 U
6	Vanadium (mg/l)	6	1	17	0.003	0.003	0.003	0.003	0.003	0.003 U	0.003	0.003	0.003 U	0.003 U
6	Endosulfan sulfate (ug/kg)	7	1	14	0.7 J	0.7 J	0.7	0.7 J	0.7 J	0.7 J	20 U	4.3	1.9 U	2 U
6	Methoxychlor (ug/kg)	7	1	14	1 J	1 J	1	1 J	1 J	1 J	40 U	13	9.5 U	9.9 U
6	Bis(2-chloroethoxy) methane (ug/kg)	23	3	13	29	30	30	29	30	19 UJ	1200 U	73	20 U	30
6	Dibutyl phthalate (ug/kg)	24	2	8	21	43	32	21	21	19 U	1200 U	72	20 U	30 U
6	N-Nitrosodipropylamine (ug/kg)	23	1	4	3 J	3 J	3	3 J	3 J	3 J	580 U	57	39 U	40 U
6	2,4-Dimethylphenol (ug/kg)	24	1	4	290	290	290	290	290	6 U	12000 U	576	20 U	300 U
6	Pentachlorophenol (ug/kg)	24	1	4	88 J	88 J	88	88 J	88 J	61 U	17000 U	872	98 UJ	440 U
6	Benzyl alcohol (ug/kg)	24	0	0						6 U	2900 U	150	20 UJ	74 U
6	Hexachlorobutadiene (ug/kg)	24	0	0						15 U	580 U	42	19 U	20 U
6	N-Nitrosodiphenylamine (ug/kg)	24	0	0						12 U	580 U	42	19 U	20 U
6	1,2-Dichlorobenzene (ug/kg)	24	0	0						1 U	580 U	41	19 U	20 U
6	1,3-Dichlorobenzene (ug/kg)	24	0	0						1 U	580 U	41	19 U	20 U
6	1,4-Dichlorobenzene (ug/kg)	24	0	0						1 U	580 U	41	19 U	20 U
6	2-Methylphenol (ug/kg)	24	0	0						6 U	12000 U	576	20 U	300 U
6	Di-n-octyl phthalate (ug/kg)	24	0	0						19 U	12000 U	576	20 U	300 U
6	Hexachlorobenzene (ug/kg)	24	0	0						15 U	580 U	42	19 U	20 U
6	2,4-Dinitrotoluene (ug/kg)	23	0	0						73 U	2900 U	214	97 U	100 U
6	2,6-Dinitrotoluene (ug/kg)	23	0	0						29 U	1200 U	131	97 U	100 U
6	2-Chloronaphthalene (ug/kg)	23	0	0						15 U	580 U	43	19 U	20 U
6	2-Nitroaniline (ug/kg)	23	0	0						29 U	1200 U	131	97 U	100 U
6	3,3'-Dichlorobenzidine (ug/kg)	23	0	0						90 U	4000 U	285	98 U	200 U
6	3-Nitroaniline (ug/kg)	23	0	0						110 UJ	12000 U	673	120 UJ	300 U
6	4-Bromophenyl phenyl ether (ug/kg)	23	0	0						15 U	580 U	43	19 U	20 U
6	4-Chloroaniline (ug/kg)	23	0	0						57 UJ	2900 U	185	59 UJ	74 U
6	4-Chlorophenyl phenyl ether (ug/kg)	23	0	0						15 U	580 U	43	19 U	20 U
6	4-Nitroaniline (ug/kg)	23	0	0						94 UJ	5800 U	357	98 UJ	150 U
6	Bis(2-chloroethyl) ether (ug/kg)	23	0	0						15 U	580 U	57	39 U	40 UJ

Table 4-5. Historical Surface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detected	Detected Concentrations Minimum	Maximum	Mean	Median	95th	Detected and Nondetected Concentrations Minimum	Maximum	Mean	Median	95th
6	Hexachlorocyclopentadiene (ug/kg)	23	0	0						94 UJ	12000 U	658	98 UJ	300 U
6	Hexachloroethane (ug/kg)	23	0	0						19 U	2300 U	127	20 U	59 U
6	Isophorone (ug/kg)	23	0	0						15 U	580 U	43	19 U	20 U
6	Nitrobenzene (ug/kg)	23	0	0						15 U	580 U	43	19 U	20 U
6	1,2,4-Trichlorobenzene (ug/kg)	23	0	0						15 U	580 U	43	19 U	20 U
6	2,4,5-Trichlorophenol (ug/kg)	23	0	0						73 U	2900 U	214	97 U	100 U
6	2,4,6-Trichlorophenol (ug/kg)	23	0	0						73 U	2900 U	214	97 U	100 U
6	2,4-Dichlorophenol (ug/kg)	23	0	0						57 U	5800 U	328	59 U	150 U
6	2-Chlorophenol (ug/kg)	23	0	0						19 U	2900 U	157	20 U	74 U
6	2-Nitrophenol (ug/kg)	23	0	0						73 U	2900 U	214	97 U	100 U
6	4,6-Dinitro-2-methylphenol (ug/kg)	23	0	0						190 U	12000 U	730	200 U	300 U
6	4-Chloro-3-methylphenol (ug/kg)	23	0	0						38 U	2900 U	171	39 U	74 U
6	4-Nitrophenol (ug/kg)	23	0	0						94 U	5800 U	357	98 U	150 U
6	Bis(2-chloro-1-methylethyl) ether (ug/kg)	17	0	0						19 UJ	20 U	19	19 U	20 U
6	Aroclor 1016 (ug/kg)	14	0	0						10 U	20 U	14	10 U	20 U
6	Aroclor 1221 (ug/kg)	14	0	0						10 U	40 U	26	20 U	39 U
6	Aroclor 1232 (ug/kg)	14	0	0						10 U	20 U	16	18 U	20 U
6	Aroclor 1242 (ug/kg)	14	0	0						10 U	20 U	15	13 U	20 U
6	Aroclor 1248 (ug/kg)	14	0	0						10 U	20 U	14	10 U	20 U
6	Aroclor 1254 (ug/kg)	14	0	0						10 U	38 U	17	10 U	29 UI
6	2,4-Dinitrophenol (ug/kg)	14	0	0						190 UJ	17000 U	1484	200 UJ	450 U
6	Aldrin (ug/kg)	8	0	0						0.94 U	20 U	3.57	0.98 U	2 U
6	Dieldrin (ug/kg)	8	0	0						1.9 U	2.3 U	2	2 U	2 U
6	gamma-Hexachlorocyclohexane (ug/kg)	8	0	0						0.94 U	20 U	3.57	0.98 U	2 U
6	Heptachlor (ug/kg)	8	0	0						0.94 U	20 U	3.57	0.98 U	2 U
6	alpha-Endosulfan (ug/kg)	7	0	0						0.94 U	20 U	3.83	0.96 U	2 U
6	alpha-Hexachlorocyclohexane (ug/kg)	7	0	0						0.94 U	20 U	3.83	0.96 U	2 U
6	beta-Endosulfan (ug/kg)	7	0	0						1.9 U	20 U	4.53	1.9 U	2 U
6	beta-Hexachlorocyclohexane (ug/kg)	7	0	0						0.94 U	20 U	3.83	0.96 U	2 U
6	delta-Hexachlorocyclohexane (ug/kg)	7	0	0						0.94 U	20 U	3.95	0.98 U	2 U
6	Endrin (ug/kg)	7	0	0						1.9 U	20 U	4.53	1.9 U	2 U
6	Endrin aldehyde (ug/kg)	7	0	0						1.9 U	20 U	4.53	1.9 U	2 U
6	Heptachlor epoxide (ug/kg)	7	0	0						0.94 U	20 U	3.83	0.96 U	2 U
6	Toxaphene (ug/kg)	7	0	0						30 U	99 U	77	94 U	98 U
6	Antimony (mg/l)	6	0	0						0.05 U	0.05 U	0.05	0.05 U	0.05 U
6	Beryllium (mg/l)	6	0	0						0.001 U	0.001 U	0.001	0.001 U	0.001 U
6	Bis(2-chloroisopropyl) ether (ug/kg)	6	0	0						15 U	580 U	109	15 U	15 U
6	Cadmium (mg/l)	6	0	0						0.002 U	0.002 U	0.002	0.002 U	0.002 U
6	Chromium (mg/l)	6	0	0						0.005 U	0.005 U	0.005	0.005 U	0.005 U
6	Dibutyltin ion (ug/l)	6	0	0						0.06 U	0.06 U	0.06	0.06 U	0.06 U
6	Mercury (mg/l)	6	0	0						0.0001 U	0.0001 U	0.0001	0.0001 U	0.0001 U
6	Nickel (mg/l)	6	0	0						0.01 U	0.01 U	0.01	0.01 U	0.01 U
6	Selenium (mg/l)	6	0	0						0.001 U	0.001 U	0.001	0.001 U	0.001 U
6	Silver (mg/l)	6	0	0						0.0002 U	0.0002 U	0.0002	0.0002 U	0.0002 U
6	Tetrabutyltin (ug/l)	6	0	0						0.02 U	0.02 U	0.02	0.02 U	0.02 U
6	Thallium (mg/l)	6	0	0						0.001 U	0.001 U	0.001	0.001 U	0.001 U
6	3- and 4-Methylphenol Coelution (ug/kg)	6	0	0						290 U	12000 U	2247	300 U	300 U
6	alpha-Chlordane (ug/kg)	6	0	0						0.94 U	1.7 U	1.09	0.96 U	0.99 U

Table 4-5. Historical Surface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detected	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
6	gamma-Chlordane (ug/kg)	6	0	0						0.94 U	1.7 U	1.09	0.96 U	0.99 U
6	Gasoline (mg/kg)	6	0	0						40 U	140 U	58	40 U	48 U
6	Endrin ketone (ug/kg)	5	0	0						1.9 U	2 U	1.94	1.9 U	2 U
6	Chlordane (cis & trans) (ug/kg)	2	0	0						10 U	10 U	10	10 U	10 U
6	Butyltin ion (ug/l)	1	0	0						0.06 U	0.06 U	0.06	0.06 U	0.06 U
7	Total organic carbon (%)	91	91	100	0.08	14 M	2.36	1.85	5.1	0.08	14 M	2.36	1.85	5.1
7	Fines (%)	90	90	100	0	93.4 J	47	50.7 J	90.3 J	0	93.4 J	47	50.7 J	90.3 J
7	Sand (%)	89	89	100	6.6 J	98.3	49	46.02	95.26	6.6 J	98.3	49	46.02	95.26
7	Chromium (mg/kg)	85	85	100	9.3	56.4	28	28.4	41	9.3	56.4	28	28.4	41
7	Zinc (mg/kg)	85	85	100	35 JM	490 JM	130	114	210	35 JM	490 JM	130	114	210
7	Copper (mg/kg)	82	82	100	12	150 M	46	44	84	12	150 M	46	44	84
7	Lead (mg/kg)	73	73	100	2.8	86.9	25	25	47	2.8	86.9	25	25	47
7	Silt (%)	71	71	100	0.4	80.7 J	50	59.54	77.9 J	0.4	80.7 J	50	59.54	77.9 J
7	Gravel (%)	64	64	100	0.01	46.31	5.68	1.66	26.95	0.01	46.31	5.68	1.66	26.95
7	Nickel (mg/kg)	60	60	100	11	37	24	23	33	11	37	24	23	33
7	Total solids (%)	45	45	100	26.5	82.2	52	45	76.5	26.5	82.2	52	45	76.5
7	Iron (mg/kg)	28	28	100	28000 J	64500	43493	43600	54200	28000 J	64500	43493	43600	54200
7	Manganese (mg/kg)	28	28	100	360	909	634	624	840	360	909	634	624	840
7	Aluminum (mg/kg)	27	27	100	14000	43300	32533	33200	42600	14000	43300	32533	33200	42600
7	Barium (mg/kg)	27	27	100	101	229	169	170	208	101	229	169	170	208
7	Calcium (mg/kg)	27	27	100	4500	10300 J	7443	7410 J	8780 J	4500	10300 J	7443	7410 J	8780 J
7	Cobalt (mg/kg)	27	27	100	11.3	27	19	18.4	23.9	11.3	27	19	18.4	23.9
7	Magnesium (mg/kg)	27	27	100	3500	7590	6007	6090	7310	3500	7590	6007	6090	7310
7	Potassium (mg/kg)	27	27	100	320	1500	1054	1080	1380	320	1500	1054	1080	1380
7	Sodium (mg/kg)	27	27	100	330	1250	891	928	1190	330	1250	891	928	1190
7	Total volatile solids (%)	27	27	100	1.1	12.3	8.3	9.2 J	10.1 J	1.1	12.3	8.3	9.2 J	10.1 J
7	Vanadium (mg/kg)	27	27	100	66.6	160	109.1	107	147	66.6	160	109	107	147
7	Tributyltin ion (ug/kg)	26	26	100	7.6 JN	410 G	123.6	93 G	240 G	7.6 JN	410 G	124	93 G	240 G
7	Mean grain size (mm)	23	23	100	0.02	0.6	0.07	0.02	0.09	0.02	0.6	0.07	0.02	0.09
7	Median grain size (mm)	23	23	100	0.01	0.5	0.06	0.02	0.06	0.01	0.5	0.06	0.02	0.06
7	Total sulfides (mg/kg)	18	18	100	1	720 G	73	20 G	170 G	1	720 G	73	20 G	170 G
7	1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin (ng/	17	17	100	26	6900 M	916	210	3800	26	6900 M	916	210	3800
7	Octachlorodibenzofuran (ng/kg)	17	17	100	15	2800 JM	341	110	740	15	2800 JM	341	110	740
7	Octachlorodibenzo-p-dioxin (ng/kg)	17	17	100	250	56000 JM	7598	1600	29000	250	56000 JM	7598	1600	29000
7	Heptachlorodibenzofuran (ng/kg)	9	9	100	12	1300	300	140	590	12	1300	300	140	590
7	Heptachlorodibenzo-p-dioxin (ng/kg)	9	9	100	87	6900	1357	320	3100	87	6900	1357	320	3100
7	Hexachlorodibenzofuran (ng/kg)	9	9	100	6.7	1100	261	83	550	6.7	1100	261	83	550
7	Titanium (mg/kg)	7	7	100	1910	3200	2543	2110	2940	1910	3200	2543	2110	2940
7	Aluminum (mg/l)	4	4	100	0.61	3.66	1.47	0.62	1	0.61	3.66	1.47	0.62	1
7	Arsenic (mg/l)	4	4	100	0.002	0.009	0.004	0.002	0.004	0.002	0.009	0.004	0.002	0.004
7	Barium (mg/l)	4	4	100	0.03	0.12	0.06	0.04	0.05	0.03	0.12	0.06	0.04	0.05
7	Calcium (mg/l)	4	4	100	14.3	66.6	36	22.8	41.6	14.3	66.6	36	22.8	41.6
7	Cobalt (mg/l)	4	4	100	0.003	0.01	0.006	0.004	0.005	0.003	0.01	0.006	0.004	0.005
7	Copper (mg/l)	4	4	100	0.002	0.02	0.007	0.003	0.003	0.002	0.02	0.007	0.003	0.003
7	Iron (mg/l)	4	4	100	5.04	33.8	12.84	5.06	7.44	5.04	33.8	12.84	5.06	7.44
7	Lead (mg/l)	4	4	100	0.002	0.01	0.004	0.002	0.002	0.002	0.01	0.004	0.002	0.002
7	Magnesium (mg/l)	4	4	100	6.03	21.2	12	7.78	12	6.03	21.2	12	7.78	12
7	Manganese (mg/l)	4	4	100	1.56	8.5	3.95	2.07	3.68	1.56	8.5	3.95	2.07	3.68

Table 4-5. Historical Surface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detected	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
7	Potassium (mg/l)	4	4	100	1.2	3.8	2.2	1.7	2.2	1.2	3.8	2.2	1.7	2.2
7	Sodium (mg/l)	4	4	100	11.1	16.1	14	14.1	14.7	11.1	16.1	14	14.1	14.7
7	Zinc (mg/l)	4	4	100	0.008	0.01	0.009	0.008	0.009	0.008	0.01	0.009	0.008	0.009
7	Heavy oil (mg/kg)	4	4	100	9.6	5100	1360	91	240	9.6	5100	1360	91	240
7	Ammonia (mg/kg)	3	3	100	14.2	128	52.5	14.2	15.3	14.2	128	52.5	14.2	15.3
7	Moisture (%)	3	3	100	41	220	104	41	51	41	220	104	41	51
7	pH (pH units)	3	3	100	6.4	7	6.7	6.4	6.6	6.4	7	6.7	6.4	6.6
7	Specific Gravity (Std_ Units)	3	3	100	2.49	2.74	2.65	2.49	2.71	2.49	2.74	2.65	2.49	2.71
7	Mean grain size (%)	1	1	100	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
7	Median grain size (%)	1	1	100	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
7	Tin (mg/kg)	1	1	100	3.46 G	3.46 G	3.46	3.46 G	3.46 G	3.46 G	3.46 G	3.46	3.46 G	3.46 G
7	Fluoranthene (ug/kg)	113	110	97	0.8 G	3000000	52573	2600 G	140000	0.8 G	3000000	51186	2400	140000
7	High Molecular Weight PAH (ug/kg)	113	110	97	2 A	12268000 A	202810	12439 A	524200 A	2 A	12268000 A	197434	11450 A	524200 A
7	Polycyclic Aromatic Hydrocarbons (ug/kg)	113	110	97	4.5 A	26408000 A	422233	17950 A	1045000 A	4.5 A	26408000 A	411032	16563 A	1045000 A
7	Pyrene (ug/kg)	113	110	97	0.8 G	3400000	55883	2500	140000	0.8 G	3400000	54408	2400	140000
7	Clay (%)	71	69	97	0.1	15.8 J	8.6	9.15	14 J	0.1	15.8 J	8.3	9.1 J	14 J
7	Total of 3 isomers: pp-DDT,-DDD,-DDE (ug/k	37	35	95	1.7 A	3800 A	276	65 A	900 A	1.7 A	3800 A	261	55 A	900 A
7	1,2,3,4,6,7,8-Heptachlorodibenzofuran (ng/kg)	17	16	94	6.3	930 JM	128	45	330	6.3	930 JM	125	45	330
7	1,2,3,4,7,8-Hexachlorodibenzofuran (ng/kg)	17	16	94	5.3	190 M	43	20	140	4.9 U	190 M	40	13	140
7	Acid Volatile Sulfides (mg/kg)	17	16	94	3.6	1100 X	126	41 X	250 X	0.7 U	1100 X	119	41 X	250 X
7	Benzo(b+k)fluoranthene (ug/kg)	113	106	94	15 A	1280000 A	21793	1900	47000 A	5 UA	1280000 A	20456	1800	47000 A
7	Chrysene (ug/kg)	113	106	94	12	1300000	21367	1200	42000	5 UG	1300000	20187	1100	42000
7	Low Molecular Weight PAH (ug/kg)	113	106	94	2.5 A	14140000 A	227703	4860 A	511000 A	2.5 A	14140000 A	213607	2890 A	511000 A
7	Phenanthrene (ug/kg)	113	106	94	1 G	5400000	90383	1700	220000	1 G	5400000	84794	1500	220000
7	Benzo(b)fluoranthene (ug/kg)	72	67	93	15	930000	19902	397	33000	5 UG	930000	18534	330 U	33000
7	Benz(a)anthracene (ug/kg)	113	105	93	11	840000	15468	1100 G	39000	5 UG	840000	14384	960	39000
7	Benzo(a)pyrene (ug/kg)	112	103	92	12	1000000	17130	1200	39000	5 UG	1000000	15776	950	39000
7	4,4'-DDT (ug/kg)	37	34	92	1.7	2500	205	36 J	900 J	1.7	2500	189	30 HJ	900 J
7	Beryllium (mg/kg)	30	27	90	0.33	0.9	0.66	0.7	0.79	0.33	1 U	0.70	0.7	1 U
7	Mercury (mg/kg)	54	48	89	0.01	0.36	0.10	0.09	0.2	0.01	0.36	0.10	0.09	0.2 U
7	Hexachlorodibenzo-p-dioxin (ng/kg)	9	8	89	5	970	209	38	450	5	970	186	23	450
7	Pentachlorodibenzofuran (ng/kg)	9	8	89	5.2	180	57	38	110	4.9 U	180	52	6.4	110
7	Benzo(k)fluoranthene (ug/kg)	72	61	85	12	350000	11436	340	21000	5 UG	350000	9718	311	21000
7	Benzo(e)pyrene (ug/kg)	25	21	84	75	13000	2163	630	5600	75	13000	2191	630	5700 UJ
7	4,4'-DDD (ug/kg)	37	31	84	4.8 J	1200	79	30 H	110	0.4 UJ	1200	66	20 H	110
7	Cadmium (mg/kg)	54	45	83	0.05	1.77 E	0.40	0.34	0.55	0.05	1.77 E	0.45	0.4	1 U
7	Anthracene (ug/kg)	113	94	83	17	1100000	21720	860 G	55000	5 UG	1100000	18080	420	52000
7	Silver (mg/kg)	51	42	82	0.06 E	1.7	0.75	0.6	1.4	0.06 E	2 U	0.84	0.8	1.7
7	1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin (ng/kg	17	14	82	2	250	54	15	230 M	1.3 U	250	45	12	230 M
7	Arsenic (mg/kg)	104	85	82	0.7	17	4.7	4.1	8.6	0.7	17	5.1	4.7	9 U
7	Naphthalene (ug/kg)	113	90	80	0.5 G	5100000	75035	350	140000	0.5 G	5100000	60456	280	130000
7	Acenaphthene (ug/kg)	113	89	79	17	1600000	36588	750	90000	5 UG	1600000	28841	380	86200
7	Fluorene (ug/kg)	113	89	79	17	800000	23763	750	94000	5 UG	800000	18731	330 U	56400
7	Cyanide (mg/kg)	9	7	78	0.3 J	2.2	1.1	0.6	1.5	0.2 U	2.2	0.9	0.5	1.5
7	1,2,3,7,8-Pentachlorodibenzofuran (ng/kg)	17	13	76	1.6 J	86	22	13	40	1.6 J	86	18	6.2	40
7	Benzo(g,h,i)perylene (ug/kg)	112	85	76	0.6 G	820000	15400	600	31000	0.6 G	820000	12234	600	26000
7	Vanadium (mg/l)	4	3	75	0.003	0.01	0.01	0.003	0.003	0.003 U	0.01	0.005	0.003	0.003
7	Indeno(1,2,3-cd)pyrene (ug/kg)	113	84	74	11	530000	11190	740	24000	5 UG	530000	8859	560	22000

Table 4-5. Historical Surface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detected	Detected Concentrations Minimum	Maximum	Mean	Median	95th	Detected and Nondetected Concentrations Minimum	Maximum	Mean	Median	95th
7	Selenium (mg/kg)	30	22	73	9	17	13	13	17	0.31 UJ	17	9.87	12	17
7	1,2,3,4,7,8,9-Heptachlorodibenzofuran (ng/kg)	17	12	71	5	100 M	20	9	33	1.6 U	100 M	15	5.6	33
7	2,3,7,8-Tetrachlorodibenzofuran (ng/kg)	17	12	71	1.7 J	20 M	12	10	20	1 U	20 M	9.0	6 J	20
7	4,4'-DDE (ug/kg)	36	25	69	2.4 J	100	9.464	5 H	10	0.54 U	100	16	5 H	96 U
7	2-Methylnaphthalene (ug/kg)	51	34	67	1 G	220000 J	9386	170	18000	1 G	220000 J	6330	130	11000
7	Tetrachlorodibenzofuran (ng/kg)	9	6	67	1.4	91	36.4	20	70	1 U	91	25	1.4	70
7	m,p-Xylene (ug/kg)	9	6	67	0.05 J	0.64	0.17	0.08 J	0.1 J	0.02 U	0.64	0.12	0.05 J	0.1 J
7	o-Xylene (ug/kg)	9	6	67	0.03 J	0.87	0.22	0.07 J	0.21	0.008 U	0.87	0.15	0.03 J	0.21
7	Tetrachlorophenol (ug/kg)	3	2	67	9	13	11	9	9	5 U	13	9	5 U	9
7	Butyltin ion (ug/kg)	26	17	65	6 G	52 J	18	12 G	39 G	5.6 U	52 J	14	11 G	26 G
7	Dibutyltin ion (ug/kg)	26	17	65	11 G	120 G	44	36 G	80 G	5.6 U	120 G	31	26 G	60 G
7	1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin (ng/kg	17	11	65	1 J	73	21	6.8	65 JM	1 J	73	14	4.9 U	65 JM
7	2,3,4,7,8-Pentachlorodibenzofuran (ng/kg)	17	11	65	1.9	45 M	17	12	34	1.9	45 M	13	7.2	34
7	Chromium hexavalent (mg/kg)	23	14	61	0.07 G	0.86 G	0.35	0.17 G	0.82 G	0.07 G	0.86 G	0.25	0.13 UG	0.75 G
7	Dibenzofuran (ug/kg)	54	32	59	20	73000	3315	120	3700	5 UG	73000	2217	92	3700
7	2,3,4,6,7,8-Hexachlorodibenzofuran (ng/kg)	17	10	59	3.6	38	15	7 J	35 JM	0.77 U	38	10	4.9 U	35 JM
7	Acenaphthylene (ug/kg)	113	63	56	7.1	190000	6197	160	6700	5 UG	190000	3678	100 U	6000 J
7	Dibenz(a,h)anthracene (ug/kg)	113	63	56	11.7	98000	2665	230	6400	5 UG	98000	2131	200 U	9100 G
7	Tetrachlorodibenzo-p-dioxin (ng/kg)	9	5	56	5	66	24	11	22	1 U	66	14	1 U	22
7	Bis(2-ethylhexyl) phthalate (ug/kg)	52	28	54	76	1100 J	400	340	700	15 U	10000 U	642	300 U	1000
7	2,4-D (ug/kg)	8	4	50	9	93	37	21	24	2.8 U	250 U	68	24	120 U
7	2,4-DB (ug/kg)	8	4	50	13	130	46	19	23	4.2 U	1000 U	224	23	500 U
7	Carbazole (ug/kg)	48	23	48	21 J	8400 J	1647	190	5500	19 U	8400 J	1238	130 UJ	5700 UJ
7	1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin (ng/kg	17	8	47	2.2	33	11	3.7	25 M	0.4 U	33	7.2	3.7	25 M
7	1,2,3,6,7,8-Hexachlorodibenzofuran (ng/kg)	17	8	47	5.5	65	21	10	45 JM	2.6 U	65	17	9.6 U	54 UJ
7	1,2,3,7,8,9-Hexachlorodibenzofuran (ng/kg)	17	8	47	3.3	24	11	7.2	20 JM	0.3 U	24	6.8	4.9 U	20 JM
7	1,2,3,7,8-Pentachlorodibenzo-p-dioxin (ng/kg)	17	8	47	1.3	18	6.7875	3	14 JM	0.44 U	18	4.9	3 U	14 JM
7	2,3,7,8-Tetrachlorodibenzo-p-dioxin (ng/kg)	17	8	47	0.51	6 M	2.27875	1.5	3.4	0.24 U	6 M	1.8	1 U	3.4
7	4-Methylphenol (ug/kg)	48	21	44	31	570	252	200	500	20 U	10000 U	567	130	900 U
7	Diesel fuels (mg/kg)	8	3	38	50 G	50 G	50	50 G	50 G	50 U	50 G	50	50 U	50 G
7	Lube Oil (mg/kg)	8	3	38	100 G	100 G	100	100 G	100 G	100 U	100 G	100	100 U	100 G
7	Antimony (mg/kg)	14	5	36	0.02 G	12 J	6.204	5.3 J	7.5 J	0.02 G	12 J	5.79	5.3 J	10 UG
7	Thallium (mg/kg)	30	10	33	0.78	8	4.241	5	8	0.5 U	10 U	4.997	5 U	9 U
7	Pentachlorodibenzo-p-dioxin (ng/kg)	9	3	33	5.6	80	37	5.6	24	1 U	80	14	4.8 U	24
7	Disulfoton (ug/kg)	3	1	33	56	56	56	56	56	50 U	56	52	50 U	50 U
7	Ethylbenzene (ug/kg)	23	7	30	0.06 J	10000	1429	0.09 J	2	0.009 U	10000	540	1 U	300 U
7	Tributyltin ion (ug/l)	8	2	25	0.18 J	0.42	0.3	0.18 J	0.18 J	0.02 U	0.42	0.09	0.02 UG	0.18 J
7	Silver (mg/l)	4	1	25	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002 U	0.0002	0.0002	0.0002 U	0.0002 U
7	Benzene (ug/kg)	23	5	22	0.05 J	22000	4401	0.36	1.4	0.01 U	22000	1062	1.3	300 U
7	Chlorobenzene (ug/kg)	6	1	17	4.6	4.6	4.6	4.6	4.6	2.5 U	15 U	5.6	4 U	5 U
7	Natural gasoline (mg/kg)	9	1	11	300	300	300	300	300	10 U	300	50	20 U	20 U
7	Pentachlorophenol (ug/kg)	91	8	9	16	860	218	26	480 J	16	30500 U	1326	240	4400 UJ
7	Toluene (ug/kg)	23	2	9	0.08 J	4200	2100	0.08 J	0.08 J	0.02 U	4200	288	1 U	300 U
7	Polychlorinated biphenyls (ug/kg)	35	3	9	13 A	54 J	39	13 A	51 A	4 UJ	2000 UA	154	54 J	300 UA
7	1,2-Dichlorobenzene (ug/kg)	36	3	8	4.8	1700 J	575.6	4.8	22	1 U	1700 J	125	20 U	700 U
7	Xylene (ug/kg)	14	1	7	18000	18000	18000	18000	18000	2 U	18000	1459	300 U	300 U
7	Aroclor 1254 (ug/kg)	31	2	6	51	54 J	53	51	51	10 U	990 U	105	70 UH	200 U
7	Dibutyl phthalate (ug/kg)	52	3	6	21	34	27	21	26.3	15 U	10000 U	298	50 U	350 U

Table 4-5. Historical Surface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detected	Detected Concentrations Minimum	Maximum	Mean	Median	95th	Detected and Nondetected Concentrations Minimum	Maximum	Mean	Median	95th
7	Benzoic acid (ug/kg)	36	2	6	100 G	1200	650	100 G	100 G	100 G	50000 U	2720	200 U	6000 U
7	1,4-Dichlorobenzene (ug/kg)	36	2	6	4.8	530	267	4.8	4.8	1 U	900 U	93	20 U	530
7	Aldrin (ug/kg)	36	2	6	2.2	60	31	2.2	2.2	0.4 UJ	60	9.6	4 UH	48 U
7	2,3,4,6-Tetrachlorophenol (ug/kg)	29	1	3	24	24	24	24	24	14 U	8000 U	982	240 U	2200 U
7	Aroclor 1260 (ug/kg)	30	1	3	13	13	13	13	13	10 U	990 U	96	40 UH	200 U
7	Endrin aldehyde (ug/kg)	33	1	3	0.56 J	0.56 J	0.56	0.56 J	0.56 J	0.56 J	99 U	14	2 UJ	95 U
7	Benzyl alcohol (ug/kg)	36	1	3	15 G	15 G	15	15 G	15 G	15 G	3500 U	320	20 UJ	900 U
7	gamma-Hexachlorocyclohexane (ug/kg)	36	1	3	540	540	540	540	540	0.4 UJ	540	23	2 UH	48 U
7	Butylbenzyl phthalate (ug/kg)	52	1	2	55 G	55 G	55	55 G	55 G	15 U	10000 U	302	50 U	350 U
7	Di-n-octyl phthalate (ug/kg)	52	1	2	5510 JB	5510 JB	5510	5510 JB	5510 JB	15 U	10000 U	403	50 U	900 U
7	Hexachlorobutadiene (ug/kg)	57	0	0						19 U	16000 U	1315	120 UJ	9700 UJ
7	2,4,5-Trichlorophenol (ug/kg)	54	0	0						14 U	29000 UJ	1353	240 U	3500 U
7	2,4,6-Trichlorophenol (ug/kg)	54	0	0						5 U	8000 U	539	100 U	1800 U
7	2,4-Dichlorophenol (ug/kg)	53	0	0						56 U	31000 U	1895	240 U	5700 UJ
7	Hexachlorobenzene (ug/kg)	53	0	0						19 U	10000 U	779	59 U	5700 UJ
7	Diethyl phthalate (ug/kg)	52	0	0						13 UJ	10000 U	297	50 U	350 U
7	Dimethyl phthalate (ug/kg)	52	0	0						13 U	10000 U	297	50 U	350 U
7	Phenol (ug/kg)	51	0	0						19 U	10000 U	377	100 U	900 U
7	2,4-Dimethylphenol (ug/kg)	50	0	0						6 U	3000 U	161	59 U	300 UG
7	2-Methylphenol (ug/kg)	48	0	0						6 U	7000 U	341	100 U	900 U
7	N-Nitrosodiphenylamine (ug/kg)	36	0	0						12 UG	60000 U	1807	20 UJ	900 U
7	1,3-Dichlorobenzene (ug/kg)	36	0	0						1 U	900 U	79	20 U	200 U
7	Dieldrin (ug/kg)	36	0	0						0.4 UJ	99 U	14	2 UH	95 U
7	Heptachlor (ug/kg)	36	0	0						0.4 UJ	60 U	8.7	2 UH	48 U
7	2,4-Dinitrotoluene (ug/kg)	33	0	0						94 U	3500 U	383	100 U	980 U
7	2,6-Dinitrotoluene (ug/kg)	33	0	0						76 U	1800 U	318	99 U	980 U
7	2-Chloronaphthalene (ug/kg)	33	0	0						15 U	900 U	138	20 U	350 U
7	2-Nitroaniline (ug/kg)	33	0	0						94 U	35000 U	2045	100 U	6000 U
7	3,3'-Dichlorobenzidine (ug/kg)	33	0	0						30 U	6000 U	689	99 UJ	2000 U
7	3-Nitroaniline (ug/kg)	33	0	0						110 U	35000 U	2078	120 U	6000 U
7	4-Bromophenyl phenyl ether (ug/kg)	33	0	0						19 U	1800 U	193	20 U	900 U
7	4-Chloroaniline (ug/kg)	33	0	0						56 U	7000 U	451	60 UJ	900 U
7	4-Chlorophenyl phenyl ether (ug/kg)	33	0	0						19 U	900 U	151	20 U	700 U
7	4-Nitroaniline (ug/kg)	33	0	0						94 U	35000 U	2045	100 U	6000 U
7	Bis(2-chloroethoxy) methane (ug/kg)	33	0	0						15 U	900 U	138	20 U	350 U
7	Bis(2-chloroethyl) ether (ug/kg)	33	0	0						30 U	900 U	183	40 U	700 U
7	Hexachloroethane (ug/kg)	33	0	0						19 U	3500 U	257	20 U	900 U
7	Isophorone (ug/kg)	33	0	0						15 U	900 U	138	20 U	350 U
7	Nitrobenzene (ug/kg)	33	0	0						19 U	1800 U	193	20 U	900 U
7	N-Nitrosodipropylamine (ug/kg)	33	0	0						38 U	3500 U	288	40 U	900 U
7	1,2,4-Trichlorobenzene (ug/kg)	33	0	0						19 U	1800 U	159	20 U	330 U
7	2,4-Dinitrophenol (ug/kg)	33	0	0						23 U	6000 U	874	200 UJ	3500 U
7	2-Chlorophenol (ug/kg)	33	0	0						19 U	1900 U	169	20 U	900 U
7	2-Nitrophenol (ug/kg)	33	0	0						23 U	1800 U	292	98 U	980 U
7	4,6-Dinitro-2-methylphenol (ug/kg)	33	0	0						190 U	7000 U	1078	200 U	6000 U
7	4-Chloro-3-methylphenol (ug/kg)	33	0	0						23 U	3500 U	262	40 U	900 U
7	4-Nitrophenol (ug/kg)	33	0	0						45 U	6000 U	722	99 U	3500 U
7	alpha-Endosulfan (ug/kg)	33	0	0						0.4 UJ	60 U	9.4	2 UH	48 U

Table 4-5. Historical Surface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detected	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
7	alpha-Hexachlorocyclohexane (ug/kg)	33	0	0						0.4 UJ	60 U	9.4	2 UH	48 U
7	beta-Endosulfan (ug/kg)	33	0	0						0.4 UJ	99 U	15	2 UH	95 U
7	beta-Hexachlorocyclohexane (ug/kg)	33	0	0						0.4 UJ	60 U	11	5 UH	48 U
7	delta-Hexachlorocyclohexane (ug/kg)	33	0	0						0.4 UJ	60 U	9.4	2 UH	48 U
7	Endosulfan sulfate (ug/kg)	33	0	0						0.4 UJ	99 U	16	2 UH	95 U
7	Endrin (ug/kg)	33	0	0						0.4 UJ	99 U	15	2 UH	95 U
7	Heptachlor epoxide (ug/kg)	33	0	0						0.4 UJ	60 U	9.4	2 UH	48 U
7	Methoxychlor (ug/kg)	33	0	0						0.8 UJ	500 U	80	20 UH	480 U
7	Toxaphene (ug/kg)	33	0	0						17 UJ	12000 U	981	180 U	4800 U
7	Aroclor 1016 (ug/kg)	30	0	0						10 U	990 U	87	40 UH	200 U
7	Aroclor 1242 (ug/kg)	30	0	0						10 U	990 U	91	40 UH	200 U
7	Aroclor 1248 (ug/kg)	30	0	0						10 U	990 U	91	40 UH	200 U
7	Aroclor 1221 (ug/kg)	29	0	0						10 U	2000 U	175	40 UH	300 UH
7	Aroclor 1232 (ug/kg)	29	0	0						10 U	990 U	98	40 UH	200 U
7	Hexachlorocyclopentadiene (ug/kg)	29	0	0						76 U	1000 U	288	99 UJ	970 U
7	2,6-Dichlorophenol (ug/kg)	28	0	0						130 U	31000 UJ	3545	550 U	16000 U
7	2,3,4,5-Tetrachlorophenol (ug/kg)	26	0	0						14 U	8000 U	911	220 U	2200 U
7	Anthanthrene (ug/kg)	25	0	0						68 U	16000 UJ	2463	310 U	9700 UJ
7	Bis(2-chloro-1-methylethyl) ether (ug/kg)	25	0	0						19 UJ	330 U	81	20 UJ	330 U
7	Chlordane (cis & trans) (ug/kg)	21	0	0						10 U	1000 U	106	70 UH	80 U
7	alpha-Chlordane (ug/kg)	15	0	0						0.45 U	50 U	12	1 UJ	48 U
7	Endrin ketone (ug/kg)	15	0	0						0.45 U	99 U	26	4 UIJ	96 U
7	gamma-Chlordane (ug/kg)	15	0	0						0.45 U	50 U	12	1.7 U	48 U
7	Tetrabutyltin (ug/kg)	10	0	0						5.6 U	6 U	5.85	5.9 U	6 U
7	Bis(2-chloroisopropyl) ether (ug/kg)	8	0	0						300 U	7000 U	1349	480 U	900 U
7	2,4,5-T (ug/kg)	8	0	0						2.8 U	50 U	12	3.4 U	25 U
7	Dalapon (ug/kg)	8	0	0						27 U	1000 U	219	32 U	500 U
7	Dicamba (ug/kg)	8	0	0						2.8 U	100 U	22	3.4 U	50 U
7	Dichloroprop (ug/kg)	8	0	0						7.8 U	250 U	57	15 U	120 U
7	Dinoseb (ug/kg)	8	0	0						4.2 UJ	250 U	52	5.1 UJ	120 U
7	MCPA (ug/kg)	8	0	0						140 U	50000 U	10100	170 U	25000 U
7	MCPP (ug/kg)	8	0	0						140 U	50000 U	10100	170 U	25000 U
7	Silvex (ug/kg)	8	0	0						2.8 U	50 U	12	3.4 U	25 U
7	Aniline (ug/kg)	6	0	0						330 U	3000 U	1332	330 U	3000 U
7	N-Nitrosodimethylamine (ug/kg)	6	0	0						330 U	6000 U	2498	330 U	6000 U
7	1,1,1-Trichloroethane (ug/kg)	5	0	0						1 U	15 U	4.6	1 U	5 U
7	1,1,2,2-Tetrachloroethane (ug/kg)	5	0	0						2 U	15 U	5.2	2 U	5 U
7	1,1,2-Trichloroethane (ug/kg)	5	0	0						2 U	15 U	5.2	2 U	5 U
7	1,1-Dichloroethane (ug/kg)	5	0	0						1 U	15 U	4.6	1 U	5 U
7	1,2-Dichloroethane (ug/kg)	5	0	0						2 U	15 U	5.2	2 U	5 U
7	1,2-Dichloropropane (ug/kg)	5	0	0						2 U	15 U	5.2	2 U	5 U
7	Bromodichloromethane (ug/kg)	5	0	0						2 U	15 U	5.2	2 U	5 U
7	Bromoform (ug/kg)	5	0	0						5 U	15 U	10	10 U	10 U
7	Bromomethane (ug/kg)	5	0	0						5 U	15 U	10	10 U	10 U
7	Carbon tetrachloride (ug/kg)	5	0	0						1 U	15 U	4.6	1 U	5 U
7	Chlorodibromomethane (ug/kg)	5	0	0						2 U	15 U	5.2	2 U	5 U
7	Chloroethane (ug/kg)	5	0	0						5 U	15 U	10	10 U	10 U
7	Chloroform (ug/kg)	5	0	0						1 U	15 U	4.6	1 U	5 U

Table 4-5. Historical Surface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detected	Detected Concentrations Minimum	Maximum	Mean	Median	95th	Detected and Nondetected Concentrations Minimum	Maximum	Mean	Median	95th
7	Chloromethane (ug/kg)	5	0	0						5 U	15 U	10	10 U	10 U
7	cis-1,3-Dichloropropene (ug/kg)	5	0	0						4 U	15 U	6.4	4 U	5 U
7	Dichlorodifluoromethane (ug/kg)	5	0	0						5 U	20 U	16	15 U	20 U
7	Ethylene dibromide (ug/kg)	5	0	0						4 U	60 U	18.4	4 U	20 U
7	Methylene chloride (ug/kg)	5	0	0						10 U	30 U	14	10 U	10 U
7	Tetrachloroethene (ug/kg)	5	0	0						1 U	15 U	4.6	1 U	5 U
7	trans-1,3-Dichloropropene (ug/kg)	5	0	0						2 U	15 U	5.2	2 U	5 U
7	Trichloroethene (ug/kg)	5	0	0						1 U	15 U	4.6	1 U	5 U
7	Trichlorofluoromethane (ug/kg)	5	0	0						5 U	20 U	16	15 U	20 U
7	Vinyl chloride (ug/kg)	5	0	0						2 U	15 U	5.2	2 U	5 U
7	Vinylidene chloride (ug/kg)	5	0	0						1 U	15 U	4.6	1 U	5 U
7	Antimony (mg/l)	4	0	0						0.05 U	0.05 U	0.05	0.05 U	0.05 U
7	Beryllium (mg/l)	4	0	0						0.001 U	0.001 U	0.001	0.001 U	0.001 U
7	Cadmium (mg/l)	4	0	0						0.002 U	0.002 U	0.002	0.002 U	0.002 U
7	Chromium (mg/l)	4	0	0						0.005 U	0.005 U	0.005	0.005 U	0.005 U
7	Dibutyltin ion (ug/l)	4	0	0						0.06 U	0.06 U	0.06	0.06 U	0.06 U
7	Mercury (mg/l)	4	0	0						0.0001 U	0.0001 U	0.0001	0.0001 U	0.0001 U
7	Nickel (mg/l)	4	0	0						0.01 U	0.01 U	0.01	0.01 U	0.01 U
7	Selenium (mg/l)	4	0	0						0.001 U	0.001 U	0.001	0.001 U	0.001 U
7	Tetrabutyltin (ug/l)	4	0	0						0.02 U	0.02 U	0.02	0.02 U	0.02 U
7	Thallium (mg/l)	4	0	0						0.001 U	0.001 U	0.001	0.001 U	0.001 U
7	1,2-Diphenylhydrazine (ug/kg)	3	0	0						1600 U	1600 U	1600	1600 U	1600 U
7	1-Chloronaphthalene (ug/kg)	3	0	0						330 U	330 U	330	330 U	330 U
7	1-Naphthylamine (ug/kg)	3	0	0						330 U	330 U	330	330 U	330 U
7	2-Methylpyridine (ug/kg)	3	0	0						330 U	330 U	330	330 U	330 U
7	2-Naphthylamine (ug/kg)	3	0	0						330 U	330 U	330	330 U	330 U
7	3-Methylcholanthrene (ug/kg)	3	0	0						330 U	330 U	330	330 U	330 U
7	4-Aminobiphenyl (ug/kg)	3	0	0						330 U	330 U	330	330 U	330 U
7	7,12-Dimethylbenz(a)anthracene (ug/kg)	3	0	0						330 U	330 U	330	330 U	330 U
7	Acetophenone (ug/kg)	3	0	0						330 U	330 U	330	330 U	330 U
7	alpha,alpha-Dimethylphenethylamine (ug/kg)	3	0	0						330 U	330 U	330	330 U	330 U
7	Benzidine (ug/kg)	3	0	0						1600 U	1600 U	1600	1600 U	1600 U
7	Diphenylamine (ug/kg)	3	0	0						330 U	330 U	330	330 U	330 U
7	Ethyl methanesulfonate (ug/kg)	3	0	0						330 U	330 U	330	330 U	330 U
7	Methyl methanesulfonate (ug/kg)	3	0	0						330 U	330 U	330	330 U	330 U
7	N-Nitrosodibutylamine (ug/kg)	3	0	0						330 U	330 U	330	330 U	330 U
7	N-Nitrosopiperidine (ug/kg)	3	0	0						330 U	330 U	330	330 U	330 U
7	p-Dimethylaminoazobenzene (ug/kg)	3	0	0						330 U	330 U	330	330 U	330 U
7	Pentachloronitrobenzene (ug/kg)	3	0	0						1600 U	1600 U	1600	1600 U	1600 U
7	Phenacetin (ug/kg)	3	0	0						330 U	330 U	330	330 U	330 U
7	Pronamide (ug/kg)	3	0	0						330 U	330 U	330	330 U	330 U
7	1,1,2-Trichloro-1,2,2-trifluoroethane (ug/kg)	3	0	0						10 U	10 U	10	10 U	10 U
7	1,2,4,5-Tetrachlorobenzene (ug/kg)	3	0	0						330 U	330 U	330	330 U	330 U
7	1,2-Dichloroethene (ug/kg)	3	0	0						1 U	1 U	1	1 U	1 U
7	2,4-Dichloro-6-methylphenol (ug/kg)	3	0	0						200 U	570 U	333	200 U	230 U
7	2-Chloroethyl vinyl ether (ug/kg)	3	0	0						10 U	10 U	10	10 U	10 U
7	4-Chloro-o-cresol (ug/kg)	3	0	0						82 U	230 U	135	82 U	92 U
7	4-Chlorophenol (ug/kg)	3	0	0						330 U	910 U	537	330 U	370 U

Table 4-5. Historical Surface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detected	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
7	Azinphosmethyl (ug/kg)	3	0	0						50 U	50 U	50	50 U	50 U
7	Bromoxynil (ug/kg)	3	0	0						25 U	250 U	132	25 U	120 U
7	Chlorpyrifos (ug/kg)	3	0	0						50 U	50 U	50	50 U	50 U
7	Coumaphos (ug/kg)	3	0	0						50 U	50 U	50	50 U	50 U
7	Cresol (ug/kg)	3	0	0						41 U	110 U	66	41 U	46 U
7	Demeton (ug/kg)	3	0	0						50 U	50 U	50	50 U	50 U
7	Diazinon (ug/kg)	3	0	0						50 U	50 U	50	50 U	50 U
7	Dichlorvos (ug/kg)	3	0	0						50 U	50 U	50	50 U	50 U
7	Ethoprop (ug/kg)	3	0	0						50 U	50 U	50	50 U	50 U
7	Fensulfothion (ug/kg)	3	0	0						50 U	50 U	50	50 U	50 U
7	Fenthion (ug/kg)	3	0	0						50 U	50 U	50	50 U	50 U
7	Malathion (ug/kg)	3	0	0						50 U	50 U	50	50 U	50 U
7	Merphos (ug/kg)	3	0	0						50 U	50 U	50	50 U	50 U
7	Methyl parathion (ug/kg)	3	0	0						50 U	50 U	50	50 U	50 U
7	Mevinphos (ug/kg)	3	0	0						50 U	50 U	50	50 U	50 U
7	Naled (ug/kg)	3	0	0						50 U	50 U	50	50 U	50 U
7	Pentachlorobenzene (ug/kg)	3	0	0						330 U	330 U	330	330 U	330 U
7	Perthane (ug/kg)	3	0	0						100 U	100 U	100	100 U	100 U
7	Phorate (ug/kg)	3	0	0						50 U	50 U	50	50 U	50 U
7	Prothiophos (ug/kg)	3	0	0						50 U	50 U	50	50 U	50 U
7	Ronnel (ug/kg)	3	0	0						50 U	50 U	50	50 U	50 U
7	Stirofos (ug/kg)	3	0	0						50 U	50 U	50	50 U	50 U
7	Sulprofos (ug/kg)	3	0	0						50 U	50 U	50	50 U	50 U
7	Tetraethyl pyrophosphate (ug/kg)	3	0	0						50 U	50 U	50	50 U	50 U
7	Trichloronate (ug/kg)	3	0	0						50 U	50 U	50	50 U	50 U
7	1,1,1,2-Tetrachloroethane (ug/kg)	2	0	0						5 U	15 U	10	5 U	5 U
7	1,1-Dichloropropene (ug/kg)	2	0	0						5 U	15 U	10	5 U	5 U
7	1,2,3-Trichlorobenzene (ug/kg)	2	0	0						20 U	60 U	40	20 U	20 U
7	1,2,3-Trichloropropane (ug/kg)	2	0	0						5 U	15 U	10	5 U	5 U
7	1,2-Dibromo-3-chloropropane (ug/kg)	2	0	0						20 U	60 U	40	20 U	20 U
7	1,3,5-Trimethylbenzene (ug/kg)	2	0	0						20 U	60 U	40	20 U	20 U
7	1,3-Dichloropropane (ug/kg)	2	0	0						5 U	15 U	10	5 U	5 U
7	2,2-Dichloropropane (ug/kg)	2	0	0						5 U	15 U	10	5 U	5 U
7	2-Chlorotoluene (ug/kg)	2	0	0						20 U	60 U	40	20 U	20 U
7	4-Chlorotoluene (ug/kg)	2	0	0						20 U	60 U	40	20 U	20 U
7	Acetone (ug/kg)	2	0	0						50 U	150 U	100	50 U	50 U
7	Bromobenzene (ug/kg)	2	0	0						5 U	15 U	10	5 U	5 U
7	Bromochloromethane (ug/kg)	2	0	0						5 U	15 U	10	5 U	5 U
7	Carbon disulfide (ug/kg)	2	0	0						5 U	15 U	10	5 U	5 U
7	cis-1,2-Dichloroethene (ug/kg)	2	0	0						5 U	15 U	10	5 U	5 U
7	Isopropylbenzene (ug/kg)	2	0	0						20 U	60 U	40	20 U	20 U
7	Methyl isobutyl ketone (ug/kg)	2	0	0						20 U	60 U	40	20 U	20 U
7	Methyl N-butyl ketone (ug/kg)	2	0	0						20 U	60 U	40	20 U	20 U
7	Methylene bromide (ug/kg)	2	0	0						5 U	15 U	10	5 U	5 U
7	Methylethyl ketone (ug/kg)	2	0	0						20 U	60 U	40	20 U	20 U
7	n-Butylbenzene (ug/kg)	2	0	0						20 U	60 U	40	20 U	20 U
7	n-Propylbenzene (ug/kg)	2	0	0						20 U	60 U	40	20 U	20 U
7	p-Cymene (ug/kg)	2	0	0						20 U	60 U	40	20 U	20 U

Table 4-5. Historical Surface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detected	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
7	Pseudocumene (ug/kg)	2	0	0						20 U	60 U	40	20 U	20 U
7	Sec-butylbenzene (ug/kg)	2	0	0						20 U	60 U	40	20 U	20 U
7	Styrene (ug/kg)	2	0	0						5 U	15 U	10	5 U	5 U
7	tert-Butylbenzene (ug/kg)	2	0	0						20 U	60 U	40	20 U	20 U
7	trans-1,2-Dichloroethene (ug/kg)	2	0	0						5 U	15 U	10	5 U	5 U
8	Total organic carbon (%)	120	120	100	0.04	5.6	1.75	1.5	3.7	0.04	5.60	1.8	1.5	3.7
8	Sand (%)	118	118	100	5.84	100	45	34	98.16	5.84	100	45	34	98.16
8	Fines (%)	114	114	100	0	93.5	52	64.4	88.5	0	93.5	52	64.4	88.5
8	Copper (mg/kg)	109	109	100	1	330	60	47	120	1	330	60	47	120
8	Chromium (mg/kg)	108	108	100	11	50.6	33	36	41	11	50.6	33	36	41
8	Gravel (%)	104	104	100	0	13.3	1.3	0.29	5.14	0	13.3	1.3	0.29	5.14
8	Zinc (mg/kg)	100	100	100	17.3 G	350	123.7	105 J	230	17.3 G	350	123.7	105 J	230
8	Silt (%)	97	97	100	0.02	85.17	54	61.13	78.84	0.02	85.17	54	61.13	78.84
8	Nickel (mg/kg)	60	60	100	16.1	38.5	27	29	32.7	16.1	38.5	27	29	32.7
8	Barium (mg/kg)	55	55	100	58.9 G	197	166	178	190	58.9 G	197	166	178	190
8	Iron (mg/kg)	49	49	100	29200	46200	41410	42500	44600	29200	46200	41410	42500	44600
8	Manganese (mg/kg)	49	49	100	277	836	631	674	770	277	836	631	674	770
8	Aluminum (mg/kg)	46	46	100	15800	45500	38128	40500	44000	15800	45500	38128	40500	44000
8	Beryllium (mg/kg)	46	46	100	0.33	0.89	0.64	0.7	0.7	0.33	0.89	0.64	0.7	0.7
8	Calcium (mg/kg)	46	46	100	4430 J	9190	7981	8370 J	8930	4430 J	9190	7981	8370 J	8930
8	Cobalt (mg/kg)	46	46	100	12.1	20 M	18	18.2	19.8	12.1	20 M	18	18.2	19.8
8	Magnesium (mg/kg)	46	46	100	3720	7860	6762	7040	7520	3720	7860	6762	7040	7520
8	Potassium (mg/kg)	46	46	100	650	1600	1258	1300	1520	650	1600	1258	1300	1520
8	Sodium (mg/kg)	46	46	100	400	21500	2026	1140 J	3960	400	21500	2026	1140 J	3960
8	Vanadium (mg/kg)	46	46	100	73.7	112	102	105	110	73.7	112	102	105	110
8	Total solids (%)	40	40	100	10.9	98.3	55	50.6	93.6	10.9	98.3	55	50.6	93.6
8	Titanium (mg/kg)	24	24	100	1300	3450	2067	2020	2190	1300	3450	2067	2020	2190
8	1,2,3,4,6,7,8-Heptachlorodibenzofuran (ng/kg)	11	11	100	8.3	7600 J	951	80	1800 J	8.3	7600 J	951	80	1800 J
8	1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin (ng/	11	11	100	40	77000 J	9746	880	18000	40	77000 J	9746	880	18000
8	Octachlorodibenzofuran (ng/kg)	11	11	100	38	32000 J	3517	170	4800 J	38	32000 J	3517	170	4800 J
8	Octachlorodibenzo-p-dioxin (ng/kg)	11	11	100	350	220000 J	35895	5800	93000 J	350	220000 J	35895	5800	93000 J
8	Total volatile solids (%)	11	11	100	2.5	7.71	6.13	6.3	7.6	2.5	7.71	6.13	6.3	7.6
8	Arsenic (mg/l)	6	6	100	0.001	0.003	0.002	0.002	0.002	0.001	0.003	0.002	0.002	0.002
8	Barium (mg/l)	6	6	100	0.05	0.12	0.09	0.1	0.11	0.05	0.12	0.09	0.1	0.11
8	Calcium (mg/l)	6	6	100	48.5	115	88.7	94.2	107	48.5	115	89	94.2	107
8	Cobalt (mg/l)	6	6	100	0.006	0.01	0.009	0.01	0.01	0.006	0.01	0.009	0.01	0.01
8	Heptachlorodibenzofuran (ng/kg)	6	6	100	33	1400	464	330	440	33	1400	464	330	440
8	Heptachlorodibenzo-p-dioxin (ng/kg)	6	6	100	83	11000	3191	1600	2900	83	11000	3191	1600	2900
8	Hexachlorodibenzofuran (ng/kg)	6	6	100	5.2	1800	456	210	300	5.2	1800	456	210	300
8	Hexachlorodibenzo-p-dioxin (ng/kg)	6	6	100	5.2	2000	549	280	560	5.2	2000	549	280	560
8	Iron (mg/l)	6	6	100	4.18	12.1	8.11	5.11	11.5	4.18	12.1	8.11	5.11	11.5
8	Magnesium (mg/l)	6	6	100	16.3	40.3	31	32.4	37.8	16.3	40.3	31	32.4	37.8
8	Manganese (mg/l)	6	6	100	3.85	12.9	9.77	10.3	12.4	3.85	12.9	9.77	10.3	12.4
8	Pentachlorodibenzofuran (ng/kg)	6	6	100	8.6	100	35	14	49	8.6	100	35	14	49
8	Potassium (mg/l)	6	6	100	2	3.9	3.3	3.5	3.6	2	3.9	3.3	3.5	3.6
8	Sodium (mg/l)	6	6	100	10.4	18.9	14	13	14.7	10.4	18.9	14	13	14.7
8	Zinc (mg/l)	6	6	100	0.005	0.01	0.007	0.007	0.008	0.005	0.01	0.007	0.007	0.008
8	Ammonia (mg/l)	5	5	100	1.01	2.71	1.774	1.04	2.5	1.01	2.71	1.774	1.04	2.5

Table 4-5. Historical Surface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detected	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
8	Mean grain size (mm)	3	3	100	0.16	0.3	0.21	0.16	0.16	0.16	0.3	0.21	0.16	0.16
8	Median grain size (mm)	3	3	100	0.08	0.32	0.16	0.08	0.08	0.08	0.32	0.16	0.08	0.08
8	Tin (mg/kg)	3	3	100	0.89 X	5.37 G	3.52	0.89 X	4.29 G	0.89 X	5.37 G	3.52	0.89 X	4.29 G
8	Ammonia (mg/kg)	2	2	100	72.4	122	97	72.4	72.4	72.4	122	97	72.4	72.4
8	Dioxin/furan TCDD toxicity equivalent (ng/kg)	2	2	100	16.09 T	38.96 T	28	16.09 T	16.09 T	16.09 T	38.96 T	28	16.09 T	16.09 T
8	Total sulfides (mg/kg)	2	2	100	7	90	48.5	7	7	7	90	48.5	7	7
8	Moisture (%)	1	1	100	39	39	39	39	39	39	39	39	39	39
8	pH (pH units)	1	1	100	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4
8	Specific Gravity (Std_ Units)	1	1	100	2.75	2.75	2.75	2.75	2.75	2.75	2.75	2.75	2.75	2.75
8	Heavy oil (mg/kg)	1	1	100	96	96	96	96	96	96	96	96	96	96
8	Clay (%)	96	95	99	0.03	23.81	8.16	8.73	13.82	0.03	23.81	8.07	8.73	13.82
8	Tributyltin ion (ug/kg)	30	29	97	3	19300 H	913	180	540 J	3	19300 H	882	180	540 J
8	Cadmium (mg/kg)	70	67	96	0.08	5.79	0.75	0.4	1.89 E	0.08	5.79	0.75	0.4	1.89 E
8	High Molecular Weight PAH (ug/kg)	139	131	94	25.5 A	2169000 A	67644	621 A	230000 A	6.7 UA	2169000 A	63754	528 A	230000 A
8	Fluoranthene (ug/kg)	139	130	94	6 G	960000	29373	144	100000	6 G	960000	27475	120	100000
8	Polycyclic Aromatic Hydrocarbons (ug/kg)	139	130	94	25.5 A	8929000 A	241498	795 A	650000 A	6.7 UA	8929000 A	225864	576 A	650000 A
8	Thallium (mg/kg)	46	43	93	0.91 J	17	9.19	8	15	0.91 J	17	8.96	8	15
8	Pyrene (ug/kg)	139	129	93	6 G	610000	19138	130	61000	6 G	610000	17764	120	61000
8	Lead (mg/kg)	80	73	91	5.9	186	20	14	44	5.9	186	20.12	14.9	44
8	1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin (ng/kg	11	10	91	15	4100	547	80	540	2 U	4100	498	59	540
8	1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin (ng/kg	11	10	91	4.9	3200 J	367	27	180	1.4 U	3200 J	334	23	180
8	Chrysene (ug/kg)	139	124	89	3 G	170000	5990	110	26000	3 G	170000	5348	61	26000
8	Chromium hexavalent (mg/kg)	35	31	89	0.1 G	0.99 G	0.46	0.44 G	0.85 G	0.1 G	0.99 G	0.42	0.42 G	0.85 G
8	Aluminum (mg/l)	6	5	83	0.03	0.11	0.068	0.04	0.1	0.02 U	0.11	0.06	0.04	0.1
8	Tetrachlorodibenzofuran (ng/kg)	6	5	83	1.1	19	6.3	1.8	6.1	1 U	19	5.4	1.8	6.1
8	Low Molecular Weight PAH (ug/kg)	139	114	82	8 A	6907000 A	197661	212 A	382000 A	6.7 UA	6907000 A	162115	108 A	368000 A
8	Phenanthrene (ug/kg)	139	114	82	4 G	1900000 J	61589	110	160000	4 G	1900000 J	50517	67	120000
8	1,2,3,4,7,8-Hexachlorodibenzofuran (ng/kg)	11	9	82	5	1300	212	15	460	1.2 U	1300	174	13	460
8	1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin (ng/kg	11	9	82	3 J	1100	145	13	89	0.48 U	1100	119	12	89
8	2,3,4,6,7,8-Hexachlorodibenzofuran (ng/kg)	11	9	82	4.5	270	45	9.9	60	0.41 U	270	37	7.7	60
8	Benzo(b+k)fluoranthene (ug/kg)	139	113	81	6 A	170000	6925	141 A	20000 JM	6 A	170000	5674	88.4 A	19300 A
8	Benzo(e)pyrene (ug/kg)	31	25	81	110	50000	9196	1100	46000	78 U	50000	7479	730	46000
8	Mercury (mg/kg)	70	56	80	0.02	0.26	0.07	0.06	0.13	0.02	0.26	0.07	0.06	0.12 U
8	Benzo(b)fluoranthene (ug/kg)	105	83	79	3 G	11000	231	44	260	3 G	11000	190	33	260
8	Selenium (mg/kg)	55	43	78	8	18	13	13	16	0.37 UJ	18	9.90	11	16
8	Benz(a)anthracene (ug/kg)	139	108	78	7.6	170000	6747	97	24000	5 UG	170000	5282	44 G	12000 J
8	Benzo(a)pyrene (ug/kg)	138	107	78	3 G	58000	2052	67	9000	3 G	58000	1610	44	8500 M
8	Silver (mg/kg)	69	53	77	0.08 E	1.4	0.81	0.9	1.2	0.08 E	1.4	0.78	0.8	1.2
8	Total of 3 isomers: pp-DDT,-DDD,-DDE (ug/k	41	30	73	2.4 A	84909 A	4842	444 A	12822 A	2.4 A	84909 A	3545	22 UA	3740 A
8	1,2,3,4,7,8,9-Heptachlorodibenzofuran (ng/kg)	11	8	73	3.1	770	125	8.3	160	1.1 U	770	91	5.9	160
8	1,2,3,7,8-Pentachlorodibenzo-p-dioxin (ng/kg)	11	8	73	3.7	590	86	8.6	48	0.45 U	590	64	6.3	48
8	Benzo(k)fluoranthene (ug/kg)	105	74	70	3 G	8300 G	178	36	200	3 G	8300 G	134	24	180
8	Bis(2-ethylhexyl) phthalate (ug/kg)	78	54	69	21	88000 J	2182	240	2300 M	20 U	88000 J	1775	210	2300 M
8	4-Methylphenol (ug/kg)	62	42	68	42	1300	471	420	880	19 U	90000 U	1977	420	1100
8	Pentachlorodibenzo-p-dioxin (ng/kg)	6	4	67	6.3	210	80	22	80	0.85 U	210	54	6.3	80
8	Tetrachlorodibenzo-p-dioxin (ng/kg)	6	4	67	1.6	12	7.4	4	12	0.93 U	12	5.255	1.6	12
8	Arsenic (mg/kg)	128	85	66	1.22	18 J	5.59	4.7	11	1.22	18 J	5.44	5 U	10
8	4,4'-DDD (ug/kg)	41	25	61	1.3	11000	749	84 L	2300	1.3	11000	459	10 U	420

Table 4-5. Historical Surface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detected	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
8	4,4'-DDT (ug/kg)	41	25	61	1.6 J	81000	4927	370	10000	1.6 J	81000	3008	17	3100
8	Benzo(g,h,i)perylene (ug/kg)	135	81	60	3 G	15000	633	41	1700	3 G	21000 U	868	30	3100 G
8	Indeno(1,2,3-cd)pyrene (ug/kg)	139	80	58	2 G	19000	528	43	2100	2 G	21000 U	956	31	4700 G
8	Anthracene (ug/kg)	139	76	55	0.8 G	290000	16100	77	41000 JM	0.8 G	290000	8814	20 U	31000
8	1,2,3,7,8,9-Hexachlorodibenzofuran (ng/kg)	11	6	55	5.1	530	100	6.6	31	0.18 U	530	56	4.9 U	31
8	2,3,7,8-Tetrachlorodibenzofuran (ng/kg)	11	6	55	1.6	90	26	4.8 J	50	1 U	90	15	1.6	50
8	2,3,7,8-Tetrachlorodibenzo-p-dioxin (ng/kg)	11	6	55	0.84	100	18	1.2	4	0.31 U	100	11	1.1	4
8	4,4'-DDE (ug/kg)	41	22	54	0.7	1480	152	26	509	0.7	1480	101	16 U	220
8	Diesel fuels (mg/kg)	2	1	50	50 G	50 G	50	50 G	50 G	50 U	50 G	50	50 U	50 U
8	Fluorene (ug/kg)	139	66	47	0.5 G	1100000 J	60515	91	96000	0.5 G	1100000 J	28748	20 U	68000
8	Naphthalene (ug/kg)	139	66	47	1 G	2500000 J	87731	61	65000 J	1 G	2500000 J	41670	20 U	15000
8	Acenaphthene (ug/kg)	139	64	46	7	1300000 J	69510	107	100000 JM	5 UG	1300000 J	32020	20 U	69000
8	1,2,3,6,7,8-Hexachlorodibenzofuran (ng/kg)	11	5	45	2	350	92	2.9	100	1.9 U	350	53	6.9	100
8	Tributyltin ion (ug/l)	16	7	44	0.01 J	0.27	0.09	0.02 J	0.14	0.01 J	0.27	0.051875	0.02 U	0.14
8	Acid Volatile Sulfides (mg/kg)	8	3	38	0.8	11.4	4.6	0.8	1.5	0.8	11.4	2.775	1.7 U	1.7 U
8	2,3,4,7,8-Pentachlorodibenzofuran (ng/kg)	11	4	36	7.6	290	109	9	130	0.65 U	290	46	4.9 U	130
8	Vanadium (mg/l)	6	2	33	0.003	0.003	0.003	0.003	0.003	0.003 U	0.003	0.003	0.003 U	0.003
8	Dibutyltin ion (ug/kg)	29	9	31	2	692 GH	85	3	33	2	692 GH	30	5.8 U	15 J
8	Chlorobenzene (ug/kg)	13	4	31	11	34000	8598	130	250	2.5 U	34000	2649	5 U	250
8	Acenaphthylene (ug/kg)	139	35	25	0.7 G	17000	1744	86	15000	0.7 G	17000	499	19 U	1800 M
8	Carbazole (ug/kg)	87	21	24	13	44000	6492	230	35000	10 U	44000	1811	20 U	4500 U
8	Antimony (mg/kg)	54	13	24	0.02 G	8 J	5.62	6.3	8 J	0.02 UG	8 J	4.73	5 UJ	7 J
8	Dibenz(a,h)anthracene (ug/kg)	139	30	22	0.7 G	4100	313	29.5	870 M	0.7 G	22000 U	890	19 U	4100
8	Dibutyl phthalate (ug/kg)	77	16	21	10	640	82	23	180	10 U	4500 U	221	20 U	1000 UG
8	Dibenzofuran (ug/kg)	80	16	20	3 G	620000	55081	35	260000 J	3 G	620000	11092	20 U	500 UG
8	1,2,3,7,8-Pentachlorodibenzofuran (ng/kg)	11	2	18	100	200	150	100	100	0.97 U	200	31	4.8 U	100
8	2-Methylnaphthalene (ug/kg)	78	14	18	1 G	1300000	123596	24	430000 J	1 G	1300000	22261	19 U	500 UG
8	Lead (mg/l)	6	1	17	0.002	0.002	0.002	0.002	0.002	0.001 U	0.002	0.001	0.001 U	0.001 U
8	Nickel (mg/l)	6	1	17	0.01	0.01	0.01	0.01	0.01	0.01 U	0.01	0.01	0.01 U	0.01 U
8	Butylbenzyl phthalate (ug/kg)	78	12	15	15	120	42	25	82	10 U	4500 UJ	149	20 U	500 UG
8	Aroclor 1254 (ug/kg)	29	4	14	22	200	69	26	27	10 U	2000 U	174	20 U	980 U
8	Polychlorinated biphenyls (ug/kg)	32	4	13	26 A	200 A	97	63 A	97 A	7.8 U	4000 UA	314	39 UA	2000 UA
8	Tetrabutyltin (ug/kg)	28	3	11	3	7.9	4.6	3	3	1 U	7.9	5.1	5.8 U	5.9 U
8	Di-n-octyl phthalate (ug/kg)	78	8	10	25	10100 B	1318	58	110	10 U	10100 B	281	20 U	500 UG
8	Pentachlorophenol (ug/kg)	116	11	9	68	7200 J	1411	680	1700	18 UJ	22000 U	858	99 U	2400 UG
8	Aroclor 1242 (ug/kg)	29	2	7	5	6	5.5	5	5	5	2000 U	166	20 U	980 U
8	Aroclor 1260 (ug/kg)	29	2	7	30	70	50	30	30	10 U	2000 U	171	20 U	980 U
8	Xylene (ug/kg)	17	1	6	23	23	23	23	23	2 U	300 U	79	50 U	300 U
8	Hexachloroethane (ug/kg)	67	3	4	38	1600	562	38	49	19 U	45000 UJ	929	20 U	1000 UG
8	Butyltin ion (ug/kg)	29	1	3	2 G	2 G	2	2 G	2 G	1 UG	11.8 UH	5.0	5.8 U	5.9 U
8	1,2,4-Trichlorobenzene (ug/kg)	67	2	3	10	190	100	10	10	10 U	22000 UJ	455	19 U	500 UG
8	Benzyl alcohol (ug/kg)	69	2	3	6 G	9	7.5	6 G	6 G	6 G	45000 U	813	20 U	500 UG
8	Diethyl phthalate (ug/kg)	78	2	3	23.5 J	26.5 J	25	23.5 J	23.5 J	10 U	4500 U	144	19 U	500 UG
8	Endosulfan sulfate (ug/kg)	39	1	3	240	240	240	240	240	0.78 U	240	38	10 U	200 U
8	Endrin aldehyde (ug/kg)	39	1	3	215	215	215	215	215	1.6 U	215	38	10 U	200 U
8	Aldrin (ug/kg)	41	1	2	0.2 J	0.2 J	0.2	0.2 J	0.2 J	0.2 J	200 U	25	9.9 U	97 U
8	Dieldrin (ug/kg)	41	1	2	0.4	0.4	0.4	0.4	0.4	0.4	235 U	40	10 U	200 U
8	Hexachlorobenzene (ug/kg)	97	2	2	19 J	340	179.5	19 J	19 J	10 U	9000 U	546	20 U	3400 U

Table 4-5. Historical Surface Sediment and Porewater Chemical Data Summary by River Mile.

River			N	%	Detected Concentrations					Detected and Nondetected Concentrations				
Mile	Analyte	N	Detected	Detected	Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
8	Hexachlorobutadiene (ug/kg)	99	2	2	200	270	235	200	200	10 U	22000 UJ	1292	20 U	8500 UJ
8	Benzoic acid (ug/kg)	66	1	2	2100	2100	2100	2100	2100	100 UG	220000 U	3965	200 U	1000 UG
8	2,6-Dinitrotoluene (ug/kg)	67	1	1	22000	22000	22000	22000	22000	10 U	22000	502	97 U	500 UG
8	4-Chloro-3-methylphenol (ug/kg)	72	1	1	45000	45000	45000	45000	45000	23 U	45000	789	39 U	500 UG
8	Dimethyl phthalate (ug/kg)	78	1	1	25	25	25	25	25	10 U	4500 U	144	19 U	500 UG
8	2,4,5-Trichlorophenol (ug/kg)	102	1	1	190 J	190 J	190	190 J	190 J	18 UJ	22000 U	792	98 U	2100 U
8	2,4,6-Trichlorophenol (ug/kg)	102	0	0						18 UJ	11000 U	445	98 U	1200 UG
8	2,4-Dichlorophenol (ug/kg)	102	0	0						56 U	45000 U	2184	100 U	9200 U
8	2,4-Dimethylphenol (ug/kg)	75	0	0						6 U	9000 U	303	20 U	1000 UG
8	Phenol (ug/kg)	75	0	0						19 U	45000 UJ	747	20 U	500 UG
8	2-Methylphenol (ug/kg)	74	0	0						6 U	90000 U	1439	20 U	500 UG
8	2-Chlorophenol (ug/kg)	72	0	0						19 U	22000 U	426	20 U	500 UG
8	4,6-Dinitro-2-methylphenol (ug/kg)	72	0	0						100 U	90000 U	1660	190 U	1000 UG
8	1,2-Dichlorobenzene (ug/kg)	70	0	0						1 U	9000 UJ	289	19 U	1000 UG
8	1,3-Dichlorobenzene (ug/kg)	70	0	0						1 U	9000 UJ	289	19 U	1000 UG
8	1,4-Dichlorobenzene (ug/kg)	70	0	0						1 U	9000 UJ	289	19 U	1000 UG
8	N-Nitrosodiphenylamine (ug/kg)	69	0	0						10 U	9000 U	231	19 UJ	500 UG
8	4-Nitrophenol (ug/kg)	69	0	0						45 U	45000 U	936	99 U	1000 UG
8	2,4-Dinitrotoluene (ug/kg)	67	0	0						20 U	45000 U	881	97 U	500 UG
8	2-Chloronaphthalene (ug/kg)	67	0	0						5 U	4500 U	162	19 U	500 UG
8	2-Nitroaniline (ug/kg)	67	0	0						10 U	450000 U	7558	97 UJ	1200 UG
8	3-Nitroaniline (ug/kg)	67	0	0						110 U	450000 U	7676	120 U	1600 U
8	4-Bromophenyl phenyl ether (ug/kg)	67	0	0						10 U	22000 U	452	19 U	500 UG
8	4-Chloroaniline (ug/kg)	67	0	0						50 U	90000 U	1813	58 UJ	2000 UG
8	4-Chlorophenyl phenyl ether (ug/kg)	67	0	0						10 U	9000 U	237	19 U	500 UG
8	4-Nitroaniline (ug/kg)	67	0	0						10 U	450000 U	7558	97 UJ	1200 UG
8	Bis(2-chloroethoxy) methane (ug/kg)	67	0	0						10 U	4500 U	163	19 U	500 UG
8	Bis(2-chloroethyl) ether (ug/kg)	67	0	0						10 U	9000 UJ	250	39 U	500 UG
8	Isophorone (ug/kg)	67	0	0						10 UG	4500 U	163	19 U	500 UG
8	Nitrobenzene (ug/kg)	67	0	0						10 U	22000 UJ	452	19 U	500 UG
8	N-Nitrosodipropylamine (ug/kg)	67	0	0						10 U	45000 U	842	39 U	500 UG
8	3,3'-Dichlorobenzidine (ug/kg)	66	0	0						40 U	9000 UJ	371	97 UJ	1000 UG
8	Bis(2-chloro-1-methylethyl) ether (ug/kg)	64	0	0						10 U	1200 UG	94	19 UJ	500 UG
8	2,4-Dinitrophenol (ug/kg)	61	0	0						23 U	45000 UJ	1233	200 UJ	2000 UG
8	2-Nitrophenol (ug/kg)	60	0	0						23 U	22000 U	557	98 U	500 UG
8	Hexachlorocyclopentadiene (ug/kg)	55	0	0						94 U	2400 UG	264	98 U	1000 UG
8	gamma-Hexachlorocyclohexane (ug/kg)	41	0	0						0.78 U	200 U	24	9.9 U	97 U
8	Heptachlor (ug/kg)	41	0	0						0.78 U	200 U	24	9.9 U	97 U
8	beta-Endosulfan (ug/kg)	39	0	0						0.78 U	200 U	33	10 U	190 U
8	beta-Hexachlorocyclohexane (ug/kg)	39	0	0						0.78 U	600 U	36	10 U	99 U
8	delta-Hexachlorocyclohexane (ug/kg)	39	0	0						0.78 U	200 U	26	10 U	99 U
8	Endrin (ug/kg)	39	0	0						0.78 U	200 U	33	10 U	190 U
8	Heptachlor epoxide (ug/kg)	39	0	0						0.78 U	360 U	30	10 U	99 U
8	Methoxychlor (ug/kg)	39	0	0						1.6 U	990 U	138	20 U	970 U
8	Toxaphene (ug/kg)	39	0	0						30 U	9900 U	1879	300 U	9700 U
8	alpha-Endosulfan (ug/kg)	38	0	0						0.78 U	99 U	21	10 U	97 U
8	alpha-Chlordane (ug/kg)	36	0	0						0.78 U	110 U	24	10 U	99 U
8	gamma-Chlordane (ug/kg)	36	0	0						0.78 U	99 U	22	10 U	97 U

Table 4-5. Historical Surface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detected	Detected Concentrations Minimum	Maximum	Mean	Median	95th	Detected and Nondetected Concentrations Minimum	Maximum	Mean	Median	95th
8	Endrin ketone (ug/kg)	35	0	0						0.78 U	200 U	37	10 U	190 U
8	2,3,4,6-Tetrachlorophenol (ug/kg)	34	0	0						18 UJ	11000 U	1105	210 U	1900 UJ
8	2,6-Dichlorophenol (ug/kg)	34	0	0						130 U	45000 U	6288	830 U	36000 UJ
8	2,3,4,5-Tetrachlorophenol (ug/kg)	33	0	0						18 UJ	11000 U	1090	200 U	1900 UJ
8	Anthanthrene (ug/kg)	29	0	0						100 U	22000 U	3782	390 U	18000 U
8	Aroclor 1016 (ug/kg)	29	0	0						10 U	2000 U	167	20 U	980 U
8	Aroclor 1221 (ug/kg)	29	0	0						10 U	4000 U	328	39 U	2000 U
8	Aroclor 1232 (ug/kg)	29	0	0						10 U	2000 U	168	20 U	980 U
8	Aroclor 1248 (ug/kg)	29	0	0						10 U	2000 U	167	20 U	980 U
8	Ethylbenzene (ug/kg)	29	0	0						1 U	300 U	49	11 U	120 UG
8	Benzene (ug/kg)	28	0	0						1 U	300 U	50	50 U	120 UG
8	Toluene (ug/kg)	28	0	0						1 U	300 U	50	50 U	120 UG
8	alpha-Hexachlorocyclohexane (ug/kg)	27	0	0						0.78 U	200 U	28	3.35 U	99 U
8	Tetrachloroethene (ug/kg)	14	0	0						1 U	11 U	7	5 U	10 U
8	Trichloroethene (ug/kg)	14	0	0						1 U	11 U	7	5 U	10 U
8	1,1,1-Trichloroethane (ug/kg)	13	0	0						1 U	11 U	7	5 U	10 U
8	1,1,2,2-Tetrachloroethane (ug/kg)	13	0	0						2 U	11 U	7	5 U	10 U
8	1,1,2-Trichloroethane (ug/kg)	13	0	0						2 U	11 U	7	5 U	10 U
8	1,1-Dichloroethane (ug/kg)	13	0	0						1 U	11 U	7	5 U	10 U
8	1,2-Dichloroethane (ug/kg)	13	0	0						2 U	11 U	7	5 U	10 U
8	1,2-Dichloropropane (ug/kg)	13	0	0						2 U	11 U	7	5 U	10 U
8	Bromodichloromethane (ug/kg)	13	0	0						2 U	11 U	7	5 U	10 U
8	Bromoform (ug/kg)	13	0	0						5 U	11 U	8	5 U	10 U
8	Bromomethane (ug/kg)	13	0	0						5 UJ	11 U	8	5 UJ	10 UG
8	Carbon tetrachloride (ug/kg)	13	0	0						1 U	11 U	7	5 U	10 U
8	Chlorodibromomethane (ug/kg)	13	0	0						2 U	11 U	7	5 U	10 U
8	Chloroethane (ug/kg)	13	0	0						5 U	11 U	8	5 U	10 U
8	Chloroform (ug/kg)	13	0	0						1 U	11 U	7	5 U	10 U
8	Chloromethane (ug/kg)	13	0	0						5 U	11 U	8	5 UJ	10 UG
8	cis-1,3-Dichloropropene (ug/kg)	13	0	0						4 U	11 U	7	5 U	10 U
8	Dichlorodifluoromethane (ug/kg)	13	0	0						5 U	20 U	8	5 UJ	11 U
8	Ethylene dibromide (ug/kg)	13	0	0						4 U	44 U	28	20 U	42 U
8	Methylene chloride (ug/kg)	13	0	0						10 U	22 U	14	10 U	21 U
8	trans-1,3-Dichloropropene (ug/kg)	13	0	0						2 U	11 U	7	5 U	10 U
8	Trichlorofluoromethane (ug/kg)	13	0	0						5 UJ	20 U	8	5 UJ	11 U
8	Vinyl chloride (ug/kg)	13	0	0						2 U	11 U	7	5 U	10 U
8	Vinylidene chloride (ug/kg)	13	0	0						1 U	11 U	7	5 U	10 U
8	1,1,1,2-Tetrachloroethane (ug/kg)	12	0	0						5 U	11 U	7	5 U	10 U
8	1,1-Dichloropropene (ug/kg)	12	0	0						5 U	11 U	7	5 U	10 U
8	1,2,3-Trichlorobenzene (ug/kg)	12	0	0						20 U	44 U	30	20 U	42 U
8	1,2,3-Trichloropropane (ug/kg)	12	0	0						5 U	11 U	7	5 U	10 U
8	1,2-Dibromo-3-chloropropane (ug/kg)	12	0	0						20 U	44 U	30	20 U	42 U
8	1,3,5-Trimethylbenzene (ug/kg)	12	0	0						20 U	44 U	30	20 U	42 U
8	1,3-Dichloropropane (ug/kg)	12	0	0						5 U	11 U	7	5 U	10 U
8	2,2-Dichloropropane (ug/kg)	12	0	0						5 U	11 U	7	5 U	10 U
8	2-Chlorotoluene (ug/kg)	12	0	0						20 U	44 U	30	20 U	42 U
8	4-Chlorotoluene (ug/kg)	12	0	0						20 U	44 U	30	20 U	42 U
8	Bromobenzene (ug/kg)	12	0	0						5 U	11 U	7	5 U	10 U

Table 4-5. Historical Surface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detected	Detected Concentrations Minimum	Maximum	Mean	Median	95th	Detected and Nondetected Concentrations Minimum	Maximum	Mean	Median	95th
8	Bromochloromethane (ug/kg)	12	0	0						5 U	11 U	7	5 U	10 U
8	Carbon disulfide (ug/kg)	12	0	0						5 U	11 U	7	5 U	10 U
8	Chlordane (cis & trans) (ug/kg)	12	0	0						10 U	150 U	66	75 U	150 U
8	cis-1,2-Dichloroethene (ug/kg)	12	0	0						5 U	11 U	7	5 U	10 U
8	Cymene (ug/kg)	12	0	0						20 U	44 U	30	20 U	42 U
8	Hexachlorocyclohexanes (ug/kg)	12	0	0						10 U	40 U	20	10 U	40 U
8	Isopropylbenzene (ug/kg)	12	0	0						20 U	44 U	30	20 U	42 U
8	m,p-Xylene (ug/kg)	12	0	0						5 U	11 U	7	5 U	10 U
8	Methyl N-butyl ketone (ug/kg)	12	0	0						20 U	44 U	30	20 U	42 U
8	Methylene bromide (ug/kg)	12	0	0						5 U	11 U	7	5 U	10 U
8	n-Butylbenzene (ug/kg)	12	0	0						20 U	44 U	30	20 U	42 U
8	n-Propylbenzene (ug/kg)	12	0	0						20 U	44 U	30	20 U	42 U
8	o-Xylene (ug/kg)	12	0	0						5 U	11 U	7	5 U	10 U
8	Pseudocumene (ug/kg)	12	0	0						20 U	44 U	30	20 U	42 U
8	Sec-butylbenzene (ug/kg)	12	0	0						20 U	44 U	30	20 U	42 UJ
8	Styrene (ug/kg)	12	0	0						5 U	11 U	7	5 U	10 U
8	tert-Butylbenzene (ug/kg)	12	0	0						20 U	44 U	30	20 U	42 U
8	trans-1,2-Dichloroethene (ug/kg)	12	0	0						5 U	11 U	7	5 U	10 U
8	Antimony (mg/l)	6	0	0						0.05 U	0.05 U	0.05	0.05 U	0.05 U
8	Beryllium (mg/l)	6	0	0						0.001 U	0.001 U	0.001	0.001 U	0.001 U
8	Cadmium (mg/l)	6	0	0						0.002 U	0.002 U	0.002	0.002 U	0.002 U
8	Chromium (mg/l)	6	0	0						0.005 U	0.005 U	0.005	0.005 U	0.005 U
8	Copper (mg/l)	6	0	0						0.002 U	0.002 U	0.002	0.002 U	0.002 U
8	Dibutyltin ion (ug/l)	6	0	0						0.06 U	0.06 U	0.06	0.06 U	0.06 U
8	Mercury (mg/l)	6	0	0						0.0001 U	0.0001 U	0.0001	0.0001 U	0.0001 U
8	Selenium (mg/l)	6	0	0						0.001 U	0.001 U	0.001	0.001 U	0.001 U
8	Silver (mg/l)	6	0	0						0.0002 U	0.0002 U	0.0002	0.0002 U	0.0002 U
8	Tetrabutyltin (ug/l)	6	0	0						0.02 U	0.02 U	0.02	0.02 U	0.02 U
8	Thallium (mg/l)	6	0	0						0.001 U	0.001 U	0.001	0.001 U	0.001 U
8	3- and 4-Methylphenol Coelution (ug/kg)	6	0	0						200 U	200 UJ	200	200 U	200 UJ
8	2,4,5-T (ug/kg)	3	0	0						2.6 U	5 U	3.6	2.6 U	3.3 U
8	2,4-D (ug/kg)	3	0	0						2.6 U	25 U	10.3	2.6 U	3.3 U
8	2,4-DB (ug/kg)	3	0	0						3.9 U	100 U	36.3	3.9 U	5 U
8	Dalapon (ug/kg)	3	0	0						25 U	100 U	52	25 U	31 U
8	Dicamba (ug/kg)	3	0	0						2.6 U	10 U	5.3	2.6 U	3.3 U
8	Dichloroprop (ug/kg)	3	0	0						2.6 U	25 U	15	2.6 U	16 U
8	Dinoseb (ug/kg)	3	0	0						3.9 UJ	25 U	11	3.9 UJ	5 UJ
8	MCPA (ug/kg)	3	0	0						130 U	5000 U	1767	130 U	170 U
8	MCPP (ug/kg)	3	0	0						130 U	5000 U	1767	130 U	170 U
8	Silvex (ug/kg)	3	0	0						2.6 U	5 U	3.6	2.6 U	3.3 U
8	Bis(2-chloroisopropyl) ether (ug/kg)	2	0	0						7600 U	90000 U	48800	7600 U	7600 U
8	Lube Oil (mg/kg)	2	0	0						100 U	100 U	100	100 U	100 U
8	Natural gasoline (mg/kg)	2	0	0						20 U	20 U	20	20 U	20 U
8	1,2-Diphenylhydrazine (ug/kg)	1	0	0						1600 U	1600 U	1600	1600 U	1600 U
8	1-Chloronaphthalene (ug/kg)	1	0	0						330 U	330 U	330	330 U	330 U
8	1-Naphthylamine (ug/kg)	1	0	0						330 U	330 U	330	330 U	330 U
8	2-Methylpyridine (ug/kg)	1	0	0						330 U	330 U	330	330 U	330 U
8	2-Naphthylamine (ug/kg)	1	0	0						330 U	330 U	330	330 U	330 U

Table 4-5. Historical Surface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detected	Detected Concentrations Minimum	Maximum	Mean	Median	95th	Detected and Nondetected Concentrations Minimum	Maximum	Mean	Median	95th
8	3-Methylcholanthrene (ug/kg)	1	0	0						330 U	330 U	330	330 U	330 U
8	4-Aminobiphenyl (ug/kg)	1	0	0						330 U	330 U	330	330 U	330 U
8	7,12-Dimethylbenz(a)anthracene (ug/kg)	1	0	0						330 U	330 U	330	330 U	330 U
8	Acetophenone (ug/kg)	1	0	0						330 U	330 U	330	330 U	330 U
8	alpha,alpha-Dimethylphenethylamine (ug/kg)	1	0	0						330 U	330 U	330	330 U	330 U
8	Aniline (ug/kg)	1	0	0						330 U	330 U	330	330 U	330 U
8	Benzidine (ug/kg)	1	0	0						1600 U	1600 U	1600	1600 U	1600 U
8	Butyltin ion (ug/l)	1	0	0						0.06 U	0.06 U	0.06	0.06 U	0.06 U
8	Diphenylamine (ug/kg)	1	0	0						330 U	330 U	330	330 U	330 U
8	Ethyl methanesulfonate (ug/kg)	1	0	0						330 U	330 U	330	330 U	330 U
8	Methyl methanesulfonate (ug/kg)	1	0	0						330 U	330 U	330	330 U	330 U
8	N-Nitrosodibutylamine (ug/kg)	1	0	0						330 U	330 U	330	330 U	330 U
8	N-Nitrosodimethylamine (ug/kg)	1	0	0						330 U	330 U	330	330 U	330 U
8	N-Nitrosopiperidine (ug/kg)	1	0	0						330 U	330 U	330	330 U	330 U
8	p-Dimethylaminoazobenzene (ug/kg)	1	0	0						330 U	330 U	330	330 U	330 U
8	Pentachloronitrobenzene (ug/kg)	1	0	0						1600 U	1600 U	1600	1600 U	1600 U
8	Phenacetin (ug/kg)	1	0	0						330 U	330 U	330	330 U	330 U
8	Pronamide (ug/kg)	1	0	0						330 U	330 U	330	330 U	330 U
8	1,1,2-Trichloro-1,2,2-trifluoroethane (ug/kg)	1	0	0						10 U	10 U	10	10 U	10 U
8	1,2,4,5-Tetrachlorobenzene (ug/kg)	1	0	0						330 U	330 U	330	330 U	330 U
8	1,2-Dichloroethene (ug/kg)	1	0	0						1 U	1 U	1	1 U	1 U
8	2,4-Dichloro-6-methylphenol (ug/kg)	1	0	0						200 U	200 U	200	200 U	200 U
8	2-Chloroethyl vinyl ether (ug/kg)	1	0	0						10 U	10 U	10	10 U	10 U
8	4-Chloro-o-cresol (ug/kg)	1	0	0						81 U	81 U	81	81 U	81 U
8	4-Chlorophenol (ug/kg)	1	0	0						330 U	330 U	330	330 U	330 U
8	Azinphosmethyl (ug/kg)	1	0	0						50 U	50 U	50	50 U	50 U
8	Bromoxynil (ug/kg)	1	0	0						25 U	25 U	25	25 U	25 U
8	Chlorpyrifos (ug/kg)	1	0	0						50 U	50 U	50	50 U	50 U
8	Coumaphos (ug/kg)	1	0	0						50 U	50 U	50	50 U	50 U
8	Cresol (ug/kg)	1	0	0						41 U	41 U	41	41 U	41 U
8	Demeton (ug/kg)	1	0	0						50 U	50 U	50	50 U	50 U
8	Diazinon (ug/kg)	1	0	0						50 U	50 U	50	50 U	50 U
8	Dichlorvos (ug/kg)	1	0	0						50 U	50 U	50	50 U	50 U
8	Disulfoton (ug/kg)	1	0	0						50 U	50 U	50	50 U	50 U
8	Endosulfan (ug/kg)	1	0	0						9 U	9 U	9	9 U	9 U
8	Ethoprop (ug/kg)	1	0	0						50 U	50 U	50	50 U	50 U
8	Fensulfothion (ug/kg)	1	0	0						50 U	50 U	50	50 U	50 U
8	Fenthion (ug/kg)	1	0	0						50 U	50 U	50	50 U	50 U
8	Malathion (ug/kg)	1	0	0						50 U	50 U	50	50 U	50 U
8	Merphos (ug/kg)	1	0	0						50 U	50 U	50	50 U	50 U
8	Methyl parathion (ug/kg)	1	0	0						50 U	50 U	50	50 U	50 U
8	Mevinphos (ug/kg)	1	0	0						50 U	50 U	50	50 U	50 U
8	Naled (ug/kg)	1	0	0						50 U	50 U	50	50 U	50 U
8	Pentachlorobenzene (ug/kg)	1	0	0						330 U	330 U	330	330 U	330 U
8	Perthane (ug/kg)	1	0	0						100 U	100 U	100	100 U	100 U
8	Phorate (ug/kg)	1	0	0						50 U	50 U	50	50 U	50 U
8	Prothiophos (ug/kg)	1	0	0						50 U	50 U	50	50 U	50 U
8	Ronnel (ug/kg)	1	0	0						50 U	50 U	50	50 U	50 U

Table 4-5. Historical Surface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detected	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
8	Stirofos (ug/kg)	1	0	0						50 U	50 U	50	50 U	50 U
8	Sulprofos (ug/kg)	1	0	0						50 U	50 U	50	50 U	50 U
8	Tetraethyl pyrophosphate (ug/kg)	1	0	0						50 U	50 U	50	50 U	50 U
8	Trichloronate (ug/kg)	1	0	0						50 U	50 U	50	50 U	50 U
9	Chromium (mg/kg)	110	110	100	11.1	148	35	33.3	56.4	11.1	148	35	33.3	56.4
9	Copper (mg/kg)	110	110	100	15 B	2000	175	75.7 B	610	15 B	2000	175	75.7 B	610
9	Nickel (mg/kg)	110	110	100	11.4 B	594	30	24.3	31	11.4 B	594	30	24.3	31
9	Zinc (mg/kg)	110	110	100	57 B	2700 L	247	183	593	57 B	2700 L	247	183	593
9	Total organic carbon (%)	92	92	100	0.07	3.8	1.66	1.72	2.61	0.07	3.8	1.66	1.72	2.61
9	Sand (%)	88	88	100	1.67 E	94.69	28	17.91	88.2	1.67 E	94.69	28	17.91	88.2
9	Silt (%)	88	88	100	1.4	95.7	61	69.9	85.7	1.4	95.7	61	69.9	85.7
9	Clay (%)	86	86	100	0.2	36	11	9.41	21.2	0.2	36	11	9.41	21.2
9	Total solids (%)	62	62	100	27.6	92.9	49	43.8	76.13	27.6	92.9	49	43.8	76.13
9	Gravel (%)	54	54	100	0.01	23.37	1.43	0.2	4.5	0.01	23.37	1.43	0.2	4.5
9	Total volatile solids (%)	49	49	100	1.62	12.1	6.77	6.87	9.23	1.62	12.1	6.77	6.87	9.23
9	Fines (%)	46	46	100	3.78	97.6	71	80.65	96.5	3.78	97.6	71	80.65	96.5
9	Aluminum (mg/kg)	42	42	100	3560	46200	24680	31700	42100	3560	46200	24680	31700	42100
9	Iron (mg/kg)	30	30	100	31600	55600	43493	42900	53500	31600	55600	43493	42900	53500
9	Manganese (mg/kg)	30	30	100	323	1000	688	691	845	323	1000	688	691	845
9	Barium (mg/kg)	24	24	100	138	276	185	181	212	138	276	185	181	212
9	Calcium (mg/kg)	24	24	100	5960 J	14400	8643	8380 J	11400 J	5960 J	14400	8643	8380 J	11400 J
9	Cobalt (mg/kg)	24	24	100	12.5	20.6	18	18.5	19.8	12.5	20.6	18	18.5	19.8
9	Magnesium (mg/kg)	24	24	100	4090	8560	6954	7100	7760	4090	8560	6954	7100	7760
9	Potassium (mg/kg)	24	24	100	570	1520	1225	1210	1420	570	1520	1225	1210	1420
9	Sodium (mg/kg)	24	24	100	693	1170 J	1014	1030 J	1130	693	1170 J	1014	1030 J	1130
9	Vanadium (mg/kg)	24	24	100	68.6	123	103	105	119	68.6	123	103	105	119
9	Diesel fuels (mg/kg)	18	18	100	16.2 JV	777 V	210	166 V	541 V	16.2 JV	777 V	210	166 V	541 V
9	Titanium (mg/kg)	17	17	100	1120	2170	1845	1900	2160	1120	2170	1845	1900	2160
9	Acid Volatile Sulfides (umol/g)	6	6	100	0.00501 G	0.03	0.016	0.01	0.03 G	0.00501 G	0.03	0.02	0.01	0.03 G
9	Tin (mg/kg)	6	6	100	1.33 X	4.06 X	2.18	1.6 X	2.94 X	1.33 X	4.06 X	2.18	1.6 X	2.94 X
9	Aluminum (mg/l)	5	5	100	0.03	19.4	5.324	0.03	6.47	0.03	19.4	5.324	0.03	6.47
9	Arsenic (mg/l)	5	5	100	0.002	0.007	0.004	0.003	0.004	0.002	0.007	0.004	0.003	0.004
9	Barium (mg/l)	5	5	100	0.09	0.18	0.134	0.11	0.16	0.09	0.18	0.134	0.11	0.16
9	Calcium (mg/l)	5	5	100	31.6	145	96	43.2	136	31.6	145	96	43.2	136
9	Cobalt (mg/l)	5	5	100	0.006	0.02	0.011	0.008	0.01	0.006	0.02	0.011	0.008	0.01
9	Iron (mg/l)	5	5	100	13	43.4	24	13.7	24.2	13	43.4	24	13.7	24.2
9	Magnesium (mg/l)	5	5	100	15	48.4	34	17.7	46.6	15	48.4	34	17.7	46.6
9	Manganese (mg/l)	5	5	100	2.78	15.9	10	4.07	15.2	2.78	15.9	10	4.07	15.2
9	Potassium (mg/l)	5	5	100	2.9	5.1	3.82	3.1	4.4	2.9	5.1	3.82	3.1	4.4
9	Sodium (mg/l)	5	5	100	14	18.8	15	14.2	14.8	14	18.8	15	14.2	14.8
9	Zinc (mg/l)	5	5	100	0.008	0.17	0.053	0.009	0.07	0.008	0.17	0.053	0.009	0.07
9	Ammonia (mg/l)	42	41	98	0.24	6.77	1.96	1.6	3.48	0.05 U	6.77	1.92	1.6	3.48
9	Lead (mg/kg)	110	105	95	5.45 B	210 B	42	26.6	120 G	5.45 B	210 B	41	26.1	120 G
9	Fluoranthene (ug/kg)	109	103	94	23.1	3600	448	258	1400	10 U	3600	442	300	1400
9	High Molecular Weight PAH (ug/kg)	109	103	94	45 A	17268 A	1919	1089 A	5486 A	10 UA	17268 A	1833	1038 A	5486 A
9	Polycyclic Aromatic Hydrocarbons (ug/kg)	109	103	94	45 A	19735 A	2382	1325 A	7626 A	10 UA	19735 A	2270	1220 A	7626 A
9	Pyrene (ug/kg)	109	103	94	19 J	4280	414	261	1100	10 U	4280	410	300 U	1100
9	Bis(2-ethylhexyl) phthalate (ug/kg)	108	102	94	56	39200 J	2063	760	3510	56	39200 J	1964	730	3510

Table 4-5. Historical Surface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detected	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
9	Lube Oil (mg/kg)	18	17	94	125	2110	598	267	1800	3.22 U	2110	565	267	1800
9	Phenanthrene (ug/kg)	109	101	93	14	2000	288	120	1100	10 U	2000	287	128	1100
9	Low Molecular Weight PAH (ug/kg)	109	100	92	14 A	3090 A	476	201 A	2173 A	10 UA	3090 A	457	201 A	2140 A
9	Benzo(b)fluoranthene (ug/kg)	84	77	92	18.8	1150	198	108	600	10 U	1150	207	120	537
9	Tributyltin ion (ug/kg)	34	31	91	2.1	42900 H	6940	1300	27100 H	2.1	42900 H	6328	1158	27100 H
9	Cadmium (mg/kg)	110	100	91	0.06 J	2.3	0.55	0.4	1.48	0.00927 U	2.3	0.5505	0.4	1.37
9	Benzo(k)fluoranthene (ug/kg)	84	76	90	12.6	1120	144	83	390	10 U	1120	156	85	500 U
9	Silver (mg/kg)	110	98	89	0.01 J	3.3	0.51	0.36 G	1.4	0.01 J	3.3	0.60	0.4	1.9
9	Benzo(b+k)fluoranthene (ug/kg)	109	94	86	22 A	2270 A	359	234 A	900	6.72 U	2270 A	331	198.1 A	890 A
9	Chrysene (ug/kg)	109	94	86	19.8	2140	242	132	590	8.97 U	2140	232	130	570
9	Benz(a)anthracene (ug/kg)	109	92	84	11.3	1480	176	99	561	9.31 U	1480	172	93	520
9	Tributyltin ion (ug/l)	42	35	83	0.02	11	1.17	0.5 J	3.51	0.02 U	11	0.98	0.34	2.24
9	Beryllium (mg/kg)	29	24	83	0.3	0.8	0.6	0.6	0.7	0.3	1 U	0.7	0.6	1 U
9	Mercury (mg/kg)	110	90	82	0.04	1.5	0.19	0.11	0.6	0.01 U	1.5	0.17	0.1	0.54
9	Benzo(a)pyrene (ug/kg)	109	88	81	13.7	1630	181	116	499	8.97 U	1630	171	100 UJ	500 U
9	Arsenic (mg/kg)	110	88	80	2	98	8.6	5.7	18	2	98	7.95	5.59	17
9	Vanadium (mg/l)	5	4	80	0.004	0.03	0.012	0.005	0.01	0.003 U	0.03	0.010	0.004	0.01
9	Indeno(1,2,3-cd)pyrene (ug/kg)	109	84	77	10	889	118	76	300	3.56 U	889	113	59	350
9	Thallium (mg/kg)	29	22	76	6	15	10	9	12	1 U	15	8	9	12
9	Benzo(g,h,i)perylene (ug/kg)	109	81	74	11	854	109	70	256	2.52 U	854	104	49	300 UH
9	Acid Volatile Sulfides (mg/kg)	42	29	69	1.9	434 H	34	8.3	84.9	1.7 U	434 H	24	4	44.1
9	trans-Chlordane (ug/kg)	18	12	67	1.99 JP	25.3 P	9.69	7.23	19.9 P	0.99 U	25.3 P	6.82	2.3 JP	19.9 P
9	Butylbenzyl phthalate (ug/kg)	108	67	62	10	2010 J	122	56	280	10 U	2010 J	114	50 U	407
9	Anthracene (ug/kg)	109	66	61	4.97 J	1100	108	40	356	4.97 J	1100	96	24 U	429
9	Polychlorinated biphenyls (ug/kg)	90	52	58	8.79 A	2500 A	291	163.9 A	710 A	6.18 UA	2500 A	187	100 UA	610 A
9	Fluorene (ug/kg)	109	59	54	9.02 J	310	77	37	230	6.7 UJ	500 U	67	20 U	285
9	Selenium (mg/kg)	47	25	53	0.61 J	20	12	12	17	0.42 U	20	6.68	1 U	16
9	Antimony (mg/kg)	104	55	53	0.03	7 J	1.70	0.59 J	6 J	0.03	10 U	2.34	0.5 G	7 J
9	Aroclor 1254 (ug/kg)	89	47	53	11	740	151	70	460	1.88 U	740	97	52	390
9	Dibutyl phthalate (ug/kg)	108	54	50	11	350	58	36.1	136	10 U	1960 UJ	149	40	500 U
9	Xylene (ug/kg)	26	13	50	13	3200	519	54	2300	5 U	3200	271	28	430
9	Total of 3 isomers: pp-DDT,-DDD,-DDE (ug/k	43	21	49	1.03 A	178.5 A	50	11 A	153 A	0.63 UA	178.5 A	27	4 UA	124.4 A
9	Acenaphthene (ug/kg)	109	53	49	8.14	1200	83	26.7	220	6.7 U	1200	70	20 U	272
9	Aroclor 1260 (ug/kg)	90	43	48	8.79	2500	144	49.5	200	3.21 U	2500	91	27	190 U
9	Dibutyltin ion (ug/kg)	19	9	47	110	2020 GH	847	639 GH	1280 GH	5.7 U	2020 GH	404	5.8 U	1280 GH
9	Di-n-octyl phthalate (ug/kg)	108	51	47	11	30100 J	989	46	2610 B	10 U	30100 J	507	43.4 U	1050 J
9	4,4'-DDE (ug/kg)	43	20	47	1.03 JP	124	29	6	78.9	0.56 U	124	15	4 U	65.1
9	Naphthalene (ug/kg)	109	50	46	8.93 J	148	41	27	120	6.7 U	500 U	50	19 U	132
9	Butyltin ion (ug/kg)	19	8	42	36 H	144 H	70	58 H	97	5.7 U	144 H	33	5.8 U	97
9	Chromium (mg/l)	5	2	40	0.006	0.02	0.013	0.006	0.006	0.005 U	0.02	0.0082	0.005 U	0.006
9	Copper (mg/l)	5	2	40	0.04	0.13	0.085	0.04	0.04	0.002 U	0.13	0.0352	0.002 U	0.04
9	Lead (mg/l)	5	2	40	0.01	0.04	0.025	0.01	0.01	0.001 U	0.04	0.0106	0.001 U	0.01
9	trans-Nonachlor (ug/kg)	18	7	39	8.64 P	19.1	13	9.74	15.3	4.9 U	19.1	8.55	6.58 U	15.3
9	alpha-Chlordane (ug/kg)	26	10	38	1.57 J	18.4 P	9.455	9.27	17.3 P	0.95 U	18.4 P	4.63	1.66 JP	15 P
9	Acetone (ug/kg)	16	6	38	71	340	222	200	310	50 U	500 U	230	200	500 U
9	gamma-Chlordane (ug/kg)	8	3	38	5	10	7	5	7	0.95 U	10	3.74	2 U	7
9	4-Methylphenol (ug/kg)	102	35	34	23	1400	469	360	1100	20 U	1400	238	100 U	780
9	Dibenzofuran (ug/kg)	102	34	33	10	204	54	33	150	10 U	500 U	58	19.4 U	240 UJ

Table 4-5. Historical Surface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detected	Detected Concentrations Minimum	Maximum	Mean	Median	95th	Detected and Nondetected Concentrations Minimum	Maximum	Mean	Median	95th
9	2,4'-DDD (ug/kg)	18	6	33	6.07 P	24	13	9.42 P	17.5 P	4.71 U	24	8.145	5.94 U	17.5 P
9	2-Methylnaphthalene (ug/kg)	103	34	33	9.42 J	210	51	26	147	2.49 U	500 U	49	19 U	189
9	4,4'-DDD (ug/kg)	43	14	33	1.1 J	82.7	23	10.6	54.5	0.47 U	82.7	9.8	4 U	36.7
9	Dibenz(a,h)anthracene (ug/kg)	109	35	32	12	125	42	34	85	3.56 U	500 U	45	19 U	120
9	Ethylbenzene (ug/kg)	26	8	31	8	2000	431	53	1000	5 U	2000	145	10 U	280
9	Aldrin (ug/kg)	43	9	21	5.03 P	28.6 P	11.77	6.48 P	24.2 P	0.95 U	200 U	23	2 U	200 U
9	Dibutyltin ion (ug/l)	5	1	20	0.1	0.1	0.1	0.1	0.1	0.06 U	0.1	0.07	0.06 U	0.06 U
9	Mercury (mg/l)	5	1	20	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001 U	0.0001	0.0001 U	0.0001 U
9	Nickel (mg/l)	5	1	20	0.02	0.02	0.02	0.02	0.02	0.01 U	0.02	0.012	0.01 U	0.01 U
9	Silver (mg/l)	5	1	20	0.0003	0.0003	0.0003	0.0003	0.0003	0.0002 U	0.0003	0.00022	0.0002 U	0.0002 U
9	Carbazole (ug/kg)	48	9	19	25 N	130	71	60	130	19 U	877 UJ	105	55	665 UJ
9	Acenaphthylene (ug/kg)	109	20	18	9.93	88	21	16	51.2	6.7 U	500 U	41	16.5	90.2 UJ
9	Benzoic acid (ug/kg)	53	9	17	178 J	4110 J	1775	480 J	3990 J	52 U	4110 J	674	200 U	3000 U
9	Tetrabutyltin (ug/kg)	12	2	17	29	32	31	29	29	5.7 U	32	9.9	5.8 U	29
9	beta-Hexachlorocyclohexane (ug/kg)	43	7	16	1.19 JP	7.03	3.24	2.31 JP	4.91	0.9 U	600 U	61	1.58 U	600 U
9	Methylene chloride (ug/kg)	19	3	16	7 B	16 B	11	7 B	9 B	5 U	1000 U	165	40 U	1000 U
9	Dimethyl phthalate (ug/kg)	108	15	14	11	171	32	16	58	10 U	500 U	49	19 U	228 UJ
9	Aroclor 1248 (ug/kg)	90	12	13	32.6	407	147	106	316	2.18 U	407	47	10 U	158
9	4,4'-DDT (ug/kg)	43	5	12	1.33 J	140	32	1.4 J	10	0.59 U	140	6.42	2 U	10 U
9	2,4'-DDE (ug/kg)	18	2	11	7.77 P	8.21 P	7.99	7.77 P	7.77 P	4.58 U	8.21 P	5.78	5.21 U	7.77 P
9	Benzene (ug/kg)	19	2	11	4.8	7.3	6.05	4.8	4.8	4 U	100 U	27	7.3	100 U
9	Chlorobenzene (ug/kg)	19	2	11	8.8	10	9.4	8.8	8.8	4 U	100 U	27	8.8	100 U
9	alpha-Endosulfan (ug/kg)	31	3	10	1.38 JP	4.95 P	3.41	1.38 JP	3.91	0.95 U	10 U	3.07	1.26 U	10 U
9	Endosulfan sulfate (ug/kg)	43	4	9	2.06 JP	4	3.42	3.74 JP	3.88 JP	0.85 U	10 U	3.21	2 U	10 U
9	Pentachlorophenol (ug/kg)	112	9	8	0.89	168	23	3.49	8.45	0.19 U	3000 U	210	100 U	434 UJ
9	Dieldrin (ug/kg)	43	3	7	6	10	7	6	6	0.75 U	10 U	3.24	2 U	10 U
9	Hexachlorobenzene (ug/kg)	59	4	7	3.2 P	440	113	4.65 P	5.44 P	2.45 U	500 U	73	19 U	440
9	cis-Nonachlor (ug/kg)	18	1	6	6.88	6.88	6.88	6.88	6.88	4.58 U	7.46 U	5.60	5.21 U	6.88
9	Methylethyl ketone (ug/kg)	19	1	5	44	44	44	44	44	20 U	1250 U	323	100 U	1250 U
9	Phenol (ug/kg)	102	5	5	24	163	83	52	119	19 U	500 U	73	50 U	341 UJ
9	Endrin aldehyde (ug/kg)	43	2	5	3	4	3.5	3	3	0.93 U	10 U	3.24	2 U	10 U
9	Aniline (ug/kg)	29	1	3	94.4 J	94.4 J	94	94.4 J	94.4 J	50 U	2000 U	463	85.4 U	2000 U
9	4-Chloro-3-methylphenol (ug/kg)	95	3	3	29.8 J	306	135	29.8 J	68 J	16.8 U	500 U	73	50 U	300 U
9	alpha-Hexachlorocyclohexane (ug/kg)	43	1	2	1.03 J	1.03 J	1.03	1.03 J	1.03 J	0.5 U	200 U	30	0.98 U	200 U
9	Endrin (ug/kg)	43	1	2	6	6	6	6	6	0.82 U	10 U	3.09	2 U	10 U
9	gamma-Hexachlorocyclohexane (ug/kg)	43	1	2	6	6	6	6	6	0.87 U	200 U	21	1.02 U	200 U
9	Heptachlor (ug/kg)	43	1	2	6	6	6	6	6	0.78 UJ	200 U	21	1 U	200 U
9	2,4-Dinitrotoluene (ug/kg)	53	1	2	260	260	260	260	260	19.9 U	500 U	119	96 U	300 UH
9	3-Nitroaniline (ug/kg)	53	1	2	475 J	475 J	475	475 J	475 J	26 U	3000 U	363	120 U	2000 UH
9	Nitrobenzene (ug/kg)	53	1	2	300	300	300	300	300	19 U	500 U	85	21.9 U	308 UJ
9	Hexachloroethane (ug/kg)	57	1	2	210	210	210	210	210	2.45 U	500 U	84	19 U	427 UJ
9	Hexachlorobutadiene (ug/kg)	65	1	2	230	230	230	230	230	2.45 U	500 U	69	20 U	300 U
9	1,4-Dichlorobenzene (ug/kg)	68	1	1	230	230	230	230	230	5 U	360 UJ	43	20 U	230
9	Aroclor 1016 (ug/kg)	90	1	1	46	46	46	46	46	5.94 U	200 U	29	10 U	100 U
9	Aroclor 1242 (ug/kg)	90	1	1	28.7	28.7	28.7	28.7	28.7	2.83 U	200 U	28	10 U	100 U
9	2,4-Dimethylphenol (ug/kg)	102	1	1	18.4 J	18.4 J	18.4	18.4 J	18.4 J	16.8 U	500 U	49	20 UG	228 UJ
9	Diethyl phthalate (ug/kg)	108	1	1	15.6	15.6	15.6	15.6	15.6	10 U	500 U	52	19 U	300 UH
9	2-Methylphenol (ug/kg)	102	0	0						18.3 U	500 U	83	50 U	248 UJ

Table 4-5. Historical Surface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detected	Detected Concentrations Minimum	Maximum	Mean	Median	95th	Detected and Nondetected Concentrations Minimum	Maximum	Mean	Median	95th
9	4-Nitrophenol (ug/kg)	99	0	0						0.15 U	3000 U	230	100 U	427 UJ
9	2,4,5-Trichlorophenol (ug/kg)	95	0	0						27.5 U	500 U	100	40 U	321 UJ
9	2,4,6-Trichlorophenol (ug/kg)	95	0	0						20.3 U	500 U	78	30 U	299 UJ
9	2,4-Dichlorophenol (ug/kg)	95	0	0						16.8 U	500 U	96	100 U	247 UJ
9	2,4-Dinitrophenol (ug/kg)	95	0	0						36.7 U	3000 U	361	300 U	539 UJ
9	2-Chlorophenol (ug/kg)	95	0	0						19 U	500 U	69	50 U	300 UH
9	2-Nitrophenol (ug/kg)	95	0	0						21.4 U	500 U	83	40 U	300 U
9	4,6-Dinitro-2-methylphenol (ug/kg)	95	0	0						56.5 U	3000 U	286	100 U	832 UJ
9	Aroclor 1221 (ug/kg)	90	0	0						2.26 U	400 U	35	10 U	100 U
9	Aroclor 1232 (ug/kg)	90	0	0						3.84 U	200 U	28	10 U	100 U
9	1,2-Dichlorobenzene (ug/kg)	68	0	0						5 U	232 UJ	32	19 U	50 U
9	1,3-Dichlorobenzene (ug/kg)	68	0	0						5 U	315 UJ	37	20 U	50 U
9	1,2,4-Trichlorobenzene (ug/kg)	61	0	0						12.7 U	500 U	68	20 U	300 U
9	2,6-Dinitrotoluene (ug/kg)	53	0	0						27.5 U	500 U	125	96 U	405 UJ
9	2-Chloronaphthalene (ug/kg)	53	0	0						4.58 U	500 U	60	19 U	300 UH
9	2-Nitroaniline (ug/kg)	53	0	0						19.9 U	3000 U	343	97 U	2000 UH
9	3,3'-Dichlorobenzidine (ug/kg)	53	0	0						16.8 U	3000 U	339	97 U	2000 UH
9	4-Bromophenyl phenyl ether (ug/kg)	53	0	0						19 U	500 U	80	21.2 U	300 UH
9	4-Chloroaniline (ug/kg)	53	0	0						14.2 UJ	500 U	90	58 U	300 UH
9	4-Chlorophenyl phenyl ether (ug/kg)	53	0	0						19 U	500 U	87	26.4 U	378 UJ
9	4-Nitroaniline (ug/kg)	53	0	0						26 U	3000 U	351	97 U	2000 UH
9	Benzyl alcohol (ug/kg)	53	0	0						19 U	500 U	95	33 U	472 UJ
9	Bis(2-chloroethoxy) methane (ug/kg)	53	0	0						18.3 U	500 U	77	20 U	300 U
9	Bis(2-chloroethyl) ether (ug/kg)	53	0	0						29.2 UJ	500 U	100	39 U	429 UJ
9	Hexachlorocyclopentadiene (ug/kg)	53	0	0						21.5 U	500 U	117	96 U	317 UJ
9	Isophorone (ug/kg)	53	0	0						19 U	500 U	81	22.3 U	315 UJ
9	N-Nitrosodiphenylamine (ug/kg)	53	0	0						12.2 U	500 U	70	19 U	300 UH
9	N-Nitrosodipropylamine (ug/kg)	53	0	0						16.8 U	500 U	84	39 U	300 UH
9	beta-Endosulfan (ug/kg)	43	0	0						0.88 U	10 U	3.02	2 U	10 U
9	delta-Hexachlorocyclohexane (ug/kg)	43	0	0						0.6 U	200 U	21	1.03 U	200 U
9	Heptachlor epoxide (ug/kg)	43	0	0						0.8 U	10 U	2.81	1.06 U	10 U
9	Methoxychlor (ug/kg)	43	0	0						2 U	20 U	6.0	4 U	20 U
9	Toxaphene (ug/kg)	43	0	0						14.3 U	300 U	64	30 U	300 U
9	Bis(2-chloro-1-methylethyl) ether (ug/kg)	35	0	0						19 U	500 U	82	20 U	500 U
9	Chlordane (cis & trans) (ug/kg)	35	0	0						1 U	100 U	18	4.07 U	100 U
9	Endrin ketone (ug/kg)	26	0	0						0.64 U	6 U	1.30	0.81 U	2 U
9	Tetrachloroethene (ug/kg)	26	0	0						5 U	250 U	33	5 U	50 U
9	Trichloroethene (ug/kg)	26	0	0						4 U	100 U	21	5 U	50 U
9	N-Nitrosodimethylamine (ug/kg)	23	0	0						16.8 U	3000 U	614	20 U	3000 U
9	1,1,1-Trichloroethane (ug/kg)	19	0	0						5 U	250 U	44	10 U	250 U
9	1,1,2,2-Tetrachloroethane (ug/kg)	19	0	0						5 U	250 U	44	10 U	250 U
9	1,1,2-Trichloroethane (ug/kg)	19	0	0						4 U	100 U	27	5 U	100 U
9	1,1-Dichloroethane (ug/kg)	19	0	0						4 U	100 U	27	5 U	100 U
9	1,2-Dichloroethane (ug/kg)	19	0	0						4 U	100 U	27	5 U	100 U
9	1,2-Dichloropropane (ug/kg)	19	0	0						4 U	100 U	27	5 U	100 U
9	Bromodichloromethane (ug/kg)	19	0	0						4 U	100 U	27	5 U	100 U
9	Bromoform (ug/kg)	19	0	0						4 U	100 U	35	5 U	100 U
9	Bromomethane (ug/kg)	19	0	0						5 U	500 UJ	145	20 U	500 UJ

Table 4-5. Historical Surface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detected	Detected Concentrations Minimum	Maximum	Mean	Median	95th	Detected and Nondetected Concentrations Minimum	Maximum	Mean	Median	95th
9	Carbon tetrachloride (ug/kg)	19	0	0						5 U	250 U	44	10 U	250 U
9	Chlorodibromomethane (ug/kg)	19	0	0						4 U	100 U	27	5 U	100 U
9	Chloroethane (ug/kg)	19	0	0						5 U	500 U	145	20 U	500 U
9	Chloroform (ug/kg)	19	0	0						4 U	100 U	27	5 U	100 U
9	Chloromethane (ug/kg)	19	0	0						5 U	500 UJ	145	20 U	500 UJ
9	Methyl isobutyl ketone (ug/kg)	19	0	0						20 U	500 U	143	50 U	500 U
9	Methyl N-butyl ketone (ug/kg)	19	0	0						20 U	500 U	143	50 U	500 U
9	Styrene (ug/kg)	19	0	0						5 U	250 U	44	10 U	250 U
9	Toluene (ug/kg)	19	0	0						4 U	100 U	27	5 U	100 U
9	Vinyl chloride (ug/kg)	19	0	0						5 U	500 U	145	20 U	500 U
9	Vinylidene chloride (ug/kg)	19	0	0						4 U	100 U	27	5 U	100 U
9	Aroclor 1262 (ug/kg)	18	0	0						3.14 U	4.62 U	3.64	3.59 U	4.46 U
9	Aroclor 1268 (ug/kg)	18	0	0						3.14 U	4.62 U	3.64	3.59 U	4.46 U
9	Bis(2-chloroisopropyl) ether (ug/kg)	18	0	0						39.7 U	584 UJ	148	45.8 U	538 UJ
9	2,4,5-T (ug/kg)	18	0	0						0.27 U	0.42 U	0.32	0.31 U	0.4 U
9	2,4-D (ug/kg)	18	0	0						0.23 U	0.36 U	0.27	0.26 U	0.34 U
9	2,4-DB (ug/kg)	18	0	0						0.16 U	0.26 U	0.19	0.19 U	0.24 U
9	2,4'-DDT (ug/kg)	18	0	0						4.58 U	7.46 U	5.52	5.21 U	6.59 U
9	Dalapon (ug/kg)	18	0	0						0.13 U	0.21 U	0.15	0.15 U	0.19 U
9	Dicamba (ug/kg)	18	0	0						0.13 U	0.21 U	0.16	0.15 U	0.2 U
9	Dichloroprop (ug/kg)	18	0	0						0.22 U	0.34 U	0.26	0.25 U	0.32 U
9	Dinoseb (ug/kg)	18	0	0						0.19 U	0.3 U	0.22	0.21 U	0.28 U
9	MCPA (ug/kg)	18	0	0						0.26 U	0.41 U	0.30	0.29 U	0.38 U
9	MCPP (ug/kg)	18	0	0						0.11 U	0.18 U	0.13	0.13 U	0.17 U
9	Oxychlordane (ug/kg)	18	0	0						4.58 U	7.46 U	5.52	5.21 U	6.59 U
9	Silvex (ug/kg)	18	0	0						0.22 U	0.35 U	0.26	0.25 U	0.32 U
9	Tetrachlorophenol (ug/kg)	18	0	0						28.9 U	425 UJ	108	33.3 U	391 UJ
9	Carbon disulfide (ug/kg)	16	0	0						5 U	500 U	134	25 U	500 U
9	1,2-Dichloroethene (ug/kg)	14	0	0						5 U	250 U	54	10 U	250 U
9	1,3-Dichloropropene (ug/kg)	14	0	0						4 U	100 U	31	10 U	100 U
9	Trichlorofluoromethane (ug/kg)	13	0	0						5 U	500 U	128	10 U	500 U
9	Endosulfan (ug/kg)	12	0	0						0.9 U	6 U	2.96	3 U	5 U
9	trans-1,2-Dichloroethene (ug/kg)	10	0	0						5 U	50 U	14.5	5 U	25 U
9	trans-1,3-Dichloropropene (ug/kg)	10	0	0						5 U	50 U	14.5	5 U	25 U
9	1,1,1,2-Tetrachloroethane (ug/kg)	8	0	0						5 U	50 U	27	25 U	50 U
9	1,1-Dichloropropene (ug/kg)	8	0	0						5 U	50 U	28	25 U	50 U
9	1,2,3-Trichlorobenzene (ug/kg)	8	0	0						20 U	100 U	51	50 U	100 U
9	1,2,3-Trichloropropane (ug/kg)	8	0	0						5 U	250 U	102	25 U	250 U
9	1,2-Dibromo-3-chloropropane (ug/kg)	8	0	0						20 U	250 U	126	100 U	250 U
9	1,3,5-Trimethylbenzene (ug/kg)	8	0	0						20 U	100 U	51	50 U	100 U
9	1,3-Dichloropropane (ug/kg)	8	0	0						5 U	50 U	28	25 U	50 U
9	2,2-Dichloropropane (ug/kg)	8	0	0						5 U	50 U	28	25 U	50 U
9	2-Chlorotoluene (ug/kg)	8	0	0						20 U	100 U	51	50 U	100 U
9	4-Chlorotoluene (ug/kg)	8	0	0						20 U	100 U	51	50 U	100 U
9	Bromobenzene (ug/kg)	8	0	0						5 U	50 U	27	25 U	50 U
9	Bromochloromethane (ug/kg)	8	0	0						5 U	100 U	46	25 U	100 U
9	Butylbenzene (ug/kg)	8	0	0						20 U	100 U	51	50 U	100 U
9	Cymene (ug/kg)	8	0	0						20 U	100 U	51	50 U	100 U

Table 4-5. Historical Surface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detected	Detected Concentrations Minimum	Maximum	Mean	Median	95th	Detected and Nondetected Concentrations Minimum	Maximum	Mean	Median	95th
9	Dichlorodifluoromethane (ug/kg)	8	0	0						5 U	500 U	196	25 U	500 U
9	Ethylene dibromide (ug/kg)	8	0	0						20 U	100 U	51	50 U	100 U
9	Isopropylbenzene (ug/kg)	8	0	0						20 U	100 U	51	50 U	100 U
9	Methylene bromide (ug/kg)	8	0	0						5 U	50 U	28	25 U	50 U
9	n-Propylbenzene (ug/kg)	8	0	0						20 U	100 U	51	50 U	100 U
9	Pseudocumene (ug/kg)	8	0	0						20 U	100 U	51	50 U	100 U
9	Benzidine (ug/kg)	6	0	0						250 U	250 U	250	250 U	250 U
9	2,3,4,6-Tetrachlorophenol (ug/kg)	6	0	0						9.63 U	15.6 U	12	10.8 U	12.5 U
9	Antimony (mg/l)	5	0	0						0.05 U	0.05 U	0.05	0.05 U	0.05 U
9	Beryllium (mg/l)	5	0	0						0.001 U	0.001 U	0.001	0.001 U	0.001 U
9	Cadmium (mg/l)	5	0	0						0.002 U	0.002 U	0.002	0.002 U	0.002 U
9	Selenium (mg/l)	5	0	0						0.001 U	0.002 U	0.0014	0.001 U	0.002 U
9	Tetrabutyltin (ug/l)	5	0	0						0.02 U	0.02 U	0.02	0.02 U	0.02 U
9	Thallium (mg/l)	5	0	0						0.001 U	0.001 U	0.001	0.001 U	0.001 U
9	2-Chloroethyl vinyl ether (ug/kg)	5	0	0						10 U	50 U	20	10 U	20 U
9	cis-1,2-Dichloroethene (ug/kg)	5	0	0						5 U	50 U	15	5 U	10 U
9	cis-1,3-Dichloropropene (ug/kg)	5	0	0						5 U	50 U	15	5 U	10 U
9	Sec-butylbenzene (ug/kg)	5	0	0						20 U	100 U	52	20 U	100 U
9	tert-Butylbenzene (ug/kg)	5	0	0						20 U	100 U	52	20 U	100 U
9	Trichlorotrifluoroethane (ug/kg)	5	0	0						10 U	50 U	20	10 U	20 U
9	Vinyl acetate (ug/kg)	5	0	0						50 U	250 U	120	50 U	200 U
9	Butyltin ion (ug/l)	3	0	0						0.06 U	0.06 U	0.06	0.06 U	0.06 U
9	Pyridine (ug/kg)	1	0	0						382 UJ	382 UJ	382	382 UJ	382 UJ
10	Chromium (mg/kg)	16	16	100	12	44	26	25	41	12	44	26	25	41
10	Lead (mg/kg)	16	16	100	10.7	95	36	22	91	10.7	95	36	22	91
10	Zinc (mg/kg)	16	16	100	60.6	1750	453	118	1480	60.6	1750	453	118	1480
10	Total organic carbon (%)	11	11	100	0.89	1.96	1.63	1.58	1.87	0.89	1.96	1.63	1.58	1.87
10	Sand (%)	9	9	100	13.98	71.05	39	30.54	70.8	13.98	71.05	39	30.54	70.8
10	Silt (%)	9	9	100	23.42	76.55	54	54	66.3	23.42	76.55	54	54	66.3
10	Clay (%)	8	8	100	1.1	9.25	5.91	5.3	8.9	1.1	9.25	5.91	5.3	8.9
10	Total solids (%)	8	8	100	43.2	84	58	46.2	79.4	43.2	84	58	46.2	79.4
10	Gravel (%)	7	7	100	0.03	1.9	0.62	0.22	1.1	0.03	1.9	0.62	0.22	1.1
10	Fines (%)	6	6	100	28.2	85.8	56	59	69.06	28.2	85.8	56	59	69.06
10	Iron (mg/kg)	6	6	100	29700	47200	37233	33100	47000	29700	47200	37233	33100	47000
10	Manganese (mg/kg)	6	6	100	475	783	615	610	699	475	783	615	610	699
10	Titanium (mg/kg)	5	5	100	1080	2120	1502	1210	1850	1080	2120	1502	1210	1850
10	Acid Volatile Sulfides (mg/kg)	3	3	100	3.3	6.1	4.4	3.3	3.7	3.3	6.1	4.4	3.3	3.7
10	Aluminum (mg/kg)	3	3	100	25900	41000	35700	25900	40200	25900	41000	35700	25900	40200
10	Ammonia (mg/l)	3	3	100	1.98	2.92	2.36	1.98	2.19	1.98	2.92	2.36	1.98	2.19
10	Barium (mg/kg)	3	3	100	148	203	182	148	194	148	203	182	148	194
10	Calcium (mg/kg)	3	3	100	6440	8740 J	7923	6440	8590 J	6440	8740 J	7923	6440	8590 J
10	Cobalt (mg/kg)	3	3	100	14	20	18	14	19.8	14	20	18	14	19.8
10	Magnesium (mg/kg)	3	3	100	6020	7530	6967	6020	7350	6020	7530	6967	6020	7350
10	Potassium (mg/kg)	3	3	100	1180	1330	1277	1180	1320	1180	1330	1277	1180	1320
10	Sodium (mg/kg)	3	3	100	805 J	1080	985	805 J	1070	805 J	1080	985	805 J	1070
10	Tin (mg/kg)	3	3	100	1.25 X	2.05 X	1.54	1.25 X	1.32 X	1.25 X	2.05 X	1.54	1.25 X	1.32 X
10	Total volatile solids (%)	3	3	100	6.87	7.03	6.94	6.87	6.93	6.87	7.03	6.94	6.87	6.93
10	Vanadium (mg/kg)	3	3	100	84.6	115	104	84.6	113	84.6	115	104	84.6	113

Table 4-5. Historical Surface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detected	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
10	Total sulfides (mg/kg)	2	2	100	3 G	3 G	3	3 G	3 G	3 G	3 G	3	3 G	3 G
10	Nickel (mg/kg)	16	15	94	16.8 G	38	22	18.3	34	10 U	38	21	18.3	34
10	Copper (mg/kg)	16	14	88	24 E	72.7	43	32.4 E	70	21.6 UG	72.7	40	32.2	70
10	Bis(2-ethylhexyl) phthalate (ug/kg)	16	14	88	100	6000	1037	410 G	3260 B	100	6000	1282	435 B	3260 B
10	Arsenic (mg/kg)	16	13	81	2 G	6	3.3	3	4	2 G	6 U	3.59	3.48	6
10	Tributyltin ion (ug/kg)	5	4	80	2	7.7	5.875	6.8	7	2	7.7	5.84	5.7 U	7
10	Toluene (ug/kg)	5	4	80	18	2400	636	54	70	5 U	2400	509	18	70
10	Benz(a)anthracene (ug/kg)	16	11	69	18 G	193	79	27 G	185	18 G	6000 U	873	94	3000 U
10	Benzo(a)pyrene (ug/kg)	16	11	69	18 G	209	83	36 G	198	18 G	6000 U	876	93	3000 U
10	Benzo(b)fluoranthene (ug/kg)	16	11	69	24 G	271	99	33.3	248	24 G	6000 U	887	120	3000 U
10	Benzo(b+k)fluoranthene (ug/kg)	16	11	69	43 A	446 A	168	56 A	392 A	43 A	6000 UA	935	206 A	3000 UA
10	Benzo(k)fluoranthene (ug/kg)	16	11	69	15.7	175	70	24 G	144	15.7	6000 U	867	96	3000 U
10	Cadmium (mg/kg)	16	11	69	0.1	1.45	0.6	0.2	1.35	0.1	1.45	0.7	1 U	1.35
10	Chrysene (ug/kg)	16	11	69	28	256	114	32 G	241	28	6000 U	897	160	3000 U
10	Fluoranthene (ug/kg)	16	11	69	38.6	409	188	96	324	38.6	6000 U	948	288	3000 U
10	High Molecular Weight PAH (ug/kg)	16	11	69	239.9 A	2212.1 A	941	326 A	2003.7 A	239.9 A	6000 UA	1466	1112 A	3000 UA
10	Indeno(1,2,3-cd)pyrene (ug/kg)	16	11	69	16	122	52	29 G	121	16	6000 U	855	68	3000 U
10	Low Molecular Weight PAH (ug/kg)	16	11	69	19 A	628 A	173	28.81 A	366.79 A	19 A	8000 UA	1388	222 A	6000 UA
10	Phenanthrene (ug/kg)	16	11	69	19	393	120	26 G	254	19	6000 U	901	163	3000 U
10	Polycyclic Aromatic Hydrocarbons (ug/kg)	16	11	69	268.71 A	2578.89 A	1114	345 A	2320.5 A	268.71 A	8000 UA	2035	1313 A	6000 UA
10	Pyrene (ug/kg)	16	11	69	45.5	445	199	82	375	45.5	6000 U	955	260	3000 U
10	Benzo(g,h,i)perylene (ug/kg)	16	10	63	18	123	55	33	113	18	6000 U	855	64	3000 U
10	Butylbenzyl phthalate (ug/kg)	16	10	63	11	2000 G	233	32.3	100	11	6000 U	924	40	3000 U
10	Tetrachloroethene (ug/kg)	5	3	60	10	60	28	10	15	5 U	60	20	10 U	15
10	Mercury (mg/kg)	16	9	56	0.05	0.27	0.15	0.07	0.27	0.05	0.27	0.15	0.2	0.27
10	Silver (mg/kg)	16	8	50	0.2	0.9	0.4	0.22 G	0.9	0.2	2 U	1.0	0.9	2 U
10	Polychlorinated biphenyls (ug/kg)	15	7	47	14 A	7000 A	1340	109 A	1000 A	10 UA	7000 A	767	40 UA	1900 UA
10	Aroclor 1260 (ug/kg)	15	6	40	14	7000 H	1537	110	1000 H	10 U	7000 H	692	20 U	1000 H
10	1,4-Dichlorobenzene (ug/kg)	10	4	40	33	160	88	73	84	1 U	160	42	20 U	84
10	Chlorobenzene (ug/kg)	5	2	40	23	31	27	23	23	5 U	31	18	10 U	23
10	Dibutyl phthalate (ug/kg)	16	6	38	12 G	445	98	24	51	10 U	6000 U	861	24	3000 U
10	Beryllium (mg/kg)	8	3	38	0.45	0.7	0.6	0.45	0.6	0.45	1 U	0.8	1 U	1 U
10	Selenium (mg/kg)	8	3	38	10	15	13	10	13	1 U	15	5.4	1 U	13
10	Carbazole (ug/kg)	3	1	33	23	23	23	23	23	19 U	23	22	19 U	23 U
10	Anthracene (ug/kg)	16	5	31	19	85	52	23	82.8	6.7 U	6000 U	841	23 U	3000 U
10	Fluorene (ug/kg)	16	5	31	18 J	73	30	19 J	21.4 J	6.7 UJ	6000 U	834	20.2 J	3000 U
10	Di-n-octyl phthalate (ug/kg)	16	5	31	10	148 B	54	21	61.1 B	10	6000 U	846	32 G	3000 U
10	4-Methylphenol (ug/kg)	13	4	31	260	810	658	760	800	20 U	6000 U	1228	300 UH	3000 UG
10	Naphthalene (ug/kg)	16	4	25	6.81	32	16	13.4	13.7	6.81	6000 U	830	20 UG	3000 U
10	Thallium (mg/kg)	8	2	25	11	15	13	11	11	1 U	15	4.4	1 U	11
10	Antimony (mg/kg)	13	3	23	5 J	8 J	6.7	5 J	7 J	0.1 UG	10 U	5	3 U	10 U
10	1,3-Dichlorobenzene (ug/kg)	10	2	20	14	36	25	14	14	1 U	36	15	14	23 U
10	Acetone (ug/kg)	5	1	20	170	170	170	170	170	8 U	300 U	156	100 U	200 U
10	Acenaphthene (ug/kg)	16	3	19	20.3	45	29.9	20.3	24.3	6.7 U	8000 UG	1282	20.3	6000 U
10	Dibenz(a,h)anthracene (ug/kg)	16	3	19	19 J	32.1	27.6	19 J	31.7	6.7 U	6000 U	831	20 UG	3000 U
10	Aroclor 1254 (ug/kg)	15	2	13	46	109	77.5	46	46	10 U	1000 UH	266	20 U	1000 U
10	Acenaphthylene (ug/kg)	16	2	13	8.79	11.6	10.195	8.79	8.79	6.7 U	6000 U	966	20 U	3000 UG
10	Benzyl alcohol (ug/kg)	10	1	10	8 G	8 G	8	8 G	8 G	6 UG	6000 U	1318	23 U	3000 U

Table 4-5. Historical Surface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detected	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
10	2-Methylnaphthalene (ug/kg)	11	1	9	36	36	36	36	36	10 UG	6000 U	1202	23 U	3000 U
10	4,4'-DDT (ug/kg)	12	1	8	3	3	3	3	3	2 U	95 U	21	6 U	70 UH
10	Total of 3 isomers: pp-DDT,-DDD,-DDE (ug/k	12	1	8	3 A	3 A	3	3 A	3 A	2 UA	95 UA	21	6 UA	70 UA
10	Dibenzofuran (ug/kg)	13	1	8	13	13	13	13	13	10 U	6000 U	1018	20 UG	3000 U
10	Diethyl phthalate (ug/kg)	16	1	6	14.7	14.7	14.7	14.7	14.7	10 U	6000 U	830	20 U	3000 U
10	Dimethyl phthalate (ug/kg)	16	0	0						10 U	6000 U	829	20 U	3000 U
10	Aroclor 1016 (ug/kg)	15	0	0						10 U	950 U	205	20 U	600 UH
10	Aroclor 1221 (ug/kg)	15	0	0						10 U	1900 U	274	40 U	600 UH
10	Aroclor 1232 (ug/kg)	15	0	0						10 U	950 U	206	20 U	600 UH
10	Aroclor 1242 (ug/kg)	15	0	0						10 U	950 U	205	20 U	600 UH
10	Aroclor 1248 (ug/kg)	15	0	0						10 U	950 U	205	20 U	600 UH
10	2,4-Dimethylphenol (ug/kg)	13	0	0						6 U	6000 U	1018	20 U	3000 UG
10	2-Methylphenol (ug/kg)	13	0	0						6 U	6000 U	1036	100 U	3000 UG
10	Pentachlorophenol (ug/kg)	13	0	0						61 U	40000 U	6749	100 U	20000 UG
10	Phenol (ug/kg)	13	0	0						19 U	6000 U	1027	50 U	3000 UG
10	4,4'-DDD (ug/kg)	12	0	0						1.7 U	95 U	14	2 U	20 U
10	4,4'-DDE (ug/kg)	12	0	0						1.7 U	95 U	14	2 U	20 U
10	Aldrin (ug/kg)	12	0	0						0.84 U	200 U	26	6 U	48 U
10	alpha-Endosulfan (ug/kg)	12	0	0						0.94 UI	48 U	10	2 U	20 U
10	alpha-Hexachlorocyclohexane (ug/kg)	12	0	0						0.84 U	200 U	25	2 U	48 U
10	beta-Endosulfan (ug/kg)	12	0	0						1.7 U	95 U	14	2 U	20 U
10	beta-Hexachlorocyclohexane (ug/kg)	12	0	0						0.84 U	60 U	20	2 U	48 U
10	delta-Hexachlorocyclohexane (ug/kg)	12	0	0						0.84 U	48 U	10	2 U	20 U
10	Dieldrin (ug/kg)	12	0	0						1.7 U	400 UH	47	6 U	95 U
10	Endosulfan sulfate (ug/kg)	12	0	0						1.7 U	95 U	20	2 U	60 UH
10	Endrin (ug/kg)	12	0	0						2 U	95 U	15	6 U	30 U
10	Endrin aldehyde (ug/kg)	12	0	0						2 U	95 U	20	3.3 UI	80 UH
10	gamma-Hexachlorocyclohexane (ug/kg)	12	0	0						0.84 U	48 U	11	6 U	20 U
10	Heptachlor (ug/kg)	12	0	0						0.84 U	48 U	11	6 U	20 U
10	Heptachlor epoxide (ug/kg)	12	0	0						0.84 U	48 U	10	2 U	20 U
10	Methoxychlor (ug/kg)	12	0	0						4 U	2000 UH	220	8.4 U	480 U
10	Toxaphene (ug/kg)	12	0	0						30 U	4800 U	923	84 U	2000 UH
10	2,4,5-Trichlorophenol (ug/kg)	11	0	0						40 U	6000 U	1230	99 U	3000 UG
10	2,4,6-Trichlorophenol (ug/kg)	11	0	0						30 U	6000 U	1228	99 U	3000 UG
10	2,4-Dichlorophenol (ug/kg)	11	0	0						57 U	6000 U	1235	100 U	3000 UG
10	2,4-Dinitrophenol (ug/kg)	11	0	0						190 U	40000 U	8047	300 U	20000 UG
10	2-Chlorophenol (ug/kg)	11	0	0						19 U	6000 U	1210	50 U	3000 UG
10	2-Nitrophenol (ug/kg)	11	0	0						40 U	6000 U	1230	99 U	3000 UG
10	4,6-Dinitro-2-methylphenol (ug/kg)	11	0	0						100 U	40000 U	7993	200 U	20000 UG
10	4-Chloro-3-methylphenol (ug/kg)	11	0	0						38 U	6000 U	1216	50 U	3000 UG
10	4-Nitrophenol (ug/kg)	11	0	0						95 U	40000 U	7965	100 U	20000 UG
10	Benzoic acid (ug/kg)	10	0	0						100 UG	40000 U	8782	230 U	20000 U
10	Hexachlorobutadiene (ug/kg)	10	0	0						19 U	6000 U	1320	23 U	3000 U
10	N-Nitrosodiphenylamine (ug/kg)	10	0	0						12 UG	6000 U	1319	23 U	3000 U
10	1,2-Dichlorobenzene (ug/kg)	10	0	0						1 U	23 U	12	10 U	20 U
10	Hexachlorobenzene (ug/kg)	10	0	0						19 U	6000 U	1320	23 U	3000 U
10	2,4-Dinitrotoluene (ug/kg)	8	0	0						95 U	6000 U	1677	300 UH	3000 U
10	2,6-Dinitrotoluene (ug/kg)	8	0	0						95 U	6000 U	1677	300 UH	3000 U

Table 4-5. Historical Surface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detected	Detected Concentrations Minimum	Maximum	Mean	Median	95th	Detected and Nondetected Concentrations Minimum	Maximum	Mean	Median	95th
10	2-Chloronaphthalene (ug/kg)	8	0	0						19 U	6000 U	1645	300 UH	3000 U
10	2-Nitroaniline (ug/kg)	8	0	0						95 U	40000 U	10914	2000 UH	20000 U
10	3,3'-Dichlorobenzidine (ug/kg)	8	0	0						95 U	40000 U	10914	2000 UH	20000 U
10	3-Nitroaniline (ug/kg)	8	0	0						110 U	40000 U	10921	2000 UH	20000 U
10	4-Bromophenyl phenyl ether (ug/kg)	8	0	0						19 U	6000 U	1645	300 UH	3000 U
10	4-Chloroaniline (ug/kg)	8	0	0						57 U	6000 U	1661	300 UH	3000 U
10	4-Chlorophenyl phenyl ether (ug/kg)	8	0	0						19 U	6000 U	1645	300 UH	3000 U
10	4-Nitroaniline (ug/kg)	8	0	0						95 U	40000 U	10914	2000 UH	20000 U
10	Bis(2-chloro-1-methylethyl) ether (ug/kg)	8	0	0						19 U	6000 U	1645	300 UH	3000 U
10	Bis(2-chloroethoxy) methane (ug/kg)	8	0	0						19 U	6000 U	1645	300 U	3000 U
10	Bis(2-chloroethyl) ether (ug/kg)	8	0	0						38 U	6000 U	1653	300 UH	3000 U
10	Hexachlorocyclopentadiene (ug/kg)	8	0	0						95 U	6000 U	1677	300 UH	3000 U
10	Hexachloroethane (ug/kg)	8	0	0						19 U	6000 U	1583	300 UH	3000 U
10	Isophorone (ug/kg)	8	0	0						19 U	6000 U	1645	300 UH	3000 U
10	Nitrobenzene (ug/kg)	8	0	0						19 U	6000 U	1645	300 UH	3000 U
10	N-Nitrosodipropylamine (ug/kg)	8	0	0						38 U	6000 U	1653	300 UH	3000 U
10	1,2,4-Trichlorobenzene (ug/kg)	8	0	0						19 U	6000 U	1645	300 UH	3000 U
10	alpha-Chlordane (ug/kg)	7	0	0						0.84 U	48 U	8	2 U	2 U
10	Endrin ketone (ug/kg)	7	0	0						2 U	95 U	16	2 U	6.4 UI
10	gamma-Chlordane (ug/kg)	7	0	0						1.4 UI	48 U	8	2 U	2 U
10	Aniline (ug/kg)	5	0	0						1000 UH	20000 U	8800	3000 UG	10000 U
10	N-Nitrosodimethylamine (ug/kg)	5	0	0						2000 UH	40000 U	17400	5000 UG	20000 U
10	Tributyltin ion (ug/l)	5	0	0						0.02 UG	0.02 U	0.02	0.02 UG	0.02 U
10	1,1,1-Trichloroethane (ug/kg)	5	0	0						5 U	20 U	12	10 U	15 U
10	1,1,2,2-Tetrachloroethane (ug/kg)	5	0	0						5 U	20 U	12	10 U	15 U
10	1,1,2-Trichloroethane (ug/kg)	5	0	0						5 U	20 U	12	10 U	15 U
10	1,1-Dichloroethane (ug/kg)	5	0	0						5 U	20 U	12	10 U	15 U
10	1,2-Dichloroethane (ug/kg)	5	0	0						5 U	20 U	12	10 U	15 U
10	1,2-Dichloropropane (ug/kg)	5	0	0						5 U	20 U	12	10 U	15 U
10	2-Chloroethyl vinyl ether (ug/kg)	5	0	0						10 U	40 U	26	20 U	39 U
10	Benzene (ug/kg)	5	0	0						5 U	20 U	12	10 U	15 U
10	Bromodichloromethane (ug/kg)	5	0	0						5 U	20 U	12	10 U	15 U
10	Bromoform (ug/kg)	5	0	0						5 U	20 U	12	10 U	15 U
10	Bromomethane (ug/kg)	5	0	0						10 U	40 U	26	20 U	39 U
10	Carbon disulfide (ug/kg)	5	0	0						100 U	400 U	240	200 U	300 U
10	Carbon tetrachloride (ug/kg)	5	0	0						5 U	20 U	12	10 U	15 U
10	Chlordane (cis & trans) (ug/kg)	5	0	0						100 U	600 UH	420	300 U	600 U
10	Chlorodibromomethane (ug/kg)	5	0	0						5 U	20 U	12	10 U	15 U
10	Chloroethane (ug/kg)	5	0	0						10 U	40 U	26	20 U	39 U
10	Chloroform (ug/kg)	5	0	0						5 U	20 U	12	10 U	15 U
10	Chloromethane (ug/kg)	5	0	0						10 U	40 U	26	20 U	39 U
10	cis-1,2-Dichloroethene (ug/kg)	5	0	0						5 U	20 U	12	10 U	15 U
10	cis-1,3-Dichloropropene (ug/kg)	5	0	0						5 U	20 U	12	10 U	15 U
10	Ethylbenzene (ug/kg)	5	0	0						5 U	20 U	12	10 U	15 U
10	Methyl isobutyl ketone (ug/kg)	5	0	0						50 U	200 U	160	150 U	200 U
10	Methyl N-butyl ketone (ug/kg)	5	0	0						50 U	200 U	160	150 U	200 U
10	Methylene chloride (ug/kg)	5	0	0						5 U	20 U	12	10 U	15 U
10	Methylethyl ketone (ug/kg)	5	0	0						100 U	400 U	240	200 U	300 U

Table 4-5. Historical Surface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detected	Detected Concentrations Minimum	Maximum	Mean	Median	95th	Detected and Nondetected Concentrations Minimum	Maximum	Mean	Median	95th
10	Styrene (ug/kg)	5	0	0						5 U	20 U	12	10 U	15 UH
10	trans-1,2-Dichloroethene (ug/kg)	5	0	0						5 U	20 U	12	10 U	15 U
10	trans-1,3-Dichloropropene (ug/kg)	5	0	0						5 U	20 U	12	10 U	15 U
10	Trichloroethene (ug/kg)	5	0	0						5 U	20 U	12	10 U	15 U
10	Trichlorofluoromethane (ug/kg)	5	0	0						10 U	40 U	26	20 U	39 U
10	Trichlorotrifluoroethane (ug/kg)	5	0	0						10 U	40 U	26	20 U	39 U
10	Vinyl acetate (ug/kg)	5	0	0						50 U	200 U	130	100 U	150 U
10	Vinyl chloride (ug/kg)	5	0	0						10 U	39 U	26	20 U	39 U
10	Vinylidene chloride (ug/kg)	5	0	0						5 U	20 U	12	10 U	15 U
10	Xylene (ug/kg)	5	0	0						5 U	15 U	11	10 U	15 U
10	Ammonia (mg/kg)	2	0	0						88.1 UJ	106 UJ	97	88.1 UJ	88.1 UJ
10	Butyltin ion (ug/kg)	2	0	0						5.7 U	5.8 U	5.75	5.7 U	5.7 U
10	Dibutyltin ion (ug/kg)	2	0	0						5.7 U	5.8 U	5.75	5.7 U	5.7 U
10	Tetrabutyltin (ug/kg)	2	0	0						5.7 U	5.8 U	5.75	5.7 U	5.7 U
11	Arsenic (mg/kg)	17	17	100	2	5.86	3.76	3.9	5.5	2	5.86	3.76	3.9	5.5
11	Chromium (mg/kg)	17	17	100	12.1	42.3	28	26.2	40.4	12.1	42.3	28	26.2	40.4
11	Lead (mg/kg)	17	17	100	9.88	61.3	22	17.3	47.6	9.88	61.3	22	17.3	47.6
11	Nickel (mg/kg)	17	17	100	10.4	34.8	24	24 E	32.8	10.4	34.8	24	24 E	32.8
11	Total organic carbon (%)	17	17	100	0.93	2.65	1.85	1.87	2.37	0.93	2.65	1.85	1.87	2.37
11	Zinc (mg/kg)	17	17	100	63.2 G	171	101	98.8	130 E	63.2 G	171	101	98.8	130 E
11	Bis(2-ethylhexyl) phthalate (ug/kg)	16	16	100	80 J	1300 B	447	220	1000	80 J	1300 B	447	220	1000
11	Silt (%)	12	12	100	27.9	69.6	55	54.5	68.6	27.9	69.6	55	54.5	68.6
11	Sand (%)	11	11	100	30.1	48.23	39	37.61	46.86	30.1	48.23	39	37.61	46.86
11	Fines (%)	10	10	100	31.9	69.6	60	58.2	68.6	31.9	69.6	60	58.2	68.6
11	Clay (%)	9	9	100	3.22	7.8	5.3	4.22	6.99	3.22	7.8	5.3	4.22	6.99
11	Gravel (%)	9	9	100	0.1	1	0.4	0.2	0.58	0.1	1	0.4	0.2	0.58
11	Total solids (%)	9	9	100	44.8	59.8	49	46.8	52	44.8	59.8	49.2	46.8	52
11	Total sulfides (mg/kg)	8	8	100	2.9	39 G	10	3.6	16.1	2.9	39 G	10	3.6	16.1
11	Acetone (ug/kg)	6	6	100	30 J	90 J	47	40 J	50 J	30 J	90 J	47	40 J	50 J
11	Chlorobenzene (ug/kg)	6	6	100	2 J	5 J	3.7	4 J	5 J	2 J	5 J	3.7	4 J	5 J
11	Acid Volatile Sulfides (mg/kg)	3	3	100	7.3	22	15	7.3	16.4	7.3	22	15	7.3	16.4
11	Beryllium (mg/kg)	3	3	100	0.22	0.46	0.32	0.22	0.29	0.22	0.46	0.32	0.22	0.29
11	Iron (mg/kg)	3	3	100	41600	47700	44600	41600	44500	41600	47700	44600	41600	44500
11	Manganese (mg/kg)	3	3	100	802	969	867	802	831	802	969	867	802	831
11	Thallium (mg/kg)	3	3	100	0.04 J	0.1	0.1	0.04 J	0.05	0.04 J	0.1	0.1	0.04 J	0.05
11	Tin (mg/kg)	3	3	100	6.16 G	14.2 G	9.1	6.16 G	7.04 G	6.16 G	14.2 G	9.1	6.16 G	7.04 G
11	Titanium (mg/kg)	3	3	100	2700	3680	3257	2700	3390	2700	3680	3257	2700	3390
11	Total volatile solids (%)	3	3	100	3.8	5.65	4.86	3.8	5.13	3.8	5.65	4.86	3.8	5.13
11	Carbazole (ug/kg)	3	3	100	2 J	9 J	6	2 J	7 J	2 J	9 J	6	2 J	7 J
11	Diesel fuels (mg/kg)	3	3	100	60 J	84	72	60 J	72	60 J	84	72	60 J	72
11	Residual Range Organics (mg/kg)	3	3	100	200 J	360	287	200 J	300 J	200 J	360	287	200 J	300 J
11	Ammonia (mg/l)	2	2	100	4.76	6.43	5.595	4.76	4.76	4.76	6.43	5.60	4.76	4.76
11	Dibutyltin ion (ug/kg)	2	2	100	0.8 J	4	2.4	0.8 J	0.8 J	0.8 J	4	2.4	0.8 J	0.8 J
11	Mean grain size (mm)	1	1	100	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21
11	Median grain size (mm)	1	1	100	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
11	Cadmium (mg/kg)	17	16	94	0.15	2.13 E	0.42	0.24	1.08 E	0.15	2.13 E	0.43	0.24	1.08 E
11	Mercury (mg/kg)	17	16	94	0.05	1.06	0.15	0.07	0.21	0.05	1.06	0.14	0.06	0.21
11	Total of 3 isomers: pp-DDT,-DDD,-DDE (ug/k	11	10	91	3 A	5.3 A	4.7	4.9 A	5.2 A	2 UA	5.3 A	4.4	4.8 A	5.2 A

Table 4-5. Historical Surface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detected	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
11	Copper (mg/kg)	17	15	88	23.3	57.2 N	37	33.8	45.4 N	20.5 UG	57.2 N	35	33.4 N	45.4 N
11	Fluoranthene (ug/kg)	17	15	88	21	1210	160	71 J	206	20 U	1210	144	66	206
11	High Molecular Weight PAH (ug/kg)	17	15	88	44 A	7905 A	857	277 A	786 A	20 UA	7905 A	759	261 A	786 A
11	Polycyclic Aromatic Hydrocarbons (ug/kg)	17	15	88	44 A	8761.2 A	973	316 A	960 A	20 UA	8761.2 A	861	309 A	960 A
11	Pyrene (ug/kg)	17	15	88	23	1820	198	72	175	20 U	1820	177	63	175
11	Silver (mg/kg)	17	14	82	0.12	0.65	0.27	0.22 G	0.6	0.12	1 UG	0.4	0.22	1 UG
11	4,4'-DDE (ug/kg)	11	9	82	2	3.7	2.6	2.4	3	2 U	3.7	2.5	2.3	3
11	Butylbenzyl phthalate (ug/kg)	10	8	80	3 J	46.9	22	18.8	33	3 J	130 U	33	22	46.9
11	Antimony (mg/kg)	13	10	77	0.1 EG	0.48	0.21	0.13 N	0.4	0.1 EG	0.48	0.20	0.13 N	0.4
11	Benzo(b)fluoranthene (ug/kg)	17	13	76	15 J	790	98	27	72 J	15 J	790	79	24	72 J
11	Benzo(b+k)fluoranthene (ug/kg)	17	13	76	20 A	1254 A	154	49 A	118.4 A	20 A	1254 A	123	32 A	118.4 A
11	Benz(a)anthracene (ug/kg)	17	12	71	10 J	472	70	32	67	10 J	472	56	25	67
11	Benzo(a)pyrene (ug/kg)	17	12	71	10 J	944	110	33 G	68.6	10 J	944	84	22	68.6
11	Chrysene (ug/kg)	17	12	71	10 J	637	95	40 G	84	10 J	637	73	27	84
11	Low Molecular Weight PAH (ug/kg)	17	12	71	25 A	856.2 A	145	66 A	198 A	20 UA	856.2 A	108	39 A	198 A
11	Phenanthrene (ug/kg)	17	12	71	20 J	552	92	48	92 J	20 J	552	71	28	92 J
11	Tributyltin ion (ug/kg)	3	2	67	3	3	3	3	3	3	5.8 U	3.9	3	3
11	Benzo(k)fluoranthene (ug/kg)	17	11	65	5 J	464	67	24	47.8	5 J	464	50	20 U	47.8
11	Dibutyl phthalate (ug/kg)	10	6	60	9 J	101	39	14	71.4	9 J	101	31	20 U	71.4
11	Benzoic acid (ug/kg)	5	3	60	40 J	70 J	53	40 J	50 J	40 J	100 U	72	50 J	100 U
11	Indeno(1,2,3-cd)pyrene (ug/kg)	17	10	59	10 J	776	105	27 G	61	10 J	776	70	20 U	61
11	Polychlorinated biphenyls (ug/kg)	17	10	59	7 A	550 A	89	17 A	105 A	7 A	550 A	65	20 UA	105 A
11	4,4'-DDD (ug/kg)	11	6	55	1.4	1.8	1.6	1.7	1.7	1 U	2 U	1.7	1.7	2 U
11	4,4'-DDT (ug/kg)	11	6	55	0.9	5	2.3	1.2	3	0.9	5	1.9	1.1	3
11	Anthracene (ug/kg)	17	9	53	5 J	117	26	11.7	28 J	5 J	117	23	20 U	28 J
11	Benzo(g,h,i)perylene (ug/kg)	17	9	53	10 J	647	101	30 G	81.3	10 J	647	63	20 U	81.3
11	Butyltin ion (ug/kg)	2	1	50	2	2	2	2	2	1 U	2	1.5	1 U	1 U
11	Naphthalene (ug/kg)	17	8	47	4 J	76.8	21	8 J	41 G	4 J	76.8	20	20 U	41 G
11	2-Methylnaphthalene (ug/kg)	12	5	42	1 J	18 G	7.2	1 J	12	1 J	20 U	14	18 G	20 U
11	Aroclor 1254 (ug/kg)	17	7	41	9 J	200	51	17	51	9 J	200	29	10 U	51
11	Aroclor 1260 (ug/kg)	17	7	41	6 J	49	25	14	40	6 J	49	18	10 U	40
11	Di-n-octyl phthalate (ug/kg)	10	4	40	27	116 JB	71.9	72 JB	72.7 JB	10 U	290 U	119	72 JB	280 U
11	Dibenz(a,h)anthracene (ug/kg)	17	6	35	3 J	145	31	10 J	10.9	3 J	145	23	20 U	29 U
11	Selenium (mg/kg)	3	1	33	2.2	2.2	2.2	2.2	2.2	1.1 U	2.2	1.8	1.1 U	1.95 U
11	Diethyl phthalate (ug/kg)	10	3	30	2 J	10 J	5	2 J	3 J	2 J	20 U	11	10 U	20 U
11	Acenaphthylene (ug/kg)	17	5	29	6 G	50.8	19	6 J	22 J	6 G	50.8	17	20 U	22 J
11	Fluorene (ug/kg)	17	5	29	2 J	34	14	7 J	15 G	2 J	34	16	15 G	20 U
11	Dibenzofuran (ug/kg)	14	4	29	0.9 J	7 G	3.7	2 J	5 J	0.9 J	20 U	14	20 U	20 U
11	gamma-Chlordane (ug/kg)	4	1	25	3	3	3	3	3	2 U	3	2.25	2 U	2 U
11	Benzyl alcohol (ug/kg)	5	1	20	9	9	9	9	9	6 U	73 U	46	9	71 U
11	1,4-Dichlorobenzene (ug/kg)	5	1	20	10 J	10 J	10	10 J	10 J	1 U	15 U	8.2	1 U	14 U
11	gamma-Hexachlorocyclohexane (ug/kg)	11	2	18	1.5	1.8	1.65	1.5	1.5	1 U	6 U	2	1.7 U	2 U
11	Acenaphthene (ug/kg)	17	3	18	10 J	25.6	17	10 J	16 G	6.7 U	25.6	16	16 G	20 U
11	Phenol (ug/kg)	7	1	14	7 J	7 J	7	7 J	7 J	7 J	73 U	42	20 U	71 U
11	Aroclor 1242 (ug/kg)	17	2	12	12	350	181	12	12	10 U	350	32	10 U	20 U
11	4-Methylphenol (ug/kg)	10	1	10	117	117	117	117	117	20 U	120 U	98	120 U	120 U
11	Dimethyl phthalate (ug/kg)	10	1	10	0.6 J	0.6 J	0.6	0.6 J	0.6 J	0.6 J	20 U	13	13 U	20 U
11	Endrin ketone (ug/kg)	10	1	10	1.2	1.2	1.2	1.2	1.2	1 U	2 U	1.4	1 U	2 U

Table 4-5. Historical Surface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detected	Detected Concentrations Minimum	Maximum	Mean	Median	95th	Detected and Nondetected Concentrations Minimum	Maximum	Mean	Median	95th
11	Aroclor 1016 (ug/kg)	17	0	0						10 U	20 U	12	10 U	20 U
11	Aroclor 1221 (ug/kg)	17	0	0						10 U	60 U	22	20 U	40 U
11	Aroclor 1232 (ug/kg)	17	0	0						10 U	50 U	16	10 U	40 U
11	Aroclor 1248 (ug/kg)	17	0	0						10 U	20 U	12	10 U	20 U
11	2,4-Dimethylphenol (ug/kg)	13	0	0						6 U	290 U	83	29 U	280 U
11	Pentachlorophenol (ug/kg)	13	0	0						61 U	440 U	170	100 U	430 U
11	Tributyltin ion (ug/l)	11	0	0						0.02 U	0.05 UX	0.04	0.05 U	0.05 UX
11	Aldrin (ug/kg)	11	0	0						1 U	6 U	2	1 U	2 U
11	alpha-Endosulfan (ug/kg)	11	0	0						1 U	2 U	1	1 U	2 U
11	alpha-Hexachlorocyclohexane (ug/kg)	11	0	0						1 U	2 U	1	1 U	2 U
11	beta-Endosulfan (ug/kg)	11	0	0						1 U	2 U	1	1 U	2 U
11	beta-Hexachlorocyclohexane (ug/kg)	11	0	0						1 U	2 U	1	1 U	2 U
11	delta-Hexachlorocyclohexane (ug/kg)	11	0	0						1 U	2 U	1	1.2 U	2 U
11	Dieldrin (ug/kg)	11	0	0						1 U	6 U	2	1 U	2 U
11	Endosulfan sulfate (ug/kg)	11	0	0						1 U	2 U	1	1 U	2 U
11	Endrin (ug/kg)	11	0	0						1 U	6 U	2	1 U	2 U
11	Endrin aldehyde (ug/kg)	11	0	0						1 U	2 U	1	1 U	2 U
11	Heptachlor (ug/kg)	11	0	0						1 U	6 U	2	1 U	2 U
11	Heptachlor epoxide (ug/kg)	11	0	0						1 U	2 U	1	1 U	2 U
11	Methoxychlor (ug/kg)	11	0	0						1 U	4 U	2	1 U	4 U
11	Toxaphene (ug/kg)	11	0	0						30 U	70 UB	49	50 U	70 UB
11	2-Methylphenol (ug/kg)	7	0	0						6 U	290 U	152	100 U	280 U
11	Chlordane (cis & trans) (ug/kg)	7	0	0						10 U	10 U	10	10 U	10 U
11	Benzene (ug/kg)	6	0	0						1 U	10 U	8	9.5 U	10 U
11	Ethylbenzene (ug/kg)	6	0	0						2 U	10 U	8	9.5 U	10 U
11	m,p-Xylene (ug/kg)	6	0	0						3 U	10 U	9	9.5 U	10 U
11	o-Xylene (ug/kg)	6	0	0						2 U	10 U	8	9.5 U	10 U
11	Tetrachloroethene (ug/kg)	6	0	0						1 U	10 U	8	9.5 U	10 U
11	Trichloroethene (ug/kg)	6	0	0						2 U	10 U	8	9.5 U	10 U
11	Xylene (ug/kg)	6	0	0						2 U	10 U	8	9.5 U	10 U
11	Hexachlorobutadiene (ug/kg)	5	0	0						14 U	20 U	17	14 U	20 U
11	N-Nitrosodiphenylamine (ug/kg)	5	0	0						12 U	15 U	13	12 U	14 U
11	1,2-Dichlorobenzene (ug/kg)	5	0	0						1 U	15 U	9	1 U	14 U
11	1,3-Dichlorobenzene (ug/kg)	5	0	0						1 U	15 U	9	1 U	14 U
11	2,4,5-Trichlorophenol (ug/kg)	5	0	0						40 U	73 U	59	40 U	71 U
11	2,4,6-Trichlorophenol (ug/kg)	5	0	0						30 U	73 U	55	30 U	71 U
11	2,4-Dichlorophenol (ug/kg)	5	0	0						100 U	150 U	126	100 U	140 U
11	2,4-Dinitrophenol (ug/kg)	5	0	0						300 U	440 U	378	300 U	430 U
11	2-Chlorophenol (ug/kg)	5	0	0						50 U	73 U	63	50 U	71 U
11	2-Nitrophenol (ug/kg)	5	0	0						40 U	73 U	59	40 U	71 U
11	4,6-Dinitro-2-methylphenol (ug/kg)	5	0	0						100 U	290 U	210	100 U	280 U
11	4-Chloro-3-methylphenol (ug/kg)	5	0	0						50 U	73 U	63	50 U	71 U
11	4-Nitrophenol (ug/kg)	5	0	0						100 U	150 U	126	100 U	140 U
11	Hexachlorobenzene (ug/kg)	5	0	0						14 U	20 U	17	14 U	20 U
11	alpha-Chlordane (ug/kg)	4	0	0						2 U	2 U	2	2 U	2 U
11	2,4-Dinitrotoluene (ug/kg)	3	0	0						71 U	73 U	72	71 U	71 U
11	2,6-Dinitrotoluene (ug/kg)	3	0	0						28 U	29 U	28	28 U	28 U
11	2-Chloronaphthalene (ug/kg)	3	0	0						14 U	15 U	14	14 U	14 U

Table 4-5. Historical Surface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detected	Detected Concentrations Minimum	Maximum	Mean	Median	95th	Detected and Nondetected Concentrations Minimum	Maximum	Mean	Median	95th
11	2-Nitroaniline (ug/kg)	3	0	0						28 U	29 U	28	28 U	28 U
11	3,3'-Dichlorobenzidine (ug/kg)	3	0	0						90 U	290 U	157	90 U	90 U
11	3-Nitroaniline (ug/kg)	3	0	0						280 U	290 U	283	280 U	280 U
11	4-Bromophenyl phenyl ether (ug/kg)	3	0	0						14 U	15 U	14	14 U	14 U
11	4-Chloroaniline (ug/kg)	3	0	0						71 U	73 U	72	71 U	71 U
11	4-Chlorophenyl phenyl ether (ug/kg)	3	0	0						14 U	15 U	14	14 U	14 U
11	4-Nitroaniline (ug/kg)	3	0	0						140 U	150 U	143	140 U	140 U
11	Bis(2-chloroethoxy) methane (ug/kg)	3	0	0						28 U	29 U	28	28 U	28 U
11	Bis(2-chloroethyl) ether (ug/kg)	3	0	0						14 U	15 U	14	14 U	14 U
11	Bis(2-chloroisopropyl) ether (ug/kg)	3	0	0						14 U	15 U	14	14 U	14 U
11	Hexachlorocyclopentadiene (ug/kg)	3	0	0						280 U	290 U	283	280 U	280 U
11	Hexachloroethane (ug/kg)	3	0	0						57 U	59 U	58	57 U	57 U
11	Isophorone (ug/kg)	3	0	0						14 U	15 U	14	14 U	14 U
11	Nitrobenzene (ug/kg)	3	0	0						14 U	15 U	14	14 U	14 U
11	N-Nitrosodipropylamine (ug/kg)	3	0	0						14 U	15 U	14	14 U	14 U
11	1,2,4-Trichlorobenzene (ug/kg)	3	0	0						14 U	15 U	14	14 U	14 U
11	3- and 4-Methylphenol Coelution (ug/kg)	3	0	0						280 U	290 U	283	280 U	280 U
11	Gasoline (mg/kg)	3	0	0						52 U	78 U	61	52 U	54 U
11	Ammonia (mg/kg)	2	0	0						96.6 UJ	167 UJ	132	96.6 UJ	96.6 UJ
11	Tetrabutyltin (ug/kg)	2	0	0						3 U	3 U	3	3 U	3 U
12	Arsenic (mg/kg)	10	10	100	2	4.7	3.3	3	4.4	2	4.7	3.3	3	4.4
12	Chromium (mg/kg)	10	10	100	23.2	41	31	30	40	23.2	41	31	30	40
12	Copper (mg/kg)	10	10	100	28.7	1640	211	46	108	28.7	1640	211	46	108
12	Lead (mg/kg)	10	10	100	10.7	333	108	91	174	10.7	333	108	91	174
12	Nickel (mg/kg)	10	10	100	13	28.9	22	22.5	26.7	13	28.9	22	22.5	26.7
12	Total solids (%)	10	10	100	46.5	83.1	72	78.1	82.4	46.5	83.1	72	78.1	82.4
12	Zinc (mg/kg)	10	10	100	86.2 N	410	197	203	271	86.2 N	410	197	203	271
12	Total organic carbon (%)	5	5	100	0.7	2.08	1.4	1.14	1.76	0.7	2.08	1.4	1.14	1.76
12	Gravel (%)	4	4	100	0.59	11.9	3.53	0.77	0.86	0.59	11.9	3.53	0.77	0.86
12	Sand (%)	4	4	100	37.31	89.1	65	65.89	66.04	37.31	89.1	65	65.89	66.04
12	Clay (%)	3	3	100	1.94	3.73	2.57	1.94	2.04	1.94	3.73	2.57	1.94	2.04
12	Fines (%)	3	3	100	26.8	62.4	41	26.8	33.4	26.8	62.4	41	26.8	33.4
12	Silt (%)	3	3	100	24.9	58.7	38	24.9	31.4	24.9	58.7	38	24.9	31.4
12	Total sulfides (mg/kg)	3	3	100	1.5	9.4	5.7	1.5	6.1	1.5	9.4	5.7	1.5	6.1
12	Carbazole (ug/kg)	2	2	100	5 J	30	17.5	5 J	5 J	5 J	30	17.5	5 J	5 J
12	Acridine (ug/kg)	1	1	100	3160	3160	3160	3160	3160	3160	3160	3160	3160	3160
12	Azulene (ug/kg)	1	1	100	260	260	260	260	260	260	260	260	260	260
12	Butyltin ion (ug/kg)	1	1	100	2	2	2	2	2	2	2	2	2	2
12	Dibenzothiophene (ug/kg)	1	1	100	3160	3160	3160	3160	3160	3160	3160	3160	3160	3160
12	Dibutyltin ion (ug/kg)	1	1	100	3	3	3	3	3	3	3	3	3	3
12	Mean grain size (mm)	1	1	100	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41
12	Median grain size (mm)	1	1	100	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
12	Perylene (ug/kg)	1	1	100	1150	1150	1150	1150	1150	1150	1150	1150	1150	1150
12	Total volatile solids (%)	1	1	100	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22
12	Tributyltin ion (ug/kg)	1	1	100	12	12	12	12	12	12	12	12	12	12
12	Diesel fuels (mg/kg)	1	1	100	80	80	80	80	80	80	80	80	80	80
12	Residual Range Organics (mg/kg)	1	1	100	300 J	300 J	300	300 J	300 J	300 J	300 J	300	300 J	300 J
12	Retene (ug/kg)	1	1	100	940	940	940	940	940	940	940	940	940	940

Table 4-5. Historical Surface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detected	Detected Concentrations Minimum	Maximum	Mean	Median	95th	Detected and Nondetected Concentrations Minimum	Maximum	Mean	Median	95th
12	Bis(2-ethylhexyl) phthalate (ug/kg)	10	6	60	100 J	38000	7145	270	4000	100 J	38000	5487	3000 U	4000
12	High Molecular Weight PAH (ug/kg)	11	5	45	20 A	43480 A	8951	53 A	793 A	20 A	43480 A	5705	3000 UA	3000 UA
12	Polycyclic Aromatic Hydrocarbons (ug/kg)	11	5	45	20 A	127750 A	25867	53 A	944 A	20 A	127750 A	13394	3000 UA	3000 UA
12	Pyrene (ug/kg)	11	5	45	20	15500	3161	28	170 J	20	15500	3073	3000 U	3000 U
12	Antimony (mg/kg)	10	4	40	0.09 N	0.24	0.15	0.12 N	0.13 N	0.09 N	10 U	6.06	10 U	10 U
12	Cadmium (mg/kg)	10	4	40	0.17	0.21	0.19	0.18	0.2	0.17	1 U	0.68	1 U	1 U
12	Mercury (mg/kg)	10	4	40	0.04	0.56	0.18	0.06	0.07	0.04	0.56	0.19	0.2 U	0.2 U
12	Silver (mg/kg)	10	4	40	0.11	0.19	0.14	0.13	0.14	0.11	2 U	1.26	2 U	2 U
12	Total of 3 isomers: pp-DDT,-DDD,-DDE (ug/k	10	4	40	1.8 A	9 A	5.6	4.8 A	6.7 A	1.8 A	10 UA	8.23	10 UA	10 UA
12	Fluoranthene (ug/kg)	11	4	36	25	17400	4431	68	230 J	20 U	17400	3249	3000 U	3000 U
12	Acetone (ug/kg)	9	3	33	10 J	20 J	13	10 J	10 J	10 J	100 U	71	100 U	100 U
12	Endrin ketone (ug/kg)	3	1	33	1.6	1.6	1.6	1.6	1.6	1 U	1.6	1.2	1 U	1 U
12	4,4'-DDD (ug/kg)	10	3	30	1.4	9	4.0	1.4	1.5	1 U	10 U	7.29	10 U	10 U
12	4,4'-DDE (ug/kg)	10	3	30	1.8	2.3	2.1	1.8	2.2	1.8	10 U	7.13	10 U	10 U
12	Anthracene (ug/kg)	11	3	27	23	8300	2787	23	37 J	20 U	8300	2400	3000 U	3000 U
12	Benz(a)anthracene (ug/kg)	11	3	27	34	2950	1028	34	100	20 U	3000 U	1920	2950	3000 U
12	Benzo(a)pyrene (ug/kg)	11	3	27	40	340	140	40	40	20 U	3000 U	1678	340	3000 U
12	Benzo(b)fluoranthene (ug/kg)	11	3	27	36	2060	724	36	75 J	20 U	3000 U	1837	2060	3000 U
12	Benzo(b+k)fluoranthene (ug/kg)	11	3	27	66 A	3380 A	1181	66 A	98 A	20 UA	3380 A	1962	3000 UA	3000 UA
12	Benzo(g,h,i)perylene (ug/kg)	11	3	27	20 J	410	155	20 J	36	20 U	3000 U	1682	410	3000 U
12	Benzo(k)fluoranthene (ug/kg)	11	3	27	23	1320	458	23	30	20 U	3000 U	1765	1320	3000 U
12	Chrysene (ug/kg)	11	3	27	44	2900	1018	44	110	20 U	3000 U	1918	2900	3000 U
12	Indeno(1,2,3-cd)pyrene (ug/kg)	11	3	27	20 J	440	166	20 J	37	20 J	3000 U	1685	440	3000 U
12	Low Molecular Weight PAH (ug/kg)	11	3	27	151 A	84270 A	28193	151 A	157 A	20 UA	84270 A	9329	3000 UA	3000 UA
12	Naphthalene (ug/kg)	11	3	27	4 J	30200	10081	4 J	38	4 J	30200	4389	3000 U	3000 U
12	Phenanthrene (ug/kg)	11	3	27	90 J	27600	9262	90 J	96	20 U	27600	4166	3000 U	3000 U
12	Chlorobenzene (ug/kg)	9	2	22	2 J	4 J	3	2 J	2 J	2 J	6.6 U	4.7	5 U	5 U
12	4,4'-DDT (ug/kg)	10	2	20	1	3.1	2.05	1	1	1	10 U	7.01	10 U	10 U
12	Aroclor 1260 (ug/kg)	10	2	20	12	19	16	12	12	10 U	100 U	65	100 U	100 U
12	Acenaphthylene (ug/kg)	11	2	18	10 J	110	60	10 J	10 J	10 J	3000 U	1653	110	3000 U
12	Dibenz(a,h)anthracene (ug/kg)	11	2	18	5 J	160	83	5 J	5 J	5 J	3000 U	1657	160	3000 U
12	Dibenzofuran (ug/kg)	11	2	18	3 J	11400	5702	3 J	3 J	3 J	11400	2678	3000 U	3000 U
12	Fluorene (ug/kg)	11	2	18	10 J	3160	1585	10 J	10 J	10 J	3160	1930	3000 U	3000 U
12	Polychlorinated biphenyls (ug/kg)	11	2	18	19 A	35 A	27	19 A	19 A	19 A	125 UA	74	100 UA	100 UA
12	Benzoic acid (ug/kg)	7	1	14	60 J	60 J	60	60 J	60 J	60 J	20000 U	17151	20000 U	20000 U
12	Beryllium (mg/kg)	7	1	14	0.42	0.42	0.42	0.42	0.42	0.42	1 U	0.9	1 U	1 U
12	Thallium (mg/kg)	7	1	14	0.06	0.06	0.06	0.06	0.06	0.06	1 U	0.9	1 U	1 U
12	1,4-Dichlorobenzene (ug/kg)	7	1	14	18	18	18	18	18	5 U	18	8	5 U	15 U
12	Butylbenzyl phthalate (ug/kg)	7	1	14	5 J	5 J	5	5 J	5 J	5 J	3000 U	2572	3000 U	3000 U
12	Diethyl phthalate (ug/kg)	7	1	14	7 J	7 J	7	7 J	7 J	7 J	3000 U	2572	3000 U	3000 U
12	Phenol (ug/kg)	7	1	14	10 J	10 J	10	10 J	10 J	10 J	3000 UG	2573	3000 UG	3000 UG
12	2-Methylnaphthalene (ug/kg)	10	1	10	2 J	2 J	2	2 J	2 J	2 J	3000 U	1806	3000 U	3000 U
12	Aroclor 1254 (ug/kg)	10	1	10	23	23	23	23	23	10 U	100 U	65	100 U	100 U
12	beta-Hexachlorocyclohexane (ug/kg)	10	1	10	18	18	18	18	18	1 U	30 U	20	30 U	30 U
12	gamma-Hexachlorocyclohexane (ug/kg)	10	1	10	1.7	1.7	1.7	1.7	1.7	1 U	10 U	6.93	10 U	10 U
12	Acenaphthene (ug/kg)	11	1	9	14900	14900	14900	14900	14900	15 U	14900	2998	3000 U	3000 U
12	Aroclor 1016 (ug/kg)	10	0	0						10 U	100 U	64	100 U	100 U
12	Aroclor 1221 (ug/kg)	10	0	0						20 U	100 U	68	100 U	100 U

Table 4-5. Historical Surface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detected	Detected Concentrations Minimum	Maximum	Mean	Median	95th	Detected and Nondetected Concentrations Minimum	Maximum	Mean	Median	95th
12	Aroclor 1232 (ug/kg)	10	0	0						10 U	100 U	64	100 U	100 U
12	Aroclor 1242 (ug/kg)	10	0	0						10 U	100 U	64	100 U	100 U
12	Aroclor 1248 (ug/kg)	10	0	0						10 U	100 U	64	100 U	100 U
12	2,4-Dimethylphenol (ug/kg)	10	0	0						29 U	3000 UG	1839	3000 U	3000 UG
12	Aldrin (ug/kg)	10	0	0						1 U	10 U	6.8	10 U	10 U
12	alpha-Endosulfan (ug/kg)	10	0	0						1 U	10 U	6.8	10 U	10 U
12	alpha-Hexachlorocyclohexane (ug/kg)	10	0	0						1 U	10 U	6.8	10 U	10 U
12	beta-Endosulfan (ug/kg)	10	0	0						1 U	10 U	6.8	10 U	10 U
12	Chlordane (cis & trans) (ug/kg)	10	0	0						10 U	100 U	66	100 U	100 U
12	delta-Hexachlorocyclohexane (ug/kg)	10	0	0						1 U	10 U	6.8	10 U	10 U
12	Dieldrin (ug/kg)	10	0	0						1 U	10 U	6.8	10 U	10 U
12	Endosulfan sulfate (ug/kg)	10	0	0						1 U	10 U	6.8	10 U	10 U
12	Endrin (ug/kg)	10	0	0						1 U	10 U	6.8	10 U	10 U
12	Endrin aldehyde (ug/kg)	10	0	0						1 U	10 U	6.8	10 U	10 U
12	Heptachlor (ug/kg)	10	0	0						1 U	10 U	6.8	10 U	10 U
12	Heptachlor epoxide (ug/kg)	10	0	0						1 U	10 U	6.8	10 U	10 U
12	Methoxychlor (ug/kg)	10	0	0						1 U	20 U	13	20 U	20 U
12	Pentachlorophenol (ug/kg)	10	0	0						100 U	20000 UG	12074	20000 U	20000 UG
12	Toxaphene (ug/kg)	10	0	0						25 U	300 U	198	300 U	300 U
12	4-Methylphenol (ug/kg)	9	0	0						120 U	3000 UG	2040	3000 U	3000 UG
12	Benzene (ug/kg)	9	0	0						5 U	7.9 U	5.8	5 U	7.3 U
12	Ethylbenzene (ug/kg)	9	0	0						5 U	7.9 U	5.8	5 U	7.3 U
12	Tetrachloroethene (ug/kg)	9	0	0						5 U	7.9 U	5.8	5 U	7.3 U
12	Trichloroethene (ug/kg)	9	0	0						5 U	7.9 U	5.8	5 U	7.3 U
12	Xylene (ug/kg)	9	0	0						5 U	7.9 U	5.8	5 U	7.3 U
12	2,4-Dinitrotoluene (ug/kg)	7	0	0						74 U	3000 U	2582	3000 U	3000 U
12	2,6-Dinitrotoluene (ug/kg)	7	0	0						30 U	3000 U	2576	3000 U	3000 U
12	2-Chloronaphthalene (ug/kg)	7	0	0						15 U	3000 U	2574	3000 U	3000 U
12	2-Nitroaniline (ug/kg)	7	0	0						30 U	20000 U	17147	20000 U	20000 U
12	3,3'-Dichlorobenzidine (ug/kg)	7	0	0						100 U	20000 U	17157	20000 U	20000 U
12	3-Nitroaniline (ug/kg)	7	0	0						300 U	20000 U	17186	20000 U	20000 U
12	4-Bromophenyl phenyl ether (ug/kg)	7	0	0						15 U	3000 U	2574	3000 U	3000 U
12	4-Chloroaniline (ug/kg)	7	0	0						74 U	3000 U	2582	3000 U	3000 U
12	4-Chlorophenyl phenyl ether (ug/kg)	7	0	0						15 U	3000 U	2574	3000 U	3000 U
12	4-Nitroaniline (ug/kg)	7	0	0						150 U	20000 U	17164	20000 U	20000 U
12	Benzyl alcohol (ug/kg)	7	0	0						74 U	3000 U	2582	3000 U	3000 U
12	Bis(2-chloroethoxy) methane (ug/kg)	7	0	0						30 U	3000 U	2576	3000 U	3000 U
12	Bis(2-chloroethyl) ether (ug/kg)	7	0	0						15 U	3000 U	2574	3000 U	3000 U
12	Hexachlorobutadiene (ug/kg)	7	0	0						15 U	3000 U	2574	3000 U	3000 U
12	Hexachlorocyclopentadiene (ug/kg)	7	0	0						300 U	3000 U	2614	3000 U	3000 U
12	Hexachloroethane (ug/kg)	7	0	0						59 U	3000 U	2580	3000 U	3000 U
12	Isophorone (ug/kg)	7	0	0						15 U	3000 U	2574	3000 U	3000 U
12	Nitrobenzene (ug/kg)	7	0	0						15 U	3000 U	2574	3000 U	3000 U
12	N-Nitrosodiphenylamine (ug/kg)	7	0	0						15 U	3000 U	2574	3000 U	3000 U
12	N-Nitrosodipropylamine (ug/kg)	7	0	0						15 U	3000 U	2574	3000 U	3000 U
12	Selenium (mg/kg)	7	0	0						1 U	1.95 U	1.1	1 U	1 U
12	1,2,4-Trichlorobenzene (ug/kg)	7	0	0						15 U	3000 U	2574	3000 U	3000 U
12	1,2-Dichlorobenzene (ug/kg)	7	0	0						5 U	15 U	6.4	5 U	5 U

Table 4-5. Historical Surface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detected	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
12	1,3-Dichlorobenzene (ug/kg)	7	0	0						5 U	15 U	6.4	5 U	5 U
12	2,4,5-Trichlorophenol (ug/kg)	7	0	0						74 U	3000 UG	2582	3000 UG	3000 UG
12	2,4,6-Trichlorophenol (ug/kg)	7	0	0						74 U	3000 UG	2582	3000 UG	3000 UG
12	2,4-Dichlorophenol (ug/kg)	7	0	0						150 U	3000 UG	2593	3000 UG	3000 UG
12	2,4-Dinitrophenol (ug/kg)	7	0	0						440 U	20000 UG	17206	20000 UG	20000 UG
12	2-Chlorophenol (ug/kg)	7	0	0						74 U	3000 UG	2582	3000 UG	3000 UG
12	2-Methylphenol (ug/kg)	7	0	0						300 U	3000 UG	2614	3000 UG	3000 UG
12	2-Nitrophenol (ug/kg)	7	0	0						74 U	3000 UG	2582	3000 UG	3000 UG
12	4,6-Dinitro-2-methylphenol (ug/kg)	7	0	0						300 U	20000 UG	17186	20000 UG	20000 UG
12	4-Chloro-3-methylphenol (ug/kg)	7	0	0						74 U	3000 UG	2582	3000 UG	3000 UG
12	4-Nitrophenol (ug/kg)	7	0	0						150 U	20000 UG	17164	20000 UG	20000 UG
12	Dibutyl phthalate (ug/kg)	7	0	0						30 U	3000 U	2576	3000 U	3000 U
12	Dimethyl phthalate (ug/kg)	7	0	0						15 U	3000 U	2574	3000 U	3000 U
12	Di-n-octyl phthalate (ug/kg)	7	0	0						300 U	3000 U	2614	3000 U	3000 U
12	Hexachlorobenzene (ug/kg)	7	0	0						15 U	3000 U	2574	3000 U	3000 U
12	Aniline (ug/kg)	6	0	0						10000 U	10000 U	10000	10000 U	10000 U
12	Bis(2-chloro-1-methylethyl) ether (ug/kg)	6	0	0						3000 U	3000 U	3000	3000 U	3000 U
12	N-Nitrosodimethylamine (ug/kg)	6	0	0						20000 U	20000 U	20000	20000 U	20000 U
12	1,1,1-Trichloroethane (ug/kg)	6	0	0						5 U	5 U	5	5 U	5 U
12	1,1,2,2-Tetrachloroethane (ug/kg)	6	0	0						5 U	5 U	5	5 U	5 U
12	1,1,2-Trichloroethane (ug/kg)	6	0	0						5 U	5 U	5	5 U	5 U
12	1,1-Dichloroethane (ug/kg)	6	0	0						5 U	5 U	5	5 U	5 U
12	1,2-Dichloroethane (ug/kg)	6	0	0						5 U	5 U	5	5 U	5 U
12	1,2-Dichloropropane (ug/kg)	6	0	0						5 U	5 U	5	5 U	5 U
12	2-Chloroethyl vinyl ether (ug/kg)	6	0	0						10 U	10 U	10	10 U	10 U
12	Bromodichloromethane (ug/kg)	6	0	0						5 U	5 U	5	5 U	5 U
12	Bromoform (ug/kg)	6	0	0						5 U	5 U	5	5 U	5 U
12	Bromomethane (ug/kg)	6	0	0						10 U	10 U	10	10 U	10 U
12	Carbon disulfide (ug/kg)	6	0	0						100 U	100 U	100	100 U	100 U
12	Carbon tetrachloride (ug/kg)	6	0	0						5 U	5 U	5	5 U	5 U
12	Chlorodibromomethane (ug/kg)	6	0	0						5 U	5 U	5	5 U	5 U
12	Chloroethane (ug/kg)	6	0	0						10 U	10 U	10	10 U	10 U
12	Chloroform (ug/kg)	6	0	0						5 U	5 U	5	5 U	5 U
12	Chloromethane (ug/kg)	6	0	0						10 U	10 U	10	10 U	10 U
12	cis-1,2-Dichloroethene (ug/kg)	6	0	0						5 U	5 U	5	5 U	5 U
12	cis-1,3-Dichloropropene (ug/kg)	6	0	0						5 U	5 U	5	5 U	5 U
12	Methyl isobutyl ketone (ug/kg)	6	0	0						50 U	50 U	50	50 U	50 U
12	Methyl N-butyl ketone (ug/kg)	6	0	0						50 U	50 U	50	50 U	50 U
12	Methylene chloride (ug/kg)	6	0	0						5 U	5 U	5	5 U	5 U
12	Methylethyl ketone (ug/kg)	6	0	0						100 U	100 U	100	100 U	100 U
12	Styrene (ug/kg)	6	0	0						5 U	5 U	5	5 U	5 U
12	Toluene (ug/kg)	6	0	0						5 U	5 U	5	5 U	5 U
12	trans-1,2-Dichloroethene (ug/kg)	6	0	0						5 U	5 U	5	5 U	5 U
12	trans-1,3-Dichloropropene (ug/kg)	6	0	0						5 U	5 U	5	5 U	5 U
12	Trichlorofluoromethane (ug/kg)	6	0	0						10 U	10 U	10	10 U	10 U
12	Trichlorotrifluoroethane (ug/kg)	6	0	0						10 U	10 U	10	10 U	10 U
12	Vinyl acetate (ug/kg)	6	0	0						50 U	50 U	50	50 U	50 U
12	Vinyl chloride (ug/kg)	6	0	0						10 U	10 U	10	10 U	10 U

Table 4-5. Historical Surface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detected	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
12	Vinylidene chloride (ug/kg)	6	0	0						5 U	5 U	5	5 U	5 U
12	Tributyltin ion (ug/l)	3	0	0						0.05 UX	0.05 UX	0.05	0.05 UX	0.05 UX
12	m,p-Xylene (ug/kg)	3	0	0						6.6 U	7.9 U	7.3	6.6 U	7.3 U
12	o-Xylene (ug/kg)	3	0	0						6.6 U	7.9 U	7.3	6.6 U	7.3 U
12	Bis(2-chloroisopropyl) ether (ug/kg)	1	0	0						15 U	15 U	15	15 U	15 U
12	Tetrabutyltin (ug/kg)	1	0	0						3 U	3 U	3	3 U	3 U
12	2,2'-Dichlorobiphenyl (ug/kg)	1	0	0						25 U	25 U	25	25 U	25 U
12	2,3,3',4,4'-Pentachlorobiphenyl (ug/kg)	1	0	0						5 U	5 U	5	5 U	5 U
12	2,3-Dichlorobiphenyl (ug/kg)	1	0	0						3 U	3 U	3	3 U	3 U
12	2-Chlorobiphenyl (ug/kg)	1	0	0						125 U	125 U	125	125 U	125 U
12	3- and 4-Methylphenol Coelution (ug/kg)	1	0	0						300 U	300 U	300	300 U	300 U
12	3,3',4,4',5,5'-Hexachlorobiphenyl (ug/kg)	1	0	0						5 U	5 U	5	5 U	5 U
12	3,3',4,4',5-Pentachlorobiphenyl (ug/kg)	1	0	0						5 U	5 U	5	5 U	5 U
12	3,3',4,4'-Tetrachlorobiphenyl (ug/kg)	1	0	0						5 U	5 U	5	5 U	5 U
12	3-Chlorobiphenyl (ug/kg)	1	0	0						5 U	5 U	5	5 U	5 U
12	4-Chlorobiphenyl (ug/kg)	1	0	0						25 U	25 U	25	25 U	25 U
12	Gasoline (mg/kg)	1	0	0						61 U	61 U	61	61 U	61 U
13	1,2,3,4,6,7,8-Heptachlorodibenzofuran (ng/kg)	1	1	100	30	30	30	30	30	30	30	30	30	30
13	1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin (ng/	1	1	100	130	130	130	130	130	130	130	130	130	130
13	1,2,3,4,7,8,9-Heptachlorodibenzofuran (ng/kg)	1	1	100	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1
13	1,2,3,4,7,8-Hexachlorodibenzofuran (ng/kg)	1	1	100	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5
13	1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin (ng/kg	1	1	100	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
13	1,2,3,6,7,8-Hexachlorodibenzofuran (ng/kg)	1	1	100	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
13	1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin (ng/kg	1	1	100	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3
13	1,2,3,7,8,9-Hexachlorodibenzofuran (ng/kg)	1	1	100	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2
13	1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin (ng/kg	1	1	100	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
13	1,2,3,7,8-Pentachlorodibenzofuran (ng/kg)	1	1	100	4	4	4	4	4	4	4	4	4	4
13	2,3,4,6,7,8-Hexachlorodibenzofuran (ng/kg)	1	1	100	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9
13	2,3,4,7,8-Pentachlorodibenzofuran (ng/kg)	1	1	100	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6
13	2,3,7,8-Tetrachlorodibenzofuran (ng/kg)	1	1	100	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7
13	Heptachlorodibenzofuran (ng/kg)	1	1	100	94	94	94	94	94	94	94	94	94	94
13	Heptachlorodibenzo-p-dioxin (ng/kg)	1	1	100	280	280	280	280	280	280	280	280	280	280
13	Hexachlorodibenzofuran (ng/kg)	1	1	100	48	48	48	48	48	48	48	48	48	48
13	Hexachlorodibenzo-p-dioxin (ng/kg)	1	1	100	38	38	38	38	38	38	38	38	38	38
13	Moisture (%)	1	1	100	51	51	51	51	51	51	51	51	51	51
13	Octachlorodibenzofuran (ng/kg)	1	1	100	150	150	150	150	150	150	150	150	150	150
13	Octachlorodibenzo-p-dioxin (ng/kg)	1	1	100	1300	1300	1300	1300	1300	1300	1300	1300	1300	1300
13	Pentachlorodibenzofuran (ng/kg)	1	1	100	15	15	15	15	15	15	15	15	15	15
13	Tetrachlorodibenzofuran (ng/kg)	1	1	100	22	22	22	22	22	22	22	22	22	22
13	Tetrachlorodibenzo-p-dioxin (ng/kg)	1	1	100	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
13	Total organic carbon (%)	1	1	100	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
13	1,2,3,7,8-Pentachlorodibenzo-p-dioxin (ng/kg)	1	0	0						0.56 U	0.56 U	0.56	0.56 U	0.56 U
13	2,3,7,8-Tetrachlorodibenzo-p-dioxin (ng/kg)	1	0	0						0.8 U	0.8 U	0.8	0.8 U	0.8 U
13	Pentachlorodibenzo-p-dioxin (ng/kg)	1	0	0						0.56 U	0.56 U	0.56	0.56 U	0.56 U
14	Arsenic (mg/kg)	4	4	100	2	2	2	2	2	2	2	2	2	2
14	Chromium (mg/kg)	4	4	100	19	47	28	22 E	25	19	47	28	22 E	25
14	Copper (mg/kg)	4	4	100	68	149 X	98	68	105	68	149 X	98	68	105
14	Lead (mg/kg)	4	4	100	145	405	257	198	278 L	145	405	257	198	278 L

Table 4-5. Historical Surface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detected	Detected Concentrations Minimum	Maximum	Mean	Median	95th	Detected and Nondetected Concentrations Minimum	Maximum	Mean	Median	95th
14	Nickel (mg/kg)	4	4	100	13	17 E	16	16	16	13	17 E	16	16	16
14	Total solids (%)	4	4	100	80	84.8	83	82.2	84.1	80	84.8	83	82.2	84.1
14	Zinc (mg/kg)	4	4	100	685	1530	1186	1110	1420	685	1530	1186	1110	1420
14	Cadmium (mg/kg)	4	3	75	1	2 E	1.7	1	2	1 U	2 E	1.5	1	2
14	Bis(2-ethylhexyl) phthalate (ug/kg)	4	3	75	3000	8000	5000	3000	4000	3000 U	8000	4500	3000	4000
14	Methylene chloride (ug/kg)	4	2	50	5 B	6 B	5.5	5 B	5 B	5 U	6 B	5.25	5 U	5 B
14	4,4'-DDT (ug/kg)	4	1	25	10	10	10	10	10	10 U	10	10	10 U	10 U
14	Aroclor 1254 (ug/kg)	4	1	25	200	200	200	200	200	100 U	200	125	100 U	100 U
14	Polychlorinated biphenyls (ug/kg)	4	1	25	200 A	200 A	200	200 A	200 A	100 UA	200 A	125	100 UA	100 UA
14	Total of 3 isomers: pp-DDT,-DDD,-DDE (ug/k	4	1	25	10 A	10 A	10	10 A	10 A	10 UA	10 A	10	10 UA	10 UA
14	Butylbenzyl phthalate (ug/kg)	4	1	25	6000	6000	6000	6000	6000	3000 U	6000	3750	3000 U	3000 U
14	Toluene (ug/kg)	4	1	25	5	5	5	5	5	5 U	5	5	5 U	5 U
14	2,4-Dinitrotoluene (ug/kg)	4	0	0						3000 U	3000 U	3000	3000 U	3000 U
14	2,6-Dinitrotoluene (ug/kg)	4	0	0						3000 U	3000 U	3000	3000 U	3000 U
14	2-Chloronaphthalene (ug/kg)	4	0	0						3000 U	3000 U	3000	3000 U	3000 U
14	2-Methylnaphthalene (ug/kg)	4	0	0						3000 U	3000 U	3000	3000 U	3000 U
14	2-Nitroaniline (ug/kg)	4	0	0						20000 U	20000 U	20000	20000 U	20000 U
14	3,3'-Dichlorobenzidine (ug/kg)	4	0	0						20000 U	20000 U	20000	20000 U	20000 U
14	3-Nitroaniline (ug/kg)	4	0	0						20000 U	20000 U	20000	20000 U	20000 U
14	4,4'-DDD (ug/kg)	4	0	0						10 U	10 U	10	10 U	10 U
14	4,4'-DDE (ug/kg)	4	0	0						10 U	10 U	10	10 U	10 U
14	4-Bromophenyl phenyl ether (ug/kg)	4	0	0						3000 U	3000 U	3000	3000 U	3000 U
14	4-Chloroaniline (ug/kg)	4	0	0						3000 U	3000 U	3000	3000 U	3000 U
14	4-Chlorophenyl phenyl ether (ug/kg)	4	0	0						3000 U	3000 U	3000	3000 U	3000 U
14	4-Nitroaniline (ug/kg)	4	0	0						20000 U	20000 U	20000	20000 U	20000 U
14	Acenaphthene (ug/kg)	4	0	0						3000 U	3000 U	3000	3000 U	3000 U
14	Acenaphthylene (ug/kg)	4	0	0						3000 U	3000 U	3000	3000 U	3000 U
14	Aniline (ug/kg)	4	0	0						10000 U	10000 U	10000	10000 U	10000 U
14	Anthracene (ug/kg)	4	0	0						3000 U	3000 U	3000	3000 U	3000 U
14	Antimony (mg/kg)	4	0	0						10 U	10 UG	10	10 U	10 U
14	Aroclor 1016 (ug/kg)	4	0	0						100 U	100 U	100	100 U	100 U
14	Aroclor 1221 (ug/kg)	4	0	0						100 U	100 U	100	100 U	100 U
14	Aroclor 1232 (ug/kg)	4	0	0						100 U	100 U	100	100 U	100 U
14	Aroclor 1242 (ug/kg)	4	0	0						100 U	100 U	100	100 U	100 U
14	Aroclor 1248 (ug/kg)	4	0	0						100 U	100 U	100	100 U	100 U
14	Aroclor 1260 (ug/kg)	4	0	0						100 U	100 U	100	100 U	100 U
14	Benz(a)anthracene (ug/kg)	4	0	0						3000 U	3000 U	3000	3000 U	3000 U
14	Benzo(a)pyrene (ug/kg)	4	0	0						3000 U	3000 U	3000	3000 U	3000 U
14	Benzo(b)fluoranthene (ug/kg)	4	0	0						3000 U	3000 U	3000	3000 U	3000 U
14	Benzo(b+k)fluoranthene (ug/kg)	4	0	0						3000 UA	3000 UA	3000	3000 UA	3000 UA
14	Benzo(g,h,i)perylene (ug/kg)	4	0	0						3000 U	3000 U	3000	3000 U	3000 U
14	Benzo(k)fluoranthene (ug/kg)	4	0	0						3000 U	3000 U	3000	3000 U	3000 U
14	Benzoic acid (ug/kg)	4	0	0						20000 U	20000 U	20000	20000 U	20000 U
14	Benzyl alcohol (ug/kg)	4	0	0						3000 U	3000 U	3000	3000 U	3000 U
14	Beryllium (mg/kg)	4	0	0						1 U	1 U	1	1 U	1 U
14	Bis(2-chloro-1-methylethyl) ether (ug/kg)	4	0	0						3000 U	3000 U	3000	3000 U	3000 U
14	Bis(2-chloroethoxy) methane (ug/kg)	4	0	0						3000 U	3000 U	3000	3000 U	3000 U
14	Bis(2-chloroethyl) ether (ug/kg)	4	0	0						3000 U	3000 U	3000	3000 U	3000 U

Table 4-5. Historical Surface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detected	Detected Concentrations Minimum	Maximum	Mean	Median	95th	Detected and Nondetected Concentrations Minimum	Maximum	Mean	Median	95th
14	Chrysene (ug/kg)	4	0	0						3000 U	3000 U	3000	3000 U	3000 U
14	Dibenz(a,h)anthracene (ug/kg)	4	0	0						3000 U	3000 U	3000	3000 U	3000 U
14	Dibenzofuran (ug/kg)	4	0	0						3000 U	3000 U	3000	3000 U	3000 U
14	Fluoranthene (ug/kg)	4	0	0						3000 U	3000 U	3000	3000 U	3000 U
14	Fluorene (ug/kg)	4	0	0						3000 U	3000 U	3000	3000 U	3000 U
14	Hexachlorobutadiene (ug/kg)	4	0	0						3000 U	3000 U	3000	3000 U	3000 U
14	Hexachlorocyclopentadiene (ug/kg)	4	0	0						3000 U	3000 U	3000	3000 U	3000 U
14	Hexachloroethane (ug/kg)	4	0	0						3000 U	3000 U	3000	3000 U	3000 U
14	High Molecular Weight PAH (ug/kg)	4	0	0						3000 UA	3000 UA	3000	3000 UA	3000 UA
14	Indeno(1,2,3-cd)pyrene (ug/kg)	4	0	0						3000 U	3000 U	3000	3000 U	3000 U
14	Isophorone (ug/kg)	4	0	0						3000 U	3000 U	3000	3000 U	3000 U
14	Low Molecular Weight PAH (ug/kg)	4	0	0						3000 UA	3000 UA	3000	3000 UA	3000 UA
14	Mercury (mg/kg)	4	0	0						0.2 U	0.2 U	0.2	0.2 U	0.2 U
14	Naphthalene (ug/kg)	4	0	0						3000 U	3000 U	3000	3000 U	3000 U
14	Nitrobenzene (ug/kg)	4	0	0						3000 U	3000 U	3000	3000 U	3000 U
14	N-Nitrosodimethylamine (ug/kg)	4	0	0						20000 U	20000 U	20000	20000 U	20000 U
14	N-Nitrosodiphenylamine (ug/kg)	4	0	0						3000 U	3000 U	3000	3000 U	3000 U
14	N-Nitrosodipropylamine (ug/kg)	4	0	0						3000 U	3000 U	3000	3000 U	3000 U
14	Phenanthrene (ug/kg)	4	0	0						3000 U	3000 U	3000	3000 U	3000 U
14	Polycyclic Aromatic Hydrocarbons (ug/kg)	4	0	0						3000 UA	3000 UA	3000	3000 UA	3000 UA
14	Pyrene (ug/kg)	4	0	0						3000 U	3000 U	3000	3000 U	3000 U
14	Selenium (mg/kg)	4	0	0						1 U	1 UG	1	1 U	1 U
14	Silver (mg/kg)	4	0	0						2 U	2 U	2	2 U	2 U
14	Thallium (mg/kg)	4	0	0						1 U	1 U	1	1 U	1 U
14	1,1,1-Trichloroethane (ug/kg)	4	0	0						5 U	5 U	5	5 U	5 U
14	1,1,2,2-Tetrachloroethane (ug/kg)	4	0	0						5 U	5 U	5	5 U	5 U
14	1,1,2-Trichloroethane (ug/kg)	4	0	0						5 U	5 U	5	5 U	5 U
14	1,1-Dichloroethane (ug/kg)	4	0	0						5 U	5 U	5	5 U	5 U
14	1,2,4-Trichlorobenzene (ug/kg)	4	0	0						3000 U	3000 U	3000	3000 U	3000 U
14	1,2-Dichlorobenzene (ug/kg)	4	0	0						5 U	5 U	5	5 U	5 U
14	1,2-Dichloroethane (ug/kg)	4	0	0						5 U	5 U	5	5 U	5 U
14	1,2-Dichloropropane (ug/kg)	4	0	0						5 U	5 U	5	5 U	5 U
14	1,3-Dichlorobenzene (ug/kg)	4	0	0						5 U	5 U	5	5 U	5 U
14	1,4-Dichlorobenzene (ug/kg)	4	0	0						5 U	5 U	5	5 U	5 U
14	2,4,5-Trichlorophenol (ug/kg)	4	0	0						3000 UG	3000 UX	3000	3000 UX	3000 UG
14	2,4,6-Trichlorophenol (ug/kg)	4	0	0						3000 UG	3000 UX	3000	3000 UX	3000 UG
14	2,4-Dichlorophenol (ug/kg)	4	0	0						3000 UG	3000 UX	3000	3000 UX	3000 UG
14	2,4-Dimethylphenol (ug/kg)	4	0	0						3000 UG	3000 UX	3000	3000 UX	3000 UG
14	2,4-Dinitrophenol (ug/kg)	4	0	0						20000 UG	20000 UX	20000	20000 UX	20000 UG
14	2-Chloroethyl vinyl ether (ug/kg)	4	0	0						10 U	10 U	10	10 U	10 U
14	2-Chlorophenol (ug/kg)	4	0	0						3000 UG	3000 UX	3000	3000 UX	3000 UG
14	2-Methylphenol (ug/kg)	4	0	0						3000 UG	3000 UX	3000	3000 UX	3000 UG
14	2-Nitrophenol (ug/kg)	4	0	0						3000 UG	3000 UX	3000	3000 UX	3000 UG
14	4,6-Dinitro-2-methylphenol (ug/kg)	4	0	0						20000 UG	20000 UX	20000	20000 UX	20000 UG
14	4-Chloro-3-methylphenol (ug/kg)	4	0	0						3000 UG	3000 UX	3000	3000 UX	3000 UG
14	4-Methylphenol (ug/kg)	4	0	0						3000 UG	3000 UX	3000	3000 UX	3000 UG
14	4-Nitrophenol (ug/kg)	4	0	0						20000 UG	20000 UX	20000	20000 UX	20000 UG
14	Acetone (ug/kg)	4	0	0						100 U	100 U	100	100 U	100 U

Table 4-5. Historical Surface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detected	Detected Concentrations Minimum	Maximum	Mean	Median	95th	Detected and Nondetected Concentrations Minimum	Maximum	Mean	Median	95th
14	Aldrin (ug/kg)	4	0	0						10 U	10 U	10	10 U	10 U
14	alpha-Endosulfan (ug/kg)	4	0	0						10 U	10 U	10	10 U	10 U
14	alpha-Hexachlorocyclohexane (ug/kg)	4	0	0						10 U	10 U	10	10 U	10 U
14	Benzene (ug/kg)	4	0	0						5 U	5 U	5	5 U	5 U
14	beta-Endosulfan (ug/kg)	4	0	0						10 U	10 U	10	10 U	10 U
14	beta-Hexachlorocyclohexane (ug/kg)	4	0	0						30 U	30 U	30	30 U	30 U
14	Bromodichloromethane (ug/kg)	4	0	0						5 U	5 U	5	5 U	5 U
14	Bromoform (ug/kg)	4	0	0						5 U	5 U	5	5 U	5 U
14	Bromomethane (ug/kg)	4	0	0						10 U	10 U	10	10 U	10 U
14	Carbon disulfide (ug/kg)	4	0	0						100 U	100 U	100	100 U	100 U
14	Carbon tetrachloride (ug/kg)	4	0	0						5 U	5 U	5	5 U	5 U
14	Chlordane (cis & trans) (ug/kg)	4	0	0						100 U	100 U	100	100 U	100 U
14	Chlorobenzene (ug/kg)	4	0	0						5 U	5 U	5	5 U	5 U
14	Chlorodibromomethane (ug/kg)	4	0	0						5 U	5 U	5	5 U	5 U
14	Chloroethane (ug/kg)	4	0	0						10 U	10 U	10	10 U	10 U
14	Chloroform (ug/kg)	4	0	0						5 U	5 U	5	5 U	5 U
14	Chloromethane (ug/kg)	4	0	0						10 U	10 U	10	10 U	10 U
14	cis-1,2-Dichloroethene (ug/kg)	4	0	0						5 U	5 U	5	5 U	5 U
14	cis-1,3-Dichloropropene (ug/kg)	4	0	0						5 U	5 U	5	5 U	5 U
14	delta-Hexachlorocyclohexane (ug/kg)	4	0	0						10 U	10 U	10	10 U	10 U
14	Dibutyl phthalate (ug/kg)	4	0	0						3000 U	3000 U	3000	3000 U	3000 U
14	Dieldrin (ug/kg)	4	0	0						10 U	10 U	10	10 U	10 U
14	Diethyl phthalate (ug/kg)	4	0	0						3000 U	3000 U	3000	3000 U	3000 U
14	Dimethyl phthalate (ug/kg)	4	0	0						3000 U	3000 U	3000	3000 U	3000 U
14	Di-n-octyl phthalate (ug/kg)	4	0	0						3000 U	3000 U	3000	3000 U	3000 U
14	Endosulfan sulfate (ug/kg)	4	0	0						10 U	10 U	10	10 U	10 U
14	Endrin (ug/kg)	4	0	0						10 U	10 U	10	10 U	10 U
14	Endrin aldehyde (ug/kg)	4	0	0						10 U	10 U	10	10 U	10 U
14	Ethylbenzene (ug/kg)	4	0	0						5 U	5 U	5	5 U	5 U
14	gamma-Hexachlorocyclohexane (ug/kg)	4	0	0						10 U	10 U	10	10 U	10 U
14	Heptachlor (ug/kg)	4	0	0						10 U	10 U	10	10 U	10 U
14	Heptachlor epoxide (ug/kg)	4	0	0						10 U	10 U	10	10 U	10 U
14	Hexachlorobenzene (ug/kg)	4	0	0						3000 U	3000 U	3000	3000 U	3000 U
14	Methoxychlor (ug/kg)	4	0	0						20 U	20 U	20	20 U	20 U
14	Methyl isobutyl ketone (ug/kg)	4	0	0						50 U	50 U	50	50 U	50 U
14	Methyl N-butyl ketone (ug/kg)	4	0	0						50 U	50 U	50	50 U	50 U
14	Methylethyl ketone (ug/kg)	4	0	0						100 U	100 U	100	100 U	100 U
14	Pentachlorophenol (ug/kg)	4	0	0						20000 UG	20000 UX	20000	20000 UX	20000 UG
14	Phenol (ug/kg)	4	0	0						3000 UG	3000 UX	3000	3000 UX	3000 UG
14	Styrene (ug/kg)	4	0	0						5 U	5 U	5	5 U	5 U
14	Tetrachloroethene (ug/kg)	4	0	0						5 U	5 U	5	5 U	5 U
14	Toxaphene (ug/kg)	4	0	0						300 U	300 U	300	300 U	300 U
14	trans-1,2-Dichloroethene (ug/kg)	4	0	0						5 U	5 U	5	5 U	5 U
14	trans-1,3-Dichloropropene (ug/kg)	4	0	0						5 U	5 U	5	5 U	5 U
14	Trichloroethene (ug/kg)	4	0	0						5 U	5 U	5	5 U	5 U
14	Trichlorofluoromethane (ug/kg)	4	0	0						10 U	10 U	10	10 U	10 U
14	Trichlorotrifluoroethane (ug/kg)	4	0	0						10 U	10 U	10	10 U	10 U
14	Vinyl acetate (ug/kg)	4	0	0						50 U	50 U	50	50 U	50 U

Table 4-5. Historical Surface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detected	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
14	Vinyl chloride (ug/kg)	4	0	0						10 U	10 U	10	10 U	10 U
14	Vinylidene chloride (ug/kg)	4	0	0						5 U	5 U	5	5 U	5 U
14	Xylene (ug/kg)	4	0	0						5 U	5 U	5	5 U	5 U
15	Clay (%)	14	14	100	2	36	17	13	36	2	36	17	13	36
15	Lead (mg/kg)	14	14	100	6.4	17.9	13	12.6	17.3	6.4	17.9	13	12.6	17.3
15	Nickel (mg/kg)	14	14	100	15.9 J	28.6	21	20.2	24.1 J	15.9 J	28.6	21	20.2	24.1 J
15	Silt (%)	14	14	100	4	76	44	35	73.4	4	76	44	35	73.4
15	Total organic carbon (%)	14	14	100	0.17	1.69	1.24	1.33	1.68	0.17	1.69	1.24	1.33	1.68
15	Total solids (%)	14	14	100	30.6	69.6	47	44.1	66.7	30.6	69.6	47	44.1	66.7
15	Zinc (mg/kg)	14	14	100	51.3 J	102	75	72.5	89.3 J	51.3 J	102	75	72.5	89.3 J
15	Sand (%)	10	10	100	1	91	33	16	64	1	91	33	16	64
15	Gravel (%)	5	5	100	0.03	49	11	0.05	7	0.03	49	11	0.05	7
15	Butyltin ion (ug/kg)	4	4	100	0.6 J	3	1.9	2	2	0.6 J	3	1.9	2	2
15	Chromium (mg/kg)	4	4	100	20.1	30.5	24	22.7	23.1	20.1	30.5	24	22.7	23.1
15	Coarse sand (%)	4	4	100	0.02	14.2	3.71	0.07	0.55	0.02	14.2	3.71	0.07	0.55
15	Dibutyltin ion (ug/kg)	4	4	100	0.6 J	3	1.6	0.9 J	2	0.6 J	3	1.6	0.9 J	2
15	Fine sand (%)	4	4	100	0.19	48.2	15	1.76	8.69	0.19	48.2	15	1.76	8.69
15	Medium sand (%)	4	4	100	0.04	42.1	14	0.23	12.2	0.04	42.1	14	0.23	12.2
15	Tributyltin ion (ug/kg)	4	4	100	0.4 J	11	4.5	0.69 J	6	0.4 J	11	4.5	0.69 J	6
15	Very coarse sand (%)	4	4	100	0.03	0.29	0.14	0.1	0.12	0.03	0.29	0.14	0.1	0.12
15	Very fine sand (%)	4	4	100	1.25	21	10.4	7.75	11.6	1.25	21	10	7.75	11.6
15	Copper (mg/kg)	14	13	93	20.4 J	55.6	33	31.6	42.9 J	14.4 U	55.6	32	31.6	42.9 J
15	Total Petroleum Hydrocarbons (mg/kg)	10	8	80	65	187	147	150	180	25 U	187	123	118	180
15	Silver (mg/kg)	14	11	79	0.16	0.38	0.27	0.27	0.34	0.16	0.38	0.26	0.26	0.34
15	High Molecular Weight PAH (ug/kg)	14	7	50	56 A	213 A	126	88 A	177 A	50 UA	213 A	88	50 UA	177 A
15	Polycyclic Aromatic Hydrocarbons (ug/kg)	14	7	50	56 A	268 A	142	102 A	209 A	50 UA	268 A	96	50 UA	209 A
15	Pyrene (ug/kg)	14	7	50	16	73	46	38	67	16	73	48	50 U	67
15	Fluoranthene (ug/kg)	14	6	43	14	69	39	29	61	14	69	45	50 U	61
15	2-Methylnaphthalene (ug/kg)	14	4	29	1 J	3 J	2	2 J	2 J	1 J	50 U	36	50 U	50 U
15	4,4'-DDD (ug/kg)	14	4	29	0.4 J	0.5 J	0.5	0.5 J	0.5 J	0.4 J	3.3 U	2.5	3.3 U	3.3 U
15	4,4'-DDE (ug/kg)	14	4	29	0.5 J	0.8 J	0.6	0.6 J	0.6 J	0.5 J	2.3 U	1.8	2.3 U	2.3 U
15	Anthracene (ug/kg)	14	4	29	1 J	5 J	2.75	1 J	4 J	1 J	50 U	37	50 U	50 U
15	Antimony (mg/kg)	14	4	29	0.08 J	0.17 J	0.13	0.12 J	0.15 J	0.08 J	2.65 U	1.77	2.33 U	2.5 U
15	Arsenic (mg/kg)	14	4	29	3	5	3.5	3	3.09	2.27 U	5	2.7	2.46 U	3.09
15	Benz(a)anthracene (ug/kg)	14	4	29	6 J	15	10	7 J	11	6 J	50 U	39	50 U	50 U
15	Benzo(a)pyrene (ug/kg)	14	4	29	6 J	18	12	8 J	17	6 J	50 U	39	50 U	50 U
15	Benzo(b)fluoranthene (ug/kg)	14	4	29	7 J	16	11	7 J	14	7 J	50 U	39	50 U	50 U
15	Benzo(b+k)fluoranthene (ug/kg)	14	4	29	13 A	29 A	20	13 A	26 A	13 A	50 UA	42	50 UA	50 UA
15	Benzo(g,h,i)perylene (ug/kg)	14	4	29	7	21	14	8	20	7	50 U	40	50 U	50 U
15	Benzo(k)fluoranthene (ug/kg)	14	4	29	6 J	13	9.25	6 J	12	6 J	50 U	38	50 U	50 U
15	Cadmium (mg/kg)	14	4	29	0.16	0.3	0.23	0.21	0.23	0.08 U	0.32 U	0.26	0.3 U	0.3
15	Chrysene (ug/kg)	14	4	29	8 J	22	14	9 J	17	8 J	50 U	40	50 U	50 U
15	Indeno(1,2,3-cd)pyrene (ug/kg)	14	4	29	6	17	11.5	7	16	6	50 U	39	50 U	50 U
15	Low Molecular Weight PAH (ug/kg)	14	4	29	11 A	55 A	28	14 A	32 A	11 A	55 A	44	50 UA	50 UA
15	Mercury (mg/kg)	14	4	29	0.04	0.08	0.07	0.06	0.08	0.04	0.2 U	0.16	0.19 U	0.2 U
15	Naphthalene (ug/kg)	14	4	29	3 J	13 J	6.5	3 J	7 J	3 J	50 U	38	50 U	50 U
15	Phenanthrene (ug/kg)	14	4	29	7 J	28	16	10 J	18	7 J	50 U	40	50 U	50 U
15	Total of 3 isomers: pp-DDT,-DDD,-DDE (ug/k	14	4	29	0.9 A	2.3 A	1.5	1.1 A	1.7 A	0.9 A	6.7 UA	5.2	6.7 UA	6.7 UA

Table 4-5. Historical Surface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detected	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
15	Bis(2-ethylhexyl) phthalate (ug/kg)	14	4	29	120	420	253	120	350	100 U	420	165	100 U	350
15	Diethyl phthalate (ug/kg)	14	4	29	2 J	5 J	3.5	3 J	4 J	2 J	100 U	72	100 U	100 U
15	Dieldrin (ug/kg)	4	1	25	0.3 J	0.3 J	0.3	0.3 J	0.3 J	0.3 J	2 U	1.58	2 U	2 U
15	Endosulfan sulfate (ug/kg)	4	1	25	0.3 J	0.3 J	0.3	0.3 J	0.3 J	0.3 J	2 U	1.58	2 U	2 U
15	Endrin aldehyde (ug/kg)	4	1	25	0.4 J	0.4 J	0.4	0.4 J	0.4 J	0.4 J	2 U	1.6	2 U	2 U
15	Aroclor 1254 (ug/kg)	14	3	21	5 J	12	8	5 J	8 J	5 J	12	10	10 U	10 U
15	Polychlorinated biphenyls (ug/kg)	14	3	21	5 A	12 A	8	5 A	8 A	5 A	20 UA	18	20 UA	20 UA
15	4,4'-DDT (ug/kg)	14	2	14	0.6 J	1 J	0.8	0.6 J	0.6 J	0.6 J	6.7 U	5.2	6.7 U	6.7 U
15	Acenaphthylene (ug/kg)	14	2	14	3 J	5 J	4	3 J	3 J	3 J	50 U	38	50 U	50 U
15	Dibenz(a,h)anthracene (ug/kg)	14	2	14	1 J	1 J	1	1 J	1 J	1 J	50 U	37	50 U	50 U
15	Dibenzofuran (ug/kg)	14	2	14	1 J	3 J	2	1 J	1 J	1 J	50 U	37	50 U	50 U
15	Dibutyl phthalate (ug/kg)	14	2	14	1 J	3 J	2	1 J	1 J	1 J	100 U	73	100 U	100 U
15	Tributyltin ion (ug/l)	10	1	10	0.1	0.1	0.1	0.1	0.1	0.02 UJ	0.1 U	0.05	0.05 U	0.1
15	Fluorene (ug/kg)	14	1	7	4 J	4 J	4	4 J	4 J	4 J	50 U	38	50 U	50 U
15	Acenaphthene (ug/kg)	14	0	0						10 U	50 U	39	50 U	50 U
15	Aroclor 1016 (ug/kg)	14	0	0						10 U	10 U	10	10 U	10 U
15	Aroclor 1221 (ug/kg)	14	0	0						20 U	20 U	20	20 U	20 U
15	Aroclor 1232 (ug/kg)	14	0	0						10 U	10 U	10	10 U	10 U
15	Aroclor 1242 (ug/kg)	14	0	0						10 U	10 U	10	10 U	10 U
15	Aroclor 1248 (ug/kg)	14	0	0						10 U	10 U	10	10 U	10 U
15	Aroclor 1260 (ug/kg)	14	0	0						10 U	10 U	10	10 U	10 U
15	Benzoic acid (ug/kg)	14	0	0						250 U	250 UJ	250	250 U	250 U
15	Benzyl alcohol (ug/kg)	14	0	0						25 U	50 U	32	25 U	50 U
15	Hexachlorobutadiene (ug/kg)	14	0	0						10 U	20 U	17	20 U	20 U
15	Hexachloroethane (ug/kg)	14	0	0						40 U	50 U	47	50 U	50 U
15	N-Nitrosodiphenylamine (ug/kg)	14	0	0						10 U	20 U	17	20 U	20 U
15	1,2,4-Trichlorobenzene (ug/kg)	14	0	0						10 U	20 U	17	20 U	20 U
15	1,2-Dichlorobenzene (ug/kg)	14	0	0						10 U	10 U	10	10 U	10 U
15	1,3-Dichlorobenzene (ug/kg)	14	0	0						10 U	10 U	10	10 U	10 U
15	1,4-Dichlorobenzene (ug/kg)	14	0	0						10 U	10 U	10	10 U	10 U
15	2,4-Dimethylphenol (ug/kg)	14	0	0						20 U	200 U	71	20 U	200 U
15	2-Methylphenol (ug/kg)	14	0	0						20 U	100 U	43	20 U	100 U
15	Benzene (ug/kg)	14	0	0						5 U	10 U	6	5 U	10 U
15	Butylbenzyl phthalate (ug/kg)	14	0	0						10 U	100 U	74	100 U	100 U
15	Dimethyl phthalate (ug/kg)	14	0	0						10 U	100 U	74	100 U	100 U
15	Di-n-octyl phthalate (ug/kg)	14	0	0						10 U	100 UJ	74	100 U	100 U
15	Ethylbenzene (ug/kg)	14	0	0						5 U	10 U	6	5 U	10 U
15	Hexachlorobenzene (ug/kg)	14	0	0						10 U	20 U	17	20 U	20 U
15	m,p-Xylene (ug/kg)	14	0	0						5 U	10 U	6	5 U	10 U
15	o-Xylene (ug/kg)	14	0	0						5 U	10 U	6	5 U	10 U
15	Pentachlorophenol (ug/kg)	14	0	0						250 U	300 U	264	250 U	300 U
15	Phenol (ug/kg)	14	0	0						50 U	100 U	86	100 U	100 U
15	Toluene (ug/kg)	14	0	0						5 U	10 U	6	5 U	10 U
15	Trichloroethene (ug/kg)	14	0	0						5 U	10 U	6	5 U	10 U
15	Butyltin ion (ug/l)	10	0	0						0.05 U	0.1 U	0.06	0.05 U	0.05 U
15	Dibutyltin ion (ug/l)	10	0	0						0.05 U	0.1 U	0.06	0.05 U	0.05 U
15	Tetrabutyltin (ug/l)	10	0	0						0.05 U	0.1 U	0.06	0.05 U	0.05 UJ
15	3- and 4-Methylphenol Coelution (ug/kg)	10	0	0						100 U	100 U	100	100 U	100 U

Table 4-5. Historical Surface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detected	Detected Concentrations Minimum	Maximum	Mean	Median	95th	Detected and Nondetected Concentrations Minimum	Maximum	Mean	Median	95th
15	Diesel fuels (mg/kg)	10	0	0						10 U	50 U	28	20 U	50 U
15	Gasoline (mg/kg)	10	0	0						10 UJ	50 UJ	28	20 UJ	50 UJ
15	Heavy oil (mg/kg)	10	0	0						25 U	120 U	68	50 U	120 U
15	Jet fuel A (mg/kg)	10	0	0						10 U	50 U	28	20 U	50 U
15	JP-4 jet fuel (mg/kg)	10	0	0						10 UJ	50 UJ	28	20 UJ	50 UJ
15	Kerosene (mg/kg)	10	0	0						10 U	50 U	28	20 U	50 U
15	Lube Oil (mg/kg)	10	0	0						25 U	120 U	68	50 U	120 U
15	Mineral spirits (mg/kg)	10	0	0						10 U	50 U	28	20 U	50 U
15	Naphtha distillate (mg/kg)	10	0	0						10 UJ	50 UJ	28	20 UJ	50 UJ
15	Non-petroleum hydrocarbons (mg/kg)	10	0	0						50 U	250 U	125	100 U	250 U
15	2,4-Dinitrotoluene (ug/kg)	4	0	0						20 U	20 U	20	20 U	20 U
15	2,6-Dinitrotoluene (ug/kg)	4	0	0						10 U	10 U	10	10 U	10 U
15	2-Chloronaphthalene (ug/kg)	4	0	0						5 U	5 U	5	5 U	5 U
15	2-Nitroaniline (ug/kg)	4	0	0						10 U	10 U	10	10 U	10 U
15	3,3'-Dichlorobenzidine (ug/kg)	4	0	0						40 U	40 U	40	40 U	40 U
15	3-Nitroaniline (ug/kg)	4	0	0						200 U	200 U	200	200 U	200 U
15	4-Bromophenyl phenyl ether (ug/kg)	4	0	0						10 U	10 U	10	10 U	10 U
15	4-Chloroaniline (ug/kg)	4	0	0						50 U	50 U	50	50 U	50 U
15	4-Chlorophenyl phenyl ether (ug/kg)	4	0	0						10 U	10 U	10	10 U	10 U
15	4-Nitroaniline (ug/kg)	4	0	0						10 U	10 U	10	10 U	10 U
15	Aniline (ug/kg)	4	0	0						200 U	200 U	200	200 U	200 U
15	Bis(2-chloro-1-methylethyl) ether (ug/kg)	4	0	0						10 U	10 U	10	10 U	10 U
15	Bis(2-chloroethoxy) methane (ug/kg)	4	0	0						10 U	10 U	10	10 U	10 U
15	Bis(2-chloroethyl) ether (ug/kg)	4	0	0						10 U	10 U	10	10 U	10 U
15	Hexachlorocyclopentadiene (ug/kg)	4	0	0						200 U	200 U	200	200 U	200 U
15	Isophorone (ug/kg)	4	0	0						10 U	10 U	10	10 U	10 U
15	Nitrobenzene (ug/kg)	4	0	0						10 U	10 U	10	10 U	10 U
15	N-Nitrosodimethylamine (ug/kg)	4	0	0						10 U	10 U	10	10 U	10 U
15	N-Nitrosodipropylamine (ug/kg)	4	0	0						10 U	10 U	10	10 U	10 U
15	Tetrabutyltin (ug/kg)	4	0	0						3 U	3 U	3	3 U	3 U
15	1,1,1,2-Tetrachloroethane (ug/kg)	4	0	0						10 U	10 U	10	10 U	10 U
15	1,1,1-Trichloroethane (ug/kg)	4	0	0						10 U	10 U	10	10 U	10 U
15	1,1,2,2-Tetrachloroethane (ug/kg)	4	0	0						10 U	10 U	10	10 U	10 U
15	1,1,2-Trichloroethane (ug/kg)	4	0	0						10 U	10 U	10	10 U	10 U
15	1,1-Dichloroethane (ug/kg)	4	0	0						10 U	10 U	10	10 U	10 U
15	1,1-Dichloropropene (ug/kg)	4	0	0						10 U	10 U	10	10 U	10 U
15	1,2,3-Trichlorobenzene (ug/kg)	4	0	0						40 U	40 U	40	40 U	40 U
15	1,2,3-Trichloropropane (ug/kg)	4	0	0						10 U	10 U	10	10 U	10 U
15	1,2-Dibromo-3-chloropropane (ug/kg)	4	0	0						40 U	40 U	40	40 U	40 U
15	1,2-Dichloroethane (ug/kg)	4	0	0						10 U	10 U	10	10 U	10 U
15	1,2-Dichloropropane (ug/kg)	4	0	0						10 U	10 U	10	10 U	10 U
15	1,3,5-Trimethylbenzene (ug/kg)	4	0	0						40 U	40 U	40	40 U	40 U
15	1,3-Dichloropropane (ug/kg)	4	0	0						10 U	10 U	10	10 U	10 U
15	2,2-Dichloropropane (ug/kg)	4	0	0						10 U	10 U	10	10 U	10 U
15	2,4,5-Trichlorophenol (ug/kg)	4	0	0						40 U	40 U	40	40 U	40 U
15	2,4,6-Trichlorophenol (ug/kg)	4	0	0						30 U	30 U	30	30 U	30 U
15	2,4-Dichlorophenol (ug/kg)	4	0	0						100 U	100 U	100	100 U	100 U
15	2,4-Dinitrophenol (ug/kg)	4	0	0						300 U	300 U	300	300 U	300 U

Table 4-5. Historical Surface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detected	Detected Concentrations Minimum	Maximum	Mean	Median	95th	Detected and Nondetected Concentrations Minimum	Maximum	Mean	Median	95th
15	2-Chlorophenol (ug/kg)	4	0	0						50 U	50 U	50	50 U	50 U
15	2-Chlorotoluene (ug/kg)	4	0	0						40 U	40 U	40	40 U	40 U
15	2-Nitrophenol (ug/kg)	4	0	0						40 U	40 U	40	40 U	40 U
15	4,6-Dinitro-2-methylphenol (ug/kg)	4	0	0						100 U	100 U	100	100 U	100 U
15	4-Chloro-3-methylphenol (ug/kg)	4	0	0						50 U	50 U	50	50 U	50 U
15	4-Chlorotoluene (ug/kg)	4	0	0						40 U	40 U	40	40 U	40 U
15	4-Methylphenol (ug/kg)	4	0	0						200 U	200 U	200	200 U	200 U
15	4-Nitrophenol (ug/kg)	4	0	0						100 U	100 U	100	100 U	100 U
15	Acetone (ug/kg)	4	0	0						100 U	100 U	100	100 U	100 U
15	Aldrin (ug/kg)	4	0	0						2 U	2 U	2	2 U	2 U
15	alpha-Chlordane (ug/kg)	4	0	0						2 U	2 U	2	2 U	2 U
15	alpha-Endosulfan (ug/kg)	4	0	0						2 U	2 U	2	2 U	2 U
15	alpha-Hexachlorocyclohexane (ug/kg)	4	0	0						2 U	2 U	2	2 U	2 U
15	beta-Endosulfan (ug/kg)	4	0	0						2 U	2 U	2	2 U	2 U
15	beta-Hexachlorocyclohexane (ug/kg)	4	0	0						2 U	2 U	2	2 U	2 U
15	Bromobenzene (ug/kg)	4	0	0						10 U	10 U	10	10 U	10 U
15	Bromochloromethane (ug/kg)	4	0	0						10 U	10 U	10	10 U	10 U
15	Bromodichloromethane (ug/kg)	4	0	0						10 U	10 U	10	10 U	10 U
15	Bromoform (ug/kg)	4	0	0						10 U	10 U	10	10 U	10 U
15	Bromomethane (ug/kg)	4	0	0						10 U	10 U	10	10 U	10 U
15	Carbon disulfide (ug/kg)	4	0	0						10 U	10 U	10	10 U	10 U
15	Carbon tetrachloride (ug/kg)	4	0	0						10 U	10 U	10	10 U	10 U
15	Chlorobenzene (ug/kg)	4	0	0						10 U	10 U	10	10 U	10 U
15	Chlorodibromomethane (ug/kg)	4	0	0						10 U	10 U	10	10 U	10 U
15	Chloroethane (ug/kg)	4	0	0						10 U	10 U	10	10 U	10 U
15	Chloroform (ug/kg)	4	0	0						10 U	10 U	10	10 U	10 U
15	Chloromethane (ug/kg)	4	0	0						10 U	10 U	10	10 U	10 U
15	cis-1,2-Dichloroethene (ug/kg)	4	0	0						10 U	10 U	10	10 U	10 U
15	cis-1,3-Dichloropropene (ug/kg)	4	0	0						10 U	10 U	10	10 U	10 U
15	delta-Hexachlorocyclohexane (ug/kg)	4	0	0						2 U	2 U	2	2 U	2 U
15	Dichlorodifluoromethane (ug/kg)	4	0	0						10 U	10 U	10	10 U	10 U
15	Endrin (ug/kg)	4	0	0						2 U	2 U	2	2 U	2 U
15	Endrin ketone (ug/kg)	4	0	0						2 U	2 U	2	2 U	2 U
15	Ethylene dibromide (ug/kg)	4	0	0						40 U	40 U	40	40 U	40 U
15	gamma-Hexachlorocyclohexane (ug/kg)	4	0	0						2 U	2 U	2	2 U	2 U
15	Heptachlor (ug/kg)	4	0	0						2 U	2 U	2	2 U	2 U
15	Heptachlor epoxide (ug/kg)	4	0	0						2 U	2 U	2	2 U	2 U
15	Isopropylbenzene (ug/kg)	4	0	0						40 U	40 U	40	40 U	40 U
15	Methoxychlor (ug/kg)	4	0	0						4 U	4 U	4	4 U	4 U
15	Methyl isobutyl ketone (ug/kg)	4	0	0						40 U	40 U	40	40 U	40 U
15	Methyl N-butyl ketone (ug/kg)	4	0	0						40 U	40 U	40	40 U	40 U
15	Methylene bromide (ug/kg)	4	0	0						10 U	10 U	10	10 U	10 U
15	Methylene chloride (ug/kg)	4	0	0						20 U	20 U	20	20 U	20 U
15	Methylethyl ketone (ug/kg)	4	0	0						40 U	40 U	40	40 U	40 U
15	n-Butylbenzene (ug/kg)	4	0	0						40 U	40 U	40	40 U	40 U
15	n-Propylbenzene (ug/kg)	4	0	0						40 U	40 U	40	40 U	40 U
15	p-Cymene (ug/kg)	4	0	0						40 U	40 U	40	40 U	40 U
15	Pseudocumene (ug/kg)	4	0	0						40 U	40 U	40	40 U	40 U

Table 4-5. Historical Surface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detected	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
15	Sec-butylbenzene (ug/kg)	4	0	0						40 U	40 U	40	40 U	40 U
15	Styrene (ug/kg)	4	0	0						10 U	10 U	10	10 U	10 U
15	tert-Butylbenzene (ug/kg)	4	0	0						40 U	40 U	40	40 U	40 U
15	Tetrachloroethene (ug/kg)	4	0	0						10 U	10 U	10	10 U	10 U
15	Toxaphene (ug/kg)	4	0	0						30 U	30 U	30	30 U	30 U
15	trans-1,2-Dichloroethene (ug/kg)	4	0	0						10 U	10 U	10	10 U	10 U
15	trans-1,3-Dichloropropene (ug/kg)	4	0	0						10 U	10 U	10	10 U	10 U
15	trans-Chlordane (ug/kg)	4	0	0						2 U	2 U	2	2 U	2 U
15	Trichlorofluoromethane (ug/kg)	4	0	0						10 U	10 U	10	10 U	10 U
15	Vinyl chloride (ug/kg)	4	0	0						10 U	10 U	10	10 U	10 U
15	Vinylidene chloride (ug/kg)	4	0	0						10 U	10 U	10	10 U	10 U
16	Total solids (%)	37	37	100	26.4	73.4	48	45	71.5	26.4	73.4	48	45	71.5
16	Lead (mg/kg)	36	36	100	4.56	27.8	14	15.1	23.6	4.56	27.8	14	15.1	23.6
16	Nickel (mg/kg)	36	36	100	12.5 J	31.3	21	20.3 J	29.7	12.5 J	31.3	21	20.3 J	29.7
16	Total organic carbon (%)	36	36	100	0.16	1.61	0.92	0.85	1.52	0.16	1.61	0.92	0.85	1.52
16	Zinc (mg/kg)	36	36	100	33.2 J	191 J	83	69.7 J	130	33.2 J	191 J	83	69.7 J	130
16	Clay (%)	31	31	100	1	37	17	15	33.8	1	37	17	15	33.8
16	Silt (%)	31	31	100	2	82.2	46	43	71.2	2	82.2	46	43	71.2
16	Sand (%)	22	22	100	2	96	54	56	93	2	96	54	56	93
16	Gravel (%)	13	13	100	0	18	1.5	0	1.02	0	18	1.5	0	1.02
16	Chromium (mg/kg)	12	12	100	14.3	33.6	26	26.4	32.4	14.3	33.6	26	26.4	32.4
16	Coarse sand (%)	12	12	100	0	1.32	0.225	0.05	0.48	0	1.32	0.225	0.05	0.48
16	Fine sand (%)	12	12	100	0.27	45.5	5.91	0.58	11.6	0.27	45.5	5.91	0.58	11.6
16	Medium sand (%)	12	12	100	0.07	37.9	3.66	0.29	2.41	0.07	37.9	3.66	0.29	2.41
16	Very coarse sand (%)	12	12	100	0.01	0.6	0.09	0.02	0.22	0.01	0.6	0.09	0.02	0.22
16	Very fine sand (%)	12	12	100	1.5	34.2	7.7	3.29	19	1.5	34.2	7.7	3.29	19
16	Butyltin ion (ug/kg)	11	11	100	3	11	6	6	8	3	11	6	6	8
16	Dibutyltin ion (ug/kg)	11	11	100	4	19	6	5	6	4	19	6	5	6
16	Tributyltin ion (ug/kg)	11	11	100	15	117	29	17	32	15	117	29	17	32
16	Fines (%)	3	3	100	4.6	7	5.9	4.6	6.1	4.6	7	5.9	4.6	6.1
16	Total volatile solids (%)	3	3	100	2.62	3.97	3.31	2.62	3.35	2.62	3.97	3.31	2.62	3.35
16	Mean grain size (mm)	2	2	100	0.21	0.22	0.215	0.21	0.21	0.21	0.22	0.215	0.21	0.21
16	Median grain size (mm)	2	2	100	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
16	Copper (mg/kg)	36	34	94	15	56.9	34	30.7	54.9	14.8 UJ	56.9	33	29.5	54.9
16	Total Petroleum Hydrocarbons (mg/kg)	24	22	92	28	470	149	110	200	25 U	470	139	110	200
16	High Molecular Weight PAH (ug/kg)	36	25	69	53 A	2080 A	489	280 A	1376 A	50 UA	2080 A	355	187 A	1376 A
16	Polycyclic Aromatic Hydrocarbons (ug/kg)	36	25	69	53 A	2240 A	530	325 A	1471 A	50 UA	2240 A	384	223 A	1471 A
16	Pyrene (ug/kg)	36	25	69	10 J	370	99	61	200	10 J	370	84	50 J	200
16	Fluoranthene (ug/kg)	36	23	64	5.6 J	280	87	70	210	5.6 J	280	74	50 U	210
16	Benz(a)anthracene (ug/kg)	36	21	58	4.8 J	160	50	23	110	4.8 J	160	50	50 U	110
16	Benzo(b)fluoranthene (ug/kg)	36	21	58	6.6 J	160	50	28	97	6.6 J	160	50	50 U	97
16	Benzo(b+k)fluoranthene (ug/kg)	36	21	58	11.6 A	300 A	84	50 A	176 A	11.6 A	300 A	70	50 UA	176 A
16	Chrysene (ug/kg)	36	21	58	5.1 J	190	61	33	130	5.1 J	190	56	50 U	130
16	Silver (mg/kg)	36	21	58	0.1	0.42	0.31	0.3	0.4	0.1	0.42	0.26	0.2 U	0.4
16	Benzo(a)pyrene (ug/kg)	36	19	53	11	270	71	31	190	11	270	61	50 U	170
16	Low Molecular Weight PAH (ug/kg)	36	18	50	10.8 A	184 A	58	45 A	160 A	10.8 A	184 A	54	50 UA	95 A
16	Phenanthrene (ug/kg)	36	18	50	4.3 J	160	46	26	110	4.3 J	160	48	50 U	95
16	Bis(2-ethylhexyl) phthalate (ug/kg)	36	18	50	40 JB	180	99	90 JB	180	40 JB	310 U	106	100 U	180

Table 4-5. Historical Surface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detected	Detected Concentrations Minimum	Maximum	Mean	Median	95th	Detected and Nondetected Concentrations Minimum	Maximum	Mean	Median	95th
16	Endrin aldehyde (ug/kg)	14	7	50	0.4 J	1 J	0.6	0.5 J	0.9 J	0.4 J	2 U	1.2	1 J	2 U
16	Benzo(g,h,i)perylene (ug/kg)	36	17	47	13	270	65	31	150	13	270	57	50 U	140
16	Benzo(k)fluoranthene (ug/kg)	36	17	47	5 J	140	42	22	130	5 J	140	46	50 U	79
16	Indeno(1,2,3-cd)pyrene (ug/kg)	36	17	47	11	260	65	27	170	11	260	57	50 U	160
16	Arsenic (mg/kg)	36	14	39	2.7	7.7	5.4	5.4	7.7	2.31 U	7.7	3.78	2.51 U	6.6
16	Tetrabutyltin (ug/kg)	11	4	36	0.3 J	1 J	0.55	0.4 J	0.5 J	0.3 J	3 U	2.1	3 U	3 U
16	Mercury (mg/kg)	36	13	36	0.02	0.8	0.14	0.08	0.18	0.02	0.8	0.17	0.18 U	0.2 U
16	Total of 3 isomers: pp-DDT,-DDD,-DDE (ug/k	38	13	34	0.73 A	2.7 A	1.67	1.4 A	2.6 A	0.73 A	6.7 UA	4.70	6.7 UA	6.7 UA
16	Antimony (mg/kg)	36	12	33	0.12 J	0.47 J	0.2	0.17 J	0.23 J	0.12 J	2.93 UJ	1.74	2.44 UJ	2.78 U
16	Naphthalene (ug/kg)	36	12	33	3 J	8	5	5 J	6 J	3 J	50 U	35	50 U	50 U
16	Tributyltin ion (ug/l)	24	8	33	0.006 J	0.08	0.037	0.03	0.07	0.006 J	0.08	0.042	0.05 U	0.05 UJ
16	4,4'-DDE (ug/kg)	38	12	32	0.3 J	2.6	0.8	0.6 J	1 J	0.3 J	2.6	1.8	2.3 U	2.3 U
16	2-Methylnaphthalene (ug/kg)	36	11	31	1 J	5 J	2	2 J	3 J	1 J	50 U	34	50 U	50 U
16	Anthracene (ug/kg)	36	11	31	1 J	25	6	4 J	9	1 J	50 U	36	50 U	50 U
16	Cadmium (mg/kg)	36	11	31	0.07	0.7	0.26	0.23	0.31	0.07	0.7 U	0.30	0.3 U	0.7
16	1,2,4-Trichlorobenzene (ug/kg)	36	11	31	2 JB	5 JB	4.3	5 JB	5 JB	2 JB	20 U	15	20 U	20 U
16	Diethyl phthalate (ug/kg)	36	11	31	2 J	4 J	2.9	3 J	4 J	2 J	100 U	68	100 U	100 U
16	4,4'-DDD (ug/kg)	38	11	29	0.2 J	1 J	0.5	0.4 J	0.9 J	0.2 J	3.3 U	2.4	3.3 U	3.3 U
16	Dieldrin (ug/kg)	14	4	29	0.2 J	0.6 J	0.325	0.2 J	0.3 J	0.2 J	2 U	1.4	1.6 U	2 U
16	Endosulfan sulfate (ug/kg)	14	4	29	0.2 J	0.3 J	0.25	0.2 J	0.3 J	0.2 J	2 U	1.4	1.6 U	2 U
16	Dibenz(a,h)anthracene (ug/kg)	36	10	28	2 J	32	7	4 J	8	2 J	50 U	36	50 U	50 U
16	4,4'-DDT (ug/kg)	38	10	26	0.3 J	1 J	0.6	0.6 J	0.73 JP	0.3 J	6.7 U	4.6	6.7 U	6.7 U
16	Acenaphthylene (ug/kg)	36	9	25	2 J	4 J	3	3 J	4 J	2 J	50 U	34.95	50 U	50 U
16	Dibenzofuran (ug/kg)	36	8	22	2 J	7	2.75	2 J	3 J	2 J	50 U	35	50 U	50 U
16	alpha-Endosulfan (ug/kg)	14	3	21	0.2 J	0.3 J	0.2	0.2 J	0.2 J	0.2 J	2 U	1.5	2 U	2 U
16	Heptachlor (ug/kg)	14	3	21	0.4 J	0.7 J	0.6	0.4 J	0.6 J	0.4 J	2 U	1.6	2 U	2 U
16	Fluorene (ug/kg)	36	7	19	2 J	15	5	3 J	5 J	2 J	50 U	36	50 U	50 U
16	1,2-Dichlorobenzene (ug/kg)	36	7	19	2 JB	3 JB	3	3 JB	3 JB	2 JB	20 U	10	10 U	20 U
16	Dibutyl phthalate (ug/kg)	36	6	17	3 J	8 J	4	3 J	4 J	3 J	100 U	69	100 U	100 U
16	Dibutyltin ion (ug/l)	24	4	17	0.007 J	0.03 J	0.014	0.009 J	0.01 J	0.007 J	0.1 U	0.048	0.05 U	0.05 U
16	Polychlorinated biphenyls (ug/kg)	38	5	13	11 A	130 A	57	11 A	116 A	11 A	130 A	27	20 UA	40 UA
16	Acenaphthene (ug/kg)	36	4	11	2 J	24	8	3 J	3 J	2 J	50 U	37	50 U	50 U
16	Phenol (ug/kg)	36	3	8	210 J	420 J	280	210 J	210 J	46 U	420 J	98	100 U	210 J
16	Aroclor 1254 (ug/kg)	38	3	8	7 J	17	12	7 J	11	7 J	20 U	11	10 U	17
16	Aldrin (ug/kg)	14	1	7	0.3 J	0.3 J	0.3	0.3 J	0.3 J	0.3 J	2 U	1.8	2 U	2 U
16	alpha-Chlordane (ug/kg)	14	1	7	0.2 J	0.2 J	0.2	0.2 J	0.2 J	0.2 J	2 U	1.8	2 U	2 U
16	Aroclor 1260 (ug/kg)	38	2	5	4 J	116	60	4 J	4 J	4 J	116	14	10 U	20 U
16	Benzyl alcohol (ug/kg)	36	1	3	160	160	160	160	160	16 U	160	36	25 U	50 U
16	Aroclor 1242 (ug/kg)	38	1	3	130	130	130	130	130	10 U	130	14	10 U	20 U
16	Aroclor 1016 (ug/kg)	38	0	0						10 U	20 U	11	10 U	16 U
16	Aroclor 1221 (ug/kg)	38	0	0						20 U	40 U	22	20 U	31 U
16	Aroclor 1232 (ug/kg)	38	0	0						10 U	20 U	11	10 U	16 U
16	Aroclor 1248 (ug/kg)	38	0	0						10 U	20 U	11	10 U	16 U
16	Hexachlorobutadiene (ug/kg)	36	0	0						10 U	20 U	17	20 U	20 U
16	Hexachloroethane (ug/kg)	36	0	0						16 U	50 UJ	46	50 U	50 U
16	N-Nitrosodiphenylamine (ug/kg)	36	0	0						10 U	20 U	17	20 U	20 U
16	1,3-Dichlorobenzene (ug/kg)	36	0	0						10 U	20 U	11	10 U	20 U
16	1,4-Dichlorobenzene (ug/kg)	36	0	0						10 U	20 U	11	10 U	20 U

Table 4-5. Historical Surface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detected	Detected Concentrations Minimum	Maximum	Mean	Median	95th	Detected and Nondetected Concentrations Minimum	Maximum	Mean	Median	95th
16	Butylbenzyl phthalate (ug/kg)	36	0	0						10 U	100 U	70	100 U	100 U
16	Dimethyl phthalate (ug/kg)	36	0	0						10 U	100 U	70	100 U	100 U
16	Di-n-octyl phthalate (ug/kg)	36	0	0						10 U	100 UJ	70	100 U	100 U
16	Hexachlorobenzene (ug/kg)	36	0	0						10 U	20 U	17	20 U	20 U
16	Benzoic acid (ug/kg)	33	0	0						250 U	310 U	252	250 U	250 U
16	2,4-Dimethylphenol (ug/kg)	33	0	0						20 U	200 U	82	20 U	200 U
16	2-Methylphenol (ug/kg)	33	0	0						16 U	100 U	47	20 U	100 U
16	Pentachlorophenol (ug/kg)	33	0	0						150 U	300 U	264	250 U	300 U
16	Diesel fuels (mg/kg)	26	0	0						10 U	50 U	22	10 U	50 U
16	Butyltin ion (ug/l)	24	0	0						0.05 U	0.1 U	0.06	0.05 U	0.07 U
16	Tetrabutyltin (ug/l)	24	0	0						0.05 U	0.1 UJ	0.06	0.05 U	0.07 U
16	Benzene (ug/kg)	24	0	0						5 U	10 U	6	5 U	10 U
16	Ethylbenzene (ug/kg)	24	0	0						5 U	10 U	6	5 U	10 U
16	Gasoline (mg/kg)	24	0	0						10 UJ	50 UJ	21	10 UJ	50 UJ
16	Heavy oil (mg/kg)	24	0	0						25 U	125 U	55	25 U	120 U
16	Jet fuel A (mg/kg)	24	0	0						10 U	50 U	23	10 U	50 U
16	JP-4 jet fuel (mg/kg)	24	0	0						10 U	50 UJ	23	10 UJ	50 UJ
16	Kerosene (mg/kg)	24	0	0						10 U	50 U	23	10 U	50 U
16	Lube Oil (mg/kg)	24	0	0						25 U	125 U	55	25 U	120 U
16	m,p-Xylene (ug/kg)	24	0	0						5 U	10 U	6	5 U	10 U
16	Mineral spirits (mg/kg)	24	0	0						10 U	50 U	23	10 U	50 U
16	Naphtha distillate (mg/kg)	24	0	0						10 U	50 UJ	23	10 UJ	50 UJ
16	Non-petroleum hydrocarbons (mg/kg)	24	0	0						50 U	250 U	113	50 U	250 U
16	o-Xylene (ug/kg)	24	0	0						5 U	10 U	6	5 U	10 U
16	Toluene (ug/kg)	24	0	0						5 U	10 U	6	5 U	10 U
16	Trichloroethene (ug/kg)	24	0	0						5 U	10 U	6	5 U	10 U
16	3- and 4-Methylphenol Coelution (ug/kg)	22	0	0						16 U	100 U	96	100 U	100 U
16	alpha-Hexachlorocyclohexane (ug/kg)	14	0	0						1.4 U	2 U	1.9	2 U	2 U
16	beta-Endosulfan (ug/kg)	14	0	0						1.4 U	2 U	1.9	2 U	2 U
16	beta-Hexachlorocyclohexane (ug/kg)	14	0	0						1.4 U	2 U	1.9	2 U	2 U
16	delta-Hexachlorocyclohexane (ug/kg)	14	0	0						1.4 U	2 U	1.9	2 U	2 U
16	Endrin (ug/kg)	14	0	0						1.4 U	2 U	1.9	2 U	2 U
16	Endrin ketone (ug/kg)	14	0	0						1.4 U	2 U	1.9	2 U	2 U
16	gamma-Chlordane (ug/kg)	14	0	0						1.4 U	2 U	1.9	2 U	2 U
16	gamma-Hexachlorocyclohexane (ug/kg)	14	0	0						1.4 U	2 U	1.9	2 U	2 U
16	Heptachlor epoxide (ug/kg)	14	0	0						1.4 U	2 U	1.9	2 U	2 U
16	Methoxychlor (ug/kg)	14	0	0						1.4 U	4 U	3.5	4 U	4 U
16	Toxaphene (ug/kg)	14	0	0						30 U	76 U	39	30 U	71 U
16	2,4-Dinitrotoluene (ug/kg)	11	0	0						20 U	20 U	20	20 U	20 U
16	2,6-Dinitrotoluene (ug/kg)	11	0	0						10 U	10 U	10	10 U	10 U
16	2-Chloronaphthalene (ug/kg)	11	0	0						5 U	5 U	5	5 U	5 U
16	2-Nitroaniline (ug/kg)	11	0	0						10 U	10 U	10	10 U	10 U
16	3,3'-Dichlorobenzidine (ug/kg)	11	0	0						40 U	40 U	40	40 U	40 U
16	3-Nitroaniline (ug/kg)	11	0	0						200 U	200 U	200	200 U	200 U
16	4-Bromophenyl phenyl ether (ug/kg)	11	0	0						10 U	10 U	10	10 U	10 U
16	4-Chloroaniline (ug/kg)	11	0	0						50 U	50 U	50	50 U	50 U
16	4-Chlorophenyl phenyl ether (ug/kg)	11	0	0						10 U	10 U	10	10 U	10 U
16	4-Nitroaniline (ug/kg)	11	0	0						10 U	10 U	10	10 U	10 U

Table 4-5. Historical Surface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detected	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
16	Aniline (ug/kg)	11	0	0						200 U	200 U	200	200 U	200 U
16	Bis(2-chloroethoxy) methane (ug/kg)	11	0	0						10 U	10 U	10	10 U	10 U
16	Bis(2-chloroethyl) ether (ug/kg)	11	0	0						10 U	10 U	10	10 U	10 U
16	Bis(2-chloroisopropyl) ether (ug/kg)	11	0	0						10 U	10 U	10	10 U	10 U
16	Hexachlorocyclopentadiene (ug/kg)	11	0	0						200 U	200 U	200	200 U	200 U
16	Isophorone (ug/kg)	11	0	0						10 U	10 U	10	10 U	10 U
16	Nitrobenzene (ug/kg)	11	0	0						10 U	10 U	10	10 U	10 U
16	N-Nitrosodimethylamine (ug/kg)	11	0	0						10 U	10 U	10	10 U	10 U
16	N-Nitrosodipropylamine (ug/kg)	11	0	0						10 U	10 U	10	10 U	10 U
16	2,4,5-Trichlorophenol (ug/kg)	11	0	0						40 U	40 U	40	40 U	40 U
16	2,4,6-Trichlorophenol (ug/kg)	11	0	0						30 U	30 U	30	30 U	30 U
16	2,4-Dichlorophenol (ug/kg)	11	0	0						100 U	100 U	100	100 U	100 U
16	2,4-Dinitrophenol (ug/kg)	11	0	0						300 U	300 U	300	300 U	300 U
16	2-Chlorophenol (ug/kg)	11	0	0						50 U	50 U	50	50 U	50 U
16	2-Nitrophenol (ug/kg)	11	0	0						40 U	40 U	40	40 U	40 U
16	4,6-Dinitro-2-methylphenol (ug/kg)	11	0	0						100 U	100 U	100	100 U	100 U
16	4-Chloro-3-methylphenol (ug/kg)	11	0	0						50 U	50 U	50	50 U	50 U
16	4-Methylphenol (ug/kg)	11	0	0						200 U	200 U	200	200 U	200 U
16	4-Nitrophenol (ug/kg)	11	0	0						100 U	100 U	100	100 U	100 U
16	Natural gasoline (mg/kg)	2	0	0						10 U	50 U	30	10 U	10 U
16	Residual Range Organics (mg/kg)	2	0	0						34 U	35 U	34.5	34 U	34 U
17	Sand (%)	2	2	100	49.2	58	53.6	49.2	49.2	49.2	58	53.6	49.2	49.2
17	Total solids (%)	2	2	100	55.1	57.7	56.4	55.1	55.1	55.1	57.7	56.4	55.1	55.1
17	Clay (%)	1	1	100	8	8	8	8	8	8	8	8	8	8
17	Copper (mg/kg)	1	1	100	21	21	21	21	21	21	21	21	21	21
17	Fines (%)	1	1	100	50.8	50.8	50.8	50.8	50.8	50.8	50.8	50.8	50.8	50.8
17	Lead (mg/kg)	1	1	100	9.69	9.69	9.69	9.69	9.69	9.69	9.69	9.69	9.69	9.69
17	Mean grain size (mm)	1	1	100	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
17	Nickel (mg/kg)	1	1	100	18.2 J	18.2 J	18.2	18.2 J	18.2 J	18.2 J	18.2 J	18.2	18.2 J	18.2 J
17	Silt (%)	1	1	100	34	34	34	34	34	34	34	34	34	34
17	Total organic carbon (%)	1	1	100	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12
17	Total volatile solids (%)	1	1	100	6.03	6.03	6.03	6.03	6.03	6.03	6.03	6.03	6.03	6.03
17	Zinc (mg/kg)	1	1	100	60.5 J	60.5 J	60.5	60.5 J	60.5 J	60.5 J	60.5 J	60.5	60.5 J	60.5 J
17	Bis(2-ethylhexyl) phthalate (ug/kg)	1	1	100	120	120	120	120	120	120	120	120	120	120
17	Residual Range Organics (mg/kg)	1	1	100	190 Z	190 Z	190	190 Z	190 Z	190 Z	190 Z	190	190 Z	190 Z
17	Total Petroleum Hydrocarbons (mg/kg)	1	1	100	240	240	240	240	240	240	240	240	240	240
17	Diesel fuels (mg/kg)	2	1	50	34 Z	34 Z	34	34 Z	34 Z	10 U	34 Z	22	10 U	10 U
17	4,4'-DDD (ug/kg)	2	0	0						1.8 U	3.3 U	2.55	1.8 U	1.8 U
17	4,4'-DDE (ug/kg)	2	0	0						1.8 U	2.3 U	2.05	1.8 U	1.8 U
17	4,4'-DDT (ug/kg)	2	0	0						1.8 U	6.7 U	4.25	1.8 U	1.8 U
17	Aroclor 1016 (ug/kg)	2	0	0						10 U	18 U	14	10 U	10 U
17	Aroclor 1221 (ug/kg)	2	0	0						20 U	35 U	28	20 U	20 U
17	Aroclor 1232 (ug/kg)	2	0	0						10 U	18 U	14	10 U	10 U
17	Aroclor 1242 (ug/kg)	2	0	0						10 U	18 U	14	10 U	10 U
17	Aroclor 1248 (ug/kg)	2	0	0						10 U	18 U	14	10 U	10 U
17	Aroclor 1254 (ug/kg)	2	0	0						10 U	18 U	14	10 U	10 U
17	Aroclor 1260 (ug/kg)	2	0	0						10 U	18 U	14	10 U	10 U
17	Polychlorinated biphenyls (ug/kg)	2	0	0						20 UA	35 UA	28	20 UA	20 UA

Table 4-5. Historical Surface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detected	Detected Concentrations Minimum	Maximum	Mean	Median	95th	Detected and Nondetected Concentrations Minimum	Maximum	Mean	Median	95th
17	Total of 3 isomers: pp-DDT,-DDD,-DDE (ug/k	2	0	0						1.8 UA	6.7 UA	4.3	1.8 UA	1.8 UA
17	Gasoline (mg/kg)	2	0	0						10 UJ	33 U	22	10 UJ	10 UJ
17	2-Methylnaphthalene (ug/kg)	1	0	0						50 U	50 U	50	50 U	50 U
17	Acenaphthene (ug/kg)	1	0	0						50 U	50 U	50	50 U	50 U
17	Acenaphthylene (ug/kg)	1	0	0						50 U	50 U	50	50 U	50 U
17	Anthracene (ug/kg)	1	0	0						50 U	50 U	50	50 U	50 U
17	Antimony (mg/kg)	1	0	0						2.52 UJ	2.52 UJ	2.52	2.52 UJ	2.52 UJ
17	Arsenic (mg/kg)	1	0	0						2.52 U	2.52 U	2.52	2.52 U	2.52 U
17	Benz(a)anthracene (ug/kg)	1	0	0						50 U	50 U	50	50 U	50 U
17	Benzo(a)pyrene (ug/kg)	1	0	0						50 U	50 U	50	50 U	50 U
17	Benzo(b)fluoranthene (ug/kg)	1	0	0						50 U	50 U	50	50 U	50 U
17	Benzo(b+k)fluoranthene (ug/kg)	1	0	0						50 UA	50 UA	50	50 UA	50 UA
17	Benzo(g,h,i)perylene (ug/kg)	1	0	0						50 U	50 U	50	50 U	50 U
17	Benzo(k)fluoranthene (ug/kg)	1	0	0						50 U	50 U	50	50 U	50 U
17	Benzoic acid (ug/kg)	1	0	0						250 U	250 U	250	250 U	250 U
17	Benzyl alcohol (ug/kg)	1	0	0						25 U	25 U	25	25 U	25 U
17	Butyltin ion (ug/l)	1	0	0						0.05 U	0.05 U	0.05	0.05 U	0.05 U
17	Cadmium (mg/kg)	1	0	0						0.3 UJ	0.3 UJ	0.3	0.3 UJ	0.3 UJ
17	Chrysene (ug/kg)	1	0	0						50 U	50 U	50	50 U	50 U
17	Dibenz(a,h)anthracene (ug/kg)	1	0	0						50 U	50 U	50	50 U	50 U
17	Dibenzofuran (ug/kg)	1	0	0						50 U	50 U	50	50 U	50 U
17	Dibutyltin ion (ug/l)	1	0	0						0.05 U	0.05 U	0.05	0.05 U	0.05 U
17	Fluoranthene (ug/kg)	1	0	0						50 U	50 U	50	50 U	50 U
17	Fluorene (ug/kg)	1	0	0						50 U	50 U	50	50 U	50 U
17	Hexachlorobutadiene (ug/kg)	1	0	0						20 U	20 U	20	20 U	20 U
17	Hexachloroethane (ug/kg)	1	0	0						50 UJ	50 UJ	50	50 UJ	50 UJ
17	High Molecular Weight PAH (ug/kg)	1	0	0						50 UA	50 UA	50	50 UA	50 UA
17	Indeno(1,2,3-cd)pyrene (ug/kg)	1	0	0						50 U	50 U	50	50 U	50 U
17	Low Molecular Weight PAH (ug/kg)	1	0	0						50 UA	50 UA	50	50 UA	50 UA
17	Mercury (mg/kg)	1	0	0						0.19 U	0.19 U	0.19	0.19 U	0.19 U
17	Naphthalene (ug/kg)	1	0	0						50 U	50 U	50	50 U	50 U
17	N-Nitrosodiphenylamine (ug/kg)	1	0	0						20 U	20 U	20	20 U	20 U
17	Phenanthrene (ug/kg)	1	0	0						50 U	50 U	50	50 U	50 U
17	Polycyclic Aromatic Hydrocarbons (ug/kg)	1	0	0						50 UA	50 UA	50	50 UA	50 UA
17	Pyrene (ug/kg)	1	0	0						50 U	50 U	50	50 U	50 U
17	Silver (mg/kg)	1	0	0						0.2 U	0.2 U	0.2	0.2 U	0.2 U
17	Tetrabutyltin (ug/l)	1	0	0						0.05 U	0.05 U	0.05	0.05 U	0.05 U
17	Tributyltin ion (ug/l)	1	0	0						0.05 U	0.05 U	0.05	0.05 U	0.05 U
17	1,2,4-Trichlorobenzene (ug/kg)	1	0	0						20 U	20 U	20	20 U	20 U
17	1,2-Dichlorobenzene (ug/kg)	1	0	0						10 U	10 U	10	10 U	10 U
17	1,3-Dichlorobenzene (ug/kg)	1	0	0						10 U	10 U	10	10 U	10 U
17	1,4-Dichlorobenzene (ug/kg)	1	0	0						10 U	10 U	10	10 U	10 U
17	2,4-Dimethylphenol (ug/kg)	1	0	0						20 U	20 U	20	20 U	20 U
17	2-Methylphenol (ug/kg)	1	0	0						20 U	20 U	20	20 U	20 U
17	3- and 4-Methylphenol Coelution (ug/kg)	1	0	0						100 U	100 U	100	100 U	100 U
17	Aldrin (ug/kg)	1	0	0						1.8 U	1.8 U	1.8	1.8 U	1.8 U
17	alpha-Chlordane (ug/kg)	1	0	0						1.8 U	1.8 U	1.8	1.8 U	1.8 U
17	alpha-Endosulfan (ug/kg)	1	0	0						1.8 U	1.8 U	1.8	1.8 U	1.8 U

Table 4-5. Historical Surface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detected	Detected Concentrations Minimum	Maximum	Mean	Median	95th	Detected and Nondetected Concentrations Minimum	Maximum	Mean	Median	95th
17	alpha-Hexachlorocyclohexane (ug/kg)	1	0	0						1.8 U	1.8 U	1.8	1.8 U	1.8 U
17	Benzene (ug/kg)	1	0	0						5 U	5 U	5	5 U	5 U
17	beta-Endosulfan (ug/kg)	1	0	0						1.8 U	1.8 U	1.8	1.8 U	1.8 U
17	beta-Hexachlorocyclohexane (ug/kg)	1	0	0						1.8 U	1.8 U	1.8	1.8 U	1.8 U
17	Butylbenzyl phthalate (ug/kg)	1	0	0						100 U	100 U	100	100 U	100 U
17	delta-Hexachlorocyclohexane (ug/kg)	1	0	0						1.8 U	1.8 U	1.8	1.8 U	1.8 U
17	Dibutyl phthalate (ug/kg)	1	0	0						100 U	100 U	100	100 U	100 U
17	Dieldrin (ug/kg)	1	0	0						1.8 U	1.8 U	1.8	1.8 U	1.8 U
17	Diethyl phthalate (ug/kg)	1	0	0						100 U	100 U	100	100 U	100 U
17	Dimethyl phthalate (ug/kg)	1	0	0						100 U	100 U	100	100 U	100 U
17	Di-n-octyl phthalate (ug/kg)	1	0	0						100 U	100 U	100	100 U	100 U
17	Endosulfan sulfate (ug/kg)	1	0	0						1.8 U	1.8 U	1.8	1.8 U	1.8 U
17	Endrin (ug/kg)	1	0	0						1.8 U	1.8 U	1.8	1.8 U	1.8 U
17	Endrin aldehyde (ug/kg)	1	0	0						1.8 U	1.8 U	1.8	1.8 U	1.8 U
17	Endrin ketone (ug/kg)	1	0	0						1.8 U	1.8 U	1.8	1.8 U	1.8 U
17	Ethylbenzene (ug/kg)	1	0	0						5 U	5 U	5	5 U	5 U
17	gamma-Chlordane (ug/kg)	1	0	0						1.8 U	1.8 U	1.8	1.8 U	1.8 U
17	gamma-Hexachlorocyclohexane (ug/kg)	1	0	0						1.8 U	1.8 U	1.8	1.8 U	1.8 U
17	Heavy oil (mg/kg)	1	0	0						25 U	25 U	25	25 U	25 U
17	Heptachlor (ug/kg)	1	0	0						1.8 U	1.8 U	1.8	1.8 U	1.8 U
17	Heptachlor epoxide (ug/kg)	1	0	0						1.8 U	1.8 U	1.8	1.8 U	1.8 U
17	Hexachlorobenzene (ug/kg)	1	0	0						20 U	20 U	20	20 U	20 U
17	Jet fuel A (mg/kg)	1	0	0						10 U	10 U	10	10 U	10 U
17	JP-4 jet fuel (mg/kg)	1	0	0						10 UJ	10 UJ	10	10 UJ	10 UJ
17	Kerosene (mg/kg)	1	0	0						10 U	10 U	10	10 U	10 U
17	Lube Oil (mg/kg)	1	0	0						25 U	25 U	25	25 U	25 U
17	m,p-Xylene (ug/kg)	1	0	0						5 U	5 U	5	5 U	5 U
17	Methoxychlor (ug/kg)	1	0	0						1.8 U	1.8 U	1.8	1.8 U	1.8 U
17	Mineral spirits (mg/kg)	1	0	0						10 U	10 U	10	10 U	10 U
17	Naphtha distillate (mg/kg)	1	0	0						10 UJ	10 UJ	10	10 UJ	10 UJ
17	Non-petroleum hydrocarbons (mg/kg)	1	0	0						50 U	50 U	50	50 U	50 U
17	o-Xylene (ug/kg)	1	0	0						5 U	5 U	5	5 U	5 U
17	Pentachlorophenol (ug/kg)	1	0	0						250 U	250 U	250	250 U	250 U
17	Phenol (ug/kg)	1	0	0						100 U	100 U	100	100 U	100 U
17	Toluene (ug/kg)	1	0	0						5 U	5 U	5	5 U	5 U
17	Toxaphene (ug/kg)	1	0	0						87 U	87 U	87	87 U	87 U
17	Trichloroethene (ug/kg)	1	0	0						5 U	5 U	5	5 U	5 U
18	Fines (%)	3	3	100	2.42	63.9	27	2.42	16	2.42	63.9	27.4	2.42	16
18	Sand (%)	3	3	100	36.1	97.49	72	36.1	83.9	36.1	97.49	72	36.1	83.9
18	Gravel (%)	2	2	100	0.09	0.1	0.10	0.09	0.09	0.09	0.1	0.10	0.09	0.09
18	Mean grain size (mm)	2	2	100	0.04	0.11	0.08	0.04	0.04	0.04	0.11	0.08	0.04	0.04
18	Total solids (%)	2	2	100	52.1	66.9	59.5	52.1	52.1	52.1	66.9	59.5	52.1	52.1
18	Total volatile solids (%)	2	2	100	4.27	7.11	5.69	4.27	4.27	4.27	7.11	5.69	4.27	4.27
18	Residual Range Organics (mg/kg)	2	2	100	72 Z	290 Z	181	72 Z	72 Z	72 Z	290 Z	181	72 Z	72 Z
18	Arsenic (mg/kg)	1	1	100	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1
18	Benz(a)anthracene (ug/kg)	1	1	100	11	11	11	11	11	11	11	11	11	11
18	Benzo(a)pyrene (ug/kg)	1	1	100	12	12	12	12	12	12	12	12	12	12
18	Benzo(b)fluoranthene (ug/kg)	1	1	100	15	15	15	15	15	15	15	15	15	15

Table 4-5. Historical Surface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detected	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
18	Benzo(b+k)fluoranthene (ug/kg)	1	1	100	15 A	15 A	15	15 A	15 A	15 A	15 A	15	15 A	15 A
18	Chrysene (ug/kg)	1	1	100	15	15	15	15	15	15	15	15	15	15
18	Fluoranthene (ug/kg)	1	1	100	19	19	19	19	19	19	19	19	19	19
18	High Molecular Weight PAH (ug/kg)	1	1	100	91 A	91 A	91	91 A	91 A	91 A	91 A	91	91 A	91 A
18	Median grain size (mm)	1	1	100	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
18	Polycyclic Aromatic Hydrocarbons (ug/kg)	1	1	100	91 A	91 A	91	91 A	91 A	91 A	91 A	91	91 A	91 A
18	Pyrene (ug/kg)	1	1	100	19	19	19	19	19	19	19	19	19	19
18	Diesel fuels (mg/kg)	2	1	50	56 Z	56 Z	56	56 Z	56 Z	28 U	56 Z	42	28 U	28 U
18	4,4'-DDD (ug/kg)	2	0	0						1.5 U	2 U	1.8	1.5 U	1.5 U
18	4,4'-DDE (ug/kg)	2	0	0						1.5 U	2 U	1.8	1.5 U	1.5 U
18	4,4'-DDT (ug/kg)	2	0	0						1.5 U	2 U	1.8	1.5 U	1.5 U
18	Aroclor 1016 (ug/kg)	2	0	0						15 U	20 U	17.5	15 U	15 U
18	Aroclor 1221 (ug/kg)	2	0	0						30 U	39 U	35	30 U	30 U
18	Aroclor 1232 (ug/kg)	2	0	0						15 U	20 U	18	15 U	15 U
18	Aroclor 1242 (ug/kg)	2	0	0						15 U	20 U	18	15 U	15 U
18	Aroclor 1248 (ug/kg)	2	0	0						15 U	20 U	18	15 U	15 U
18	Aroclor 1254 (ug/kg)	2	0	0						15 U	20 U	18	15 U	15 U
18	Aroclor 1260 (ug/kg)	2	0	0						15 U	20 U	18	15 U	15 U
18	Polychlorinated biphenyls (ug/kg)	2	0	0						30 UA	39 UA	35	30 UA	30 UA
18	Total of 3 isomers: pp-DDT,-DDD,-DDE (ug/k	2	0	0						1.5 UA	2 UA	1.8	1.5 UA	1.5 UA
18	Aldrin (ug/kg)	2	0	0						1.5 U	2 U	1.8	1.5 U	1.5 U
18	alpha-Chlordane (ug/kg)	2	0	0						1.5 U	2 U	1.8	1.5 U	1.5 U
18	alpha-Endosulfan (ug/kg)	2	0	0						1.5 U	2 U	1.8	1.5 U	1.5 U
18	alpha-Hexachlorocyclohexane (ug/kg)	2	0	0						1.5 U	2 U	1.8	1.5 U	1.5 U
18	beta-Endosulfan (ug/kg)	2	0	0						1.5 U	2 U	1.8	1.5 U	1.5 U
18	beta-Hexachlorocyclohexane (ug/kg)	2	0	0						1.5 U	2 U	1.8	1.5 U	1.5 U
18	delta-Hexachlorocyclohexane (ug/kg)	2	0	0						1.5 U	2 U	1.8	1.5 U	1.5 U
18	Dieldrin (ug/kg)	2	0	0						1.5 U	2 U	1.8	1.5 U	1.5 U
18	Endosulfan sulfate (ug/kg)	2	0	0						1.5 U	2 U	1.8	1.5 U	1.5 U
18	Endrin (ug/kg)	2	0	0						1.5 U	2 U	1.8	1.5 U	1.5 U
18	Endrin aldehyde (ug/kg)	2	0	0						1.5 U	2 U	1.8	1.5 U	1.5 U
18	Endrin ketone (ug/kg)	2	0	0						1.5 U	2 U	1.8	1.5 U	1.5 U
18	gamma-Chlordane (ug/kg)	2	0	0						1.5 U	2 U	1.8	1.5 U	1.5 U
18	gamma-Hexachlorocyclohexane (ug/kg)	2	0	0						1.5 U	2 U	1.8	1.5 U	1.5 U
18	Gasoline (mg/kg)	2	0	0						28 U	37 U	33	28 U	28 U
18	Heptachlor (ug/kg)	2	0	0						1.5 U	2 U	1.8	1.5 U	1.5 U
18	Heptachlor epoxide (ug/kg)	2	0	0						1.5 U	2 U	1.8	1.5 U	1.5 U
18	Methoxychlor (ug/kg)	2	0	0						1.5 U	2 U	1.8	1.5 U	1.5 U
18	Toxaphene (ug/kg)	2	0	0						75 U	96 U	86	75 U	75 U
18	Acenaphthene (ug/kg)	1	0	0						10 U	10 U	10	10 U	10 U
18	Acenaphthylene (ug/kg)	1	0	0						10 U	10 U	10	10 U	10 U
18	Anthracene (ug/kg)	1	0	0						10 U	10 U	10	10 U	10 U
18	Benzo(g,h,i)perylene (ug/kg)	1	0	0						10 U	10 U	10	10 U	10 U
18	Benzo(k)fluoranthene (ug/kg)	1	0	0						10 U	10 U	10	10 U	10 U
18	Dibenz(a,h)anthracene (ug/kg)	1	0	0						10 U	10 U	10	10 U	10 U
18	Fluorene (ug/kg)	1	0	0						10 U	10 U	10	10 U	10 U
18	Indeno(1,2,3-cd)pyrene (ug/kg)	1	0	0						10 U	10 U	10	10 U	10 U
18	Low Molecular Weight PAH (ug/kg)	1	0	0						10 UA	10 UA	10	10 UA	10 UA

Table 4-5. Historical Surface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detected	Detected Concentrations Minimum	Maximum	Mean	Median	95th	Detected and Nondetected Concentrations Minimum	Maximum	Mean	Median	95th
18	Naphthalene (ug/kg)	1	0	0						10 U	10 U	10	10 U	10 U
18	Phenanthrene (ug/kg)	1	0	0						10 U	10 U	10	10 U	10 U
18	Pentachlorophenol (ug/kg)	1	0	0						60 U	60 U	60	60 U	60 U
19	Fines (%)	3	3	100	3.3	66.3	42	3.3	55	3.3	66.3	42	3.3	55
19	Total volatile solids (%)	3	3	100	2.35	7.23	5.25	2.35	6.16	2.35	7.23	5.25	2.35	6.16
19	Gravel (%)	2	2	100	0.1	19.6	9.85	0.1	0.1	0.1	19.6	9.85	0.1	0.1
19	Mean grain size (mm)	2	2	100	0.03	1.55	0.79	0.03	0.03	0.03	1.55	0.79	0.03	0.03
19	Sand (%)	2	2	100	45	77.1	61	45	45	45	77.1	61	45	45
19	Total solids (%)	2	2	100	54.1	77.9	66	54.1	54.1	54.1	77.9	66	54.1	54.1
19	Acenaphthylene (ug/kg)	1	1	100	4.5 J	4.5 J	4.5	4.5 J	4.5 J	4.5 J	4.5 J	4.5	4.5 J	4.5 J
19	Antimony (mg/kg)	1	1	100	0.06 J	0.06 J	0.06	0.06 J	0.06 J	0.06 J	0.06 J	0.06	0.06 J	0.06 J
19	Arsenic (mg/kg)	1	1	100	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3
19	Benz(a)anthracene (ug/kg)	1	1	100	8.1 J	8.1 J	8.1	8.1 J	8.1 J	8.1 J	8.1 J	8.1	8.1 J	8.1 J
19	Benzo(a)pyrene (ug/kg)	1	1	100	8.8 J	8.8 J	8.8	8.8 J	8.8 J	8.8 J	8.8 J	8.8	8.8 J	8.8 J
19	Benzo(b)fluoranthene (ug/kg)	1	1	100	11 J	11 J	11	11 J	11 J	11 J	11 J	11	11 J	11 J
19	Benzo(b+k)fluoranthene (ug/kg)	1	1	100	15.4 A	15.4 A	15.4	15.4 A	15.4 A	15.4 A	15.4 A	15.4	15.4 A	15.4 A
19	Benzo(g,h,i)perylene (ug/kg)	1	1	100	9.6 J	9.6 J	9.6	9.6 J	9.6 J	9.6 J	9.6 J	9.6	9.6 J	9.6 J
19	Benzo(k)fluoranthene (ug/kg)	1	1	100	4.4 J	4.4 J	4.4	4.4 J	4.4 J	4.4 J	4.4 J	4.4	4.4 J	4.4 J
19	Benzoic acid (ug/kg)	1	1	100	64 J	64 J	64	64 J	64 J	64 J	64 J	64	64 J	64 J
19	Cadmium (mg/kg)	1	1	100	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
19	Chromium (mg/kg)	1	1	100	40.5	40.5	40.5	40.5	40.5	40.5	40.5	40.5	40.5	40.5
19	Chrysene (ug/kg)	1	1	100	9.5 J	9.5 J	9.5	9.5 J	9.5 J	9.5 J	9.5 J	9.5	9.5 J	9.5 J
19	Coarse sand (%)	1	1	100	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
19	Copper (mg/kg)	1	1	100	50.9	50.9	50.9	50.9	50.9	50.9	50.9	50.9	50.9	50.9
19	Dibutyltin ion (ug/l)	1	1	100	0.03 J	0.03 J	0.03	0.03 J	0.03 J	0.03 J	0.03 J	0.03	0.03 J	0.03 J
19	Fine sand (%)	1	1	100	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8
19	Fluoranthene (ug/kg)	1	1	100	18 J	18 J	18	18 J	18 J	18 J	18 J	18	18 J	18 J
19	High Molecular Weight PAH (ug/kg)	1	1	100	96.6 A	96.6 A	96.6	96.6 A	96.6 A	96.6 A	96.6 A	96.6	96.6 A	96.6 A
19	Indeno(1,2,3-cd)pyrene (ug/kg)	1	1	100	8.2 J	8.2 J	8.2	8.2 J	8.2 J	8.2 J	8.2 J	8.2	8.2 J	8.2 J
19	Lead (mg/kg)	1	1	100	12.6	12.6	12.6	12.6	12.6	12.6	12.6	12.6	12.6	12.6
19	Low Molecular Weight PAH (ug/kg)	1	1	100	23.3 A	23.3 A	23.3	23.3 A	23.3 A	23.3 A	23.3 A	23.3	23.3 A	23.3 A
19	Median grain size (mm)	1	1	100	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
19	Medium sand (%)	1	1	100	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
19	Mercury (mg/kg)	1	1	100	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
19	Naphthalene (ug/kg)	1	1	100	7.8 J	7.8 J	7.8	7.8 J	7.8 J	7.8 J	7.8 J	7.8	7.8 J	7.8 J
19	Nickel (mg/kg)	1	1	100	35.7	35.7	35.7	35.7	35.7	35.7	35.7	35.7	35.7	35.7
19	Phenanthrene (ug/kg)	1	1	100	11 J	11 J	11	11 J	11 J	11 J	11 J	11	11 J	11 J
19	Polycyclic Aromatic Hydrocarbons (ug/kg)	1	1	100	119.9 A	119.9 A	119.9	119.9 A	119.9 A	119.9 A	119.9 A	119.9	119.9 A	119.9 A
19	Pyrene (ug/kg)	1	1	100	19 J	19 J	19	19 J	19 J	19 J	19 J	19	19 J	19 J
19	Silver (mg/kg)	1	1	100	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21
19	Total organic carbon (%)	1	1	100	1.77	1.77	1.77	1.77	1.77	1.77	1.77	1.77	1.77	1.77
19	Tributyltin ion (ug/l)	1	1	100	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
19	Very coarse sand (%)	1	1	100	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
19	Very fine sand (%)	1	1	100	24.5	24.5	24.5	24.5	24.5	24.5	24.5	24.5	24.5	24.5
19	Zinc (mg/kg)	1	1	100	96.8	96.8	96.8	96.8	96.8	96.8	96.8	96.8	96.8	96.8
19	3- and 4-Methylphenol Coelution (ug/kg)	1	1	100	11 J	11 J	11	11 J	11 J	11 J	11 J	11	11 J	11 J
19	Dibutyl phthalate (ug/kg)	1	1	100	9 J	9 J	9	9 J	9 J	9 J	9 J	9	9 J	9 J
19	Diesel fuels (mg/kg)	2	1	50	39 Z	39 Z	39	39 Z	39 Z	13 U	39 Z	26	13 U	13 U

Table 4-5. Historical Surface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detected	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
19	Residual Range Organics (mg/kg)	2	1	50	230 Z	230 Z	230	230 Z	230 Z	32 U	230 Z	131	32 U	32 U
19	4,4'-DDD (ug/kg)	3	1	33	0.99 JP	0.99 JP	0.99	0.99 JP	0.99 JP	0.99 JP	1.9 U	1.4	0.99 JP	1.3 U
19	4,4'-DDE (ug/kg)	3	1	33	0.76 J	0.76 J	0.76	0.76 J	0.76 J	0.76 J	1.9 U	1.32	0.76 J	1.3 U
19	4,4'-DDT (ug/kg)	3	1	33	1.4 JP	1.4 JP	1.4	1.4 JP	1.4 JP	1.3 U	1.9 U	1.5	1.3 U	1.4 JP
19	Total of 3 isomers: pp-DDT,-DDD,-DDE (ug/k	3	1	33	3.15 A	3.15 A	3.15	3.15 A	3.15 A	1.3 UA	3.15 A	2.1	1.3 UA	1.9 UA
19	Aroclor 1016 (ug/kg)	3	0	0						13 U	21 U	18	13 U	19 U
19	Aroclor 1221 (ug/kg)	3	0	0						26 U	42 U	35	26 U	37 U
19	Aroclor 1232 (ug/kg)	3	0	0						13 U	21 U	18	13 U	19 U
19	Aroclor 1242 (ug/kg)	3	0	0						13 U	21 U	18	13 U	19 U
19	Aroclor 1248 (ug/kg)	3	0	0						13 U	21 U	18	13 U	19 U
19	Aroclor 1254 (ug/kg)	3	0	0						13 U	21 U	18	13 U	19 U
19	Aroclor 1260 (ug/kg)	3	0	0						13 U	21 U	18	13 U	19 U
19	Polychlorinated biphenyls (ug/kg)	3	0	0						26 UA	42 UA	35	26 UA	37 UA
19	Aldrin (ug/kg)	3	0	0						1.3 U	2.1 U	1.8	1.3 U	1.9 U
19	alpha-Chlordane (ug/kg)	3	0	0						1.3 U	2.1 U	1.8	1.3 U	1.9 U
19	alpha-Endosulfan (ug/kg)	3	0	0						1.3 U	2.1 U	1.8	1.3 U	1.9 U
19	alpha-Hexachlorocyclohexane (ug/kg)	3	0	0						1.3 U	2.1 U	1.8	1.3 U	1.9 U
19	beta-Endosulfan (ug/kg)	3	0	0						1.3 U	2.1 U	1.8	1.3 U	1.9 U
19	beta-Hexachlorocyclohexane (ug/kg)	3	0	0						1.3 U	2.1 U	1.8	1.3 U	1.9 U
19	delta-Hexachlorocyclohexane (ug/kg)	3	0	0						1.3 U	2.1 U	1.8	1.3 U	1.9 U
19	Dieldrin (ug/kg)	3	0	0						1.3 U	2.1 U	1.8	1.3 U	1.9 U
19	Endosulfan sulfate (ug/kg)	3	0	0						1.3 U	2.1 U	1.8	1.3 U	1.9 U
19	Endrin (ug/kg)	3	0	0						1.3 U	2.1 U	1.8	1.3 U	1.9 U
19	Endrin aldehyde (ug/kg)	3	0	0						1.3 U	2.1 U	1.8	1.3 U	1.9 U
19	Endrin ketone (ug/kg)	3	0	0						1.3 U	2.1 U	1.8	1.3 U	1.9 U
19	gamma-Chlordane (ug/kg)	3	0	0						1.3 U	2.1 U	1.8	1.3 U	1.9 U
19	gamma-Hexachlorocyclohexane (ug/kg)	3	0	0						1.3 U	2.1 U	1.8	1.3 U	1.9 U
19	Heptachlor (ug/kg)	3	0	0						1.3 U	2.1 U	1.8	1.3 U	1.9 U
19	Heptachlor epoxide (ug/kg)	3	0	0						1.3 U	2.1 U	1.8	1.3 U	1.9 U
19	Methoxychlor (ug/kg)	3	0	0						1.3 U	2.4 U	1.9	1.3 U	1.9 U
19	Toxaphene (ug/kg)	3	0	0						65 U	110 U	89	65 U	93 U
19	Gasoline (mg/kg)	2	0	0						13 U	35 U	24	13 U	13 U
19	2-Methylnaphthalene (ug/kg)	1	0	0						21 U	21 U	21	21 U	21 U
19	Acenaphthene (ug/kg)	1	0	0						21 U	21 U	21	21 U	21 U
19	Anthracene (ug/kg)	1	0	0						21 U	21 U	21	21 U	21 U
19	Benzyl alcohol (ug/kg)	1	0	0						21 U	21 U	21	21 U	21 U
19	Butyltin ion (ug/l)	1	0	0						0.05 U	0.05 U	0.05	0.05 U	0.05 U
19	Dibenz(a,h)anthracene (ug/kg)	1	0	0						21 U	21 U	21	21 U	21 U
19	Dibenzofuran (ug/kg)	1	0	0						21 U	21 U	21	21 U	21 U
19	Fluorene (ug/kg)	1	0	0						21 U	21 U	21	21 U	21 U
19	Hexachlorobutadiene (ug/kg)	1	0	0						21 U	21 U	21	21 U	21 U
19	Hexachloroethane (ug/kg)	1	0	0						21 U	21 U	21	21 U	21 U
19	N-Nitrosodiphenylamine (ug/kg)	1	0	0						21 U	21 U	21	21 U	21 U
19	Tetrabutyltin (ug/l)	1	0	0						0.05 U	0.05 U	0.05	0.05 U	0.05 U
19	1,2,4-Trichlorobenzene (ug/kg)	1	0	0						21 U	21 U	21	21 U	21 U
19	1,2-Dichlorobenzene (ug/kg)	1	0	0						21 U	21 U	21	21 U	21 U
19	1,3-Dichlorobenzene (ug/kg)	1	0	0						21 U	21 U	21	21 U	21 U
19	1,4-Dichlorobenzene (ug/kg)	1	0	0						21 U	21 U	21	21 U	21 U

Table 4-5. Historical Surface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detected	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
19	2,4-Dimethylphenol (ug/kg)	1	0	0						110 U	110 U	110	110 U	110 U
19	2-Methylphenol (ug/kg)	1	0	0						21 U	21 U	21	21 U	21 U
19	Bis(2-ethylhexyl) phthalate (ug/kg)	1	0	0						420 U	420 U	420	420 U	420 U
19	Butylbenzyl phthalate (ug/kg)	1	0	0						21 U	21 U	21	21 U	21 U
19	Diethyl phthalate (ug/kg)	1	0	0						21 U	21 U	21	21 U	21 U
19	Dimethyl phthalate (ug/kg)	1	0	0						21 U	21 U	21	21 U	21 U
19	Di-n-octyl phthalate (ug/kg)	1	0	0						21 U	21 U	21	21 U	21 U
19	Hexachlorobenzene (ug/kg)	1	0	0						21 U	21 U	21	21 U	21 U
19	Pentachlorophenol (ug/kg)	1	0	0						210 U	210 U	210	210 U	210 U
19	Phenol (ug/kg)	1	0	0						63 U	63 U	63	63 U	63 U
22	Arsenic (mg/kg)	1	1	100	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3
22	Fines (%)	1	1	100	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28
22	Gravel (%)	1	1	100	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36
22	Sand (%)	1	1	100	99.36	99.36	99.36	99.36	99.36	99.36	99.36	99.36	99.36	99.36
22	Acenaphthene (ug/kg)	1	0	0						10 U	10 U	10	10 U	10 U
22	Acenaphthylene (ug/kg)	1	0	0						10 U	10 U	10	10 U	10 U
22	Anthracene (ug/kg)	1	0	0						10 U	10 U	10	10 U	10 U
22	Benz(a)anthracene (ug/kg)	1	0	0						10 U	10 U	10	10 U	10 U
22	Benzo(a)pyrene (ug/kg)	1	0	0						10 U	10 U	10	10 U	10 U
22	Benzo(b)fluoranthene (ug/kg)	1	0	0						10 U	10 U	10	10 U	10 U
22	Benzo(b+k)fluoranthene (ug/kg)	1	0	0						10 UA	10 UA	10	10 UA	10 UA
22	Benzo(g,h,i)perylene (ug/kg)	1	0	0						10 U	10 U	10	10 U	10 U
22	Benzo(k)fluoranthene (ug/kg)	1	0	0						10 U	10 U	10	10 U	10 U
22	Chrysene (ug/kg)	1	0	0						10 U	10 U	10	10 U	10 U
22	Dibenz(a,h)anthracene (ug/kg)	1	0	0						10 U	10 U	10	10 U	10 U
22	Fluoranthene (ug/kg)	1	0	0						10 U	10 U	10	10 U	10 U
22	Fluorene (ug/kg)	1	0	0						10 U	10 U	10	10 U	10 U
22	High Molecular Weight PAH (ug/kg)	1	0	0						10 UA	10 UA	10	10 UA	10 UA
22	Indeno(1,2,3-cd)pyrene (ug/kg)	1	0	0						10 U	10 U	10	10 U	10 U
22	Low Molecular Weight PAH (ug/kg)	1	0	0						10 UA	10 UA	10	10 UA	10 UA
22	Naphthalene (ug/kg)	1	0	0						10 U	10 U	10	10 U	10 U
22	Phenanthrene (ug/kg)	1	0	0						10 U	10 U	10	10 U	10 U
22	Polycyclic Aromatic Hydrocarbons (ug/kg)	1	0	0						10 UA	10 UA	10	10 UA	10 UA
22	Pyrene (ug/kg)	1	0	0						10 U	10 U	10	10 U	10 U
22	Pentachlorophenol (ug/kg)	1	0	0						60 U	60 U	60	60 U	60 U
23	Fines (%)	2	2	100	0.46	38.5	19.48	0.46	0.46	0.46	38.5	19.48	0.46	0.46
23	Gravel (%)	2	2	100	0.2	0.39	0.30	0.2	0.2	0.2	0.39	0.30	0.2	0.2
23	Arsenic (mg/kg)	1	1	100	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
23	Benz(a)anthracene (ug/kg)	1	1	100	20	20	20	20	20	20	20	20	20	20
23	Benzo(a)pyrene (ug/kg)	1	1	100	28	28	28	28	28	28	28	28	28	28
23	Benzo(b)fluoranthene (ug/kg)	1	1	100	32	32	32	32	32	32	32	32	32	32
23	Benzo(b+k)fluoranthene (ug/kg)	1	1	100	43 A	43 A	43	43 A	43 A	43 A	43 A	43	43 A	43 A
23	Benzo(g,h,i)perylene (ug/kg)	1	1	100	18	18	18	18	18	18	18	18	18	18
23	Benzo(k)fluoranthene (ug/kg)	1	1	100	11	11	11	11	11	11	11	11	11	11
23	Chrysene (ug/kg)	1	1	100	32	32	32	32	32	32	32	32	32	32
23	Coarse sand (%)	1	1	100	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2
23	Fine sand (%)	1	1	100	17.5	17.5	17.5	17.5	17.5	17.5	17.5	17.5	17.5	17.5
23	Fluoranthene (ug/kg)	1	1	100	75	75	75	75	75	75	75	75	75	75

Table 4-5. Historical Surface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detected	Detected Concentrations Minimum	Maximum	Mean	Median	95th	Detected and Nondetected Concentrations Minimum	Maximum	Mean	Median	95th
23	High Molecular Weight PAH (ug/kg)	1	1	100	305 A	305 A	305	305 A	305 A	305 A	305 A	305	305 A	305 A
23	Indeno(1,2,3-cd)pyrene (ug/kg)	1	1	100	14	14	14	14	14	14	14	14	14	14
23	Low Molecular Weight PAH (ug/kg)	1	1	100	71 A	71 A	71	71 A	71 A	71 A	71 A	71	71 A	71 A
23	Medium sand (%)	1	1	100	25	25	25	25	25	25	25	25	25	25
23	Phenanthrene (ug/kg)	1	1	100	71	71	71	71	71	71	71	71	71	71
23	Polycyclic Aromatic Hydrocarbons (ug/kg)	1	1	100	376 A	376 A	376	376 A	376 A	376 A	376 A	376	376 A	376 A
23	Pyrene (ug/kg)	1	1	100	75	75	75	75	75	75	75	75	75	75
23	Sand (%)	1	1	100	99.15	99.15	99.15	99.15	99.15	99.15	99.15	99.15	99.15	99.15
23	Total organic carbon (%)	1	1	100	1.49	1.49	1.49	1.49	1.49	1.49	1.49	1.49	1.49	1.49
23	Total solids (%)	1	1	100	54.3	54.3	54.3	54.3	54.3	54.3	54.3	54.3	54.3	54.3
23	Total volatile solids (%)	1	1	100	4.83	4.83	4.83	4.83	4.83	4.83	4.83	4.83	4.83	4.83
23	Very coarse sand (%)	1	1	100	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
23	Very fine sand (%)	1	1	100	16.1	16.1	16.1	16.1	16.1	16.1	16.1	16.1	16.1	16.1
23	Acenaphthene (ug/kg)	1	0	0						10 U	10 U	10	10 U	10 U
23	Acenaphthylene (ug/kg)	1	0	0						10 U	10 U	10	10 U	10 U
23	Anthracene (ug/kg)	1	0	0						10 U	10 U	10	10 U	10 U
23	Dibenz(a,h)anthracene (ug/kg)	1	0	0						10 U	10 U	10	10 U	10 U
23	Fluorene (ug/kg)	1	0	0						10 U	10 U	10	10 U	10 U
23	Naphthalene (ug/kg)	1	0	0						10 U	10 U	10	10 U	10 U
23	Pentachlorophenol (ug/kg)	1	0	0						60 U	60 U	60	60 U	60 U
24	Fines (%)	8	8	100	1.05	89.9	48.6	51.1	73.2	1.05	89.9	49	51.1	73.2
24	Total volatile solids (%)	7	7	100	4.39	7.41	5.9	5	6.65	4.39	7.41	5.9	5	6.65
24	Gravel (%)	6	6	100	0.1	0.3	0.1	0.1	0.15	0.1	0.3	0.1	0.1	0.15
24	Total solids (%)	6	6	100	33.2	59.3	49.1	50.9	57.5	33.2	59.3	49.1	50.9	57.5
24	Coarse sand (%)	5	5	100	0.2	1.6	0.6	0.3	0.5	0.2	1.6	0.6	0.3	0.5
24	Fine sand (%)	5	5	100	5	29.9	18.6	6.2	26.7	5	29.9	19	6.2	26.7
24	Medium sand (%)	5	5	100	0.6	25.6	9.28	2.1	13.5	0.6	25.6	9.28	2.1	13.5
24	Total organic carbon (%)	5	5	100	1.18	2.27	1.60	1.23	2.04	1.18	2.27	1.60	1.23	2.04
24	Very coarse sand (%)	5	5	100	0.1	0.3	0.26	0.3	0.3	0.1	0.3	0.26	0.3	0.3
24	Very fine sand (%)	5	5	100	2.2	21.2	13.5	7.9	19.3	2.2	21.2	13.5	7.9	19.3
24	Sand (%)	3	3	100	41.2	98.8	66.5	41.2	59.4	41.2	98.8	66	41.2	59.4
24	Arsenic (mg/kg)	2	2	100	3	3.3	3.15	3	3	3	3.3	3.15	3	3
24	Mean grain size (mm)	2	2	100	0.07	0.11	0.09	0.07	0.07	0.07	0.11	0.09	0.07	0.07
24	Residual Range Organics (mg/kg)	2	2	100	160 Z	200 Z	180	160 Z	160 Z	160 Z	200 Z	180	160 Z	160 Z
24	Antimony (mg/kg)	1	1	100	0.05 J	0.05 J	0.05	0.05 J	0.05 J	0.05 J	0.05 J	0.05	0.05 J	0.05 J
24	Benzoic acid (ug/kg)	1	1	100	35 J	35 J	35	35 J	35 J	35 J	35 J	35	35 J	35 J
24	Cadmium (mg/kg)	1	1	100	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
24	Chromium (mg/kg)	1	1	100	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4
24	Copper (mg/kg)	1	1	100	34.1	34.1	34.1	34.1	34.1	34.1	34.1	34.1	34.1	34.1
24	Dibutyltin ion (ug/l)	1	1	100	0.01 J	0.01 J	0.01	0.01 J	0.01 J	0.01 J	0.01 J	0.01	0.01 J	0.01 J
24	Lead (mg/kg)	1	1	100	9.21	9.21	9.21	9.21	9.21	9.21	9.21	9.21	9.21	9.21
24	Median grain size (mm)	1	1	100	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
24	Mercury (mg/kg)	1	1	100	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
24	Nickel (mg/kg)	1	1	100	27.2	27.2	27.2	27.2	27.2	27.2	27.2	27.2	27.2	27.2
24	Silver (mg/kg)	1	1	100	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14
24	Tributyltin ion (ug/l)	1	1	100	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
24	Zinc (mg/kg)	1	1	100	72.7	72.7	72.7	72.7	72.7	72.7	72.7	72.7	72.7	72.7
24	3- and 4-Methylphenol Coelution (ug/kg)	1	1	100	7.3 J	7.3 J	7.3	7.3 J	7.3 J	7.3 J	7.3 J	7.3	7.3 J	7.3 J

Table 4-5. Historical Surface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detected	Detected Concentrations Minimum	Maximum	Mean	Median	95th	Detected and Nondetected Concentrations Minimum	Maximum	Mean	Median	95th
24	Dibutyl phthalate (ug/kg)	1	1	100	6.5 J	6.5 J	6.5	6.5 J	6.5 J	6.5 J	6.5 J	6.5	6.5 J	6.5 J
24	Phenol (ug/kg)	1	1	100	11 J	11 J	11	11 J	11 J	11 J	11 J	11	11 J	11 J
24	Acenaphthylene (ug/kg)	2	1	50	3.5 J	3.5 J	3.5	3.5 J	3.5 J	3.5 J	10 U	6.8	3.5 J	3.5 J
24	Anthracene (ug/kg)	2	1	50	5 J	5 J	5	5 J	5 J	5 J	10 U	7.5	5 J	5 J
24	Benz(a)anthracene (ug/kg)	2	1	50	13 J	13 J	13	13 J	13 J	10 U	13 J	12	10 U	10 U
24	Benzo(a)pyrene (ug/kg)	2	1	50	13 J	13 J	13	13 J	13 J	10 U	13 J	12	10 U	10 U
24	Benzo(b)fluoranthene (ug/kg)	2	1	50	14 J	14 J	14	14 J	14 J	10 U	14 J	12	10 U	10 U
24	Benzo(b+k)fluoranthene (ug/kg)	2	1	50	19.2 A	19.2 A	19.2	19.2 A	19.2 A	10 UA	19.2 A	15	10 UA	10 UA
24	Benzo(g,h,i)perylene (ug/kg)	2	1	50	14 J	14 J	14	14 J	14 J	10 U	14 J	12	10 U	10 U
24	Benzo(k)fluoranthene (ug/kg)	2	1	50	5.2 J	5.2 J	5.2	5.2 J	5.2 J	5.2 J	10 U	7.6	5.2 J	5.2 J
24	Chrysene (ug/kg)	2	1	50	13 J	13 J	13	13 J	13 J	10 U	13 J	12	10 U	10 U
24	Fluoranthene (ug/kg)	2	1	50	21	21	21	21	21	10 U	21	16	10 U	10 U
24	High Molecular Weight PAH (ug/kg)	2	1	50	131.2 A	131.2 A	131.2	131.2 A	131.2 A	10 UA	131.2 A	71	10 UA	10 UA
24	Indeno(1,2,3-cd)pyrene (ug/kg)	2	1	50	8 J	8 J	8	8 J	8 J	8 J	10 U	9	8 J	8 J
24	Low Molecular Weight PAH (ug/kg)	2	1	50	28.6 A	28.6 A	28.6	28.6 A	28.6 A	10 UA	28.6 A	19.3	10 UA	10 UA
24	Naphthalene (ug/kg)	2	1	50	6.1 J	6.1 J	6.1	6.1 J	6.1 J	6.1 J	10 U	8.1	6.1 J	6.1 J
24	Phenanthrene (ug/kg)	2	1	50	14 J	14 J	14	14 J	14 J	10 U	14 J	12	10 U	10 U
24	Polycyclic Aromatic Hydrocarbons (ug/kg)	2	1	50	159.8 A	159.8 A	159.8	159.8 A	159.8 A	10 UA	159.8 A	85	10 UA	10 UA
24	Pyrene (ug/kg)	2	1	50	30	30	30	30	30	10 U	30	20	10 U	10 U
24	Diesel fuels (mg/kg)	2	1	50	38 Z	38 Z	38	38 Z	38 Z	28 U	38 Z	33	28 U	28 U
24	4,4'-DDD (ug/kg)	3	1	33	0.77 J	0.77 J	0.77	0.77 J	0.77 J	0.77 J	2 U	1.49	0.77 J	1.7 U
24	4,4'-DDE (ug/kg)	3	1	33	0.8 J	0.8 J	0.8	0.8 J	0.8 J	0.8 J	2 U	1.5	0.8 J	1.7 U
24	4,4'-DDT (ug/kg)	3	1	33	13	13	13	13	13	1.7 U	13	5.6	1.7 U	2 U
24	Total of 3 isomers: pp-DDT,-DDD,-DDE (ug/k	3	1	33	14.57 A	14.57 A	14.57	14.57 A	14.57 A	1.7 UA	14.57 A	6.09	1.7 UA	2 UA
24	Aroclor 1016 (ug/kg)	3	0	0						17 U	20 U	19	17 U	19 U
24	Aroclor 1221 (ug/kg)	3	0	0						34 U	40 U	37	34 U	38 U
24	Aroclor 1232 (ug/kg)	3	0	0						17 U	20 U	19	17 U	19 U
24	Aroclor 1242 (ug/kg)	3	0	0						17 U	20 U	19	17 U	19 U
24	Aroclor 1248 (ug/kg)	3	0	0						17 U	20 U	19	17 U	19 U
24	Aroclor 1254 (ug/kg)	3	0	0						17 U	20 U	19	17 U	19 U
24	Aroclor 1260 (ug/kg)	3	0	0						17 U	20 U	19	17 U	19 U
24	Polychlorinated biphenyls (ug/kg)	3	0	0						34 UA	40 UA	37	34 UA	38 UA
24	Aldrin (ug/kg)	3	0	0						1.7 U	2 U	1.9	1.7 U	1.9 U
24	alpha-Chlordane (ug/kg)	3	0	0						1.7 U	2 U	1.9	1.7 U	1.9 U
24	alpha-Endosulfan (ug/kg)	3	0	0						1.7 U	2 U	1.9	1.7 U	1.9 U
24	alpha-Hexachlorocyclohexane (ug/kg)	3	0	0						1.7 U	2 U	1.9	1.7 U	1.9 U
24	beta-Endosulfan (ug/kg)	3	0	0						1.7 U	2 U	1.9	1.7 U	1.9 U
24	beta-Hexachlorocyclohexane (ug/kg)	3	0	0						1.7 U	2 U	1.9	1.7 U	1.9 U
24	delta-Hexachlorocyclohexane (ug/kg)	3	0	0						1.7 U	2 U	1.9	1.7 U	1.9 U
24	Dieldrin (ug/kg)	3	0	0						1.7 U	2 U	1.9	1.7 U	1.9 U
24	Endosulfan sulfate (ug/kg)	3	0	0						1.7 U	2 U	1.9	1.7 U	1.9 U
24	Endrin (ug/kg)	3	0	0						1.7 U	2 U	1.9	1.7 U	1.9 U
24	Endrin aldehyde (ug/kg)	3	0	0						1.7 U	2 U	1.9	1.7 U	1.9 U
24	Endrin ketone (ug/kg)	3	0	0						1.7 U	2 U	1.9	1.7 U	1.9 U
24	gamma-Chlordane (ug/kg)	3	0	0						1.7 U	2 U	1.9	1.7 U	1.9 U
24	gamma-Hexachlorocyclohexane (ug/kg)	3	0	0						1.7 U	2 U	1.9	1.7 U	1.9 U
24	Heptachlor (ug/kg)	3	0	0						1.7 U	2 U	1.9	1.7 U	1.9 U
24	Heptachlor epoxide (ug/kg)	3	0	0						1.7 U	2 U	1.9	1.7 U	1.9 U

Table 4-5. Historical Surface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detected	Detected Concentrations Minimum	Maximum	Mean	Median	95th	Detected and Nondetected Concentrations Minimum	Maximum	Mean	Median	95th
24	Methoxychlor (ug/kg)	3	0	0						1.7 U	2 U	1.9	1.7 U	1.9 U
24	Toxaphene (ug/kg)	3	0	0						85 U	98 U	92	85 U	93 U
24	Acenaphthene (ug/kg)	2	0	0						10 U	19 U	15	10 U	10 U
24	Dibenz(a,h)anthracene (ug/kg)	2	0	0						10 U	19 U	15	10 U	10 U
24	Fluorene (ug/kg)	2	0	0						10 U	19 U	15	10 U	10 U
24	Gasoline (mg/kg)	2	0	0						28 U	34 U	31	28 U	28 U
24	Pentachlorophenol (ug/kg)	2	0	0						60 U	190 U	125	60 U	60 U
24	2-Methylnaphthalene (ug/kg)	1	0	0						19 U	19 U	19	19 U	19 U
24	Benzyl alcohol (ug/kg)	1	0	0						19 U	19 U	19	19 U	19 U
24	Butyltin ion (ug/l)	1	0	0						0.05 U	0.05 U	0.05	0.05 U	0.05 U
24	Dibenzofuran (ug/kg)	1	0	0						19 U	19 U	19	19 U	19 U
24	Hexachlorobutadiene (ug/kg)	1	0	0						19 U	19 U	19	19 U	19 U
24	Hexachloroethane (ug/kg)	1	0	0						19 U	19 U	19	19 U	19 U
24	N-Nitrosodiphenylamine (ug/kg)	1	0	0						19 U	19 U	19	19 U	19 U
24	Tetrabutyltin (ug/l)	1	0	0						0.05 U	0.05 U	0.05	0.05 U	0.05 U
24	1,2,4-Trichlorobenzene (ug/kg)	1	0	0						19 U	19 U	19	19 U	19 U
24	1,2-Dichlorobenzene (ug/kg)	1	0	0						19 U	19 U	19	19 U	19 U
24	1,3-Dichlorobenzene (ug/kg)	1	0	0						19 U	19 U	19	19 U	19 U
24	1,4-Dichlorobenzene (ug/kg)	1	0	0						19 U	19 U	19	19 U	19 U
24	2,4-Dimethylphenol (ug/kg)	1	0	0						94 U	94 U	94	94 U	94 U
24	2-Methylphenol (ug/kg)	1	0	0						19 U	19 U	19	19 U	19 U
24	Bis(2-ethylhexyl) phthalate (ug/kg)	1	0	0						380 U	380 U	380	380 U	380 U
24	Butylbenzyl phthalate (ug/kg)	1	0	0						19 U	19 U	19	19 U	19 U
24	Diethyl phthalate (ug/kg)	1	0	0						19 U	19 U	19	19 U	19 U
24	Dimethyl phthalate (ug/kg)	1	0	0						19 U	19 U	19	19 U	19 U
24	Di-n-octyl phthalate (ug/kg)	1	0	0						19 U	19 U	19	19 U	19 U
24	Hexachlorobenzene (ug/kg)	1	0	0						19 U	19 U	19	19 U	19 U

Notes:
A - Detected quantities of analytes added together as defined in WAC 173-204-320 for LPAH and HPAH, as in DMMO 2000 for DDT, and for all Aroclors or congeners for PCB.
B - Possible method blank contamination.
E - Estimate, usually applied because the value exceeded the instrument calibration range.
G - Estimate is greater than value shown.
H - Holding time exceeded.
J - Estimate, usually applied because the value is less than the method reporting limit but greater than the method detection limit, or for QA/QC concerns.
L - Value is less than the maximum shown.
N - Presumptive evidence of presence of material.
U - Not detected at detection limit shown.
X - Recovery less than 10%.
Surface sediment is defined as any sediment sample that was exposed to the water column at the time of collection to a maximum depth of 30 cm.

Table 4-6. Historical Subsurface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detects	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
1	Tributyltin ion (ug/l)	1	0	0						0.05 U	0.05 U	0.05	0.05 U	0.05 U
1	4,4'-DDT (ug/kg)	9	0	0						2 U	2 U	2	2 U	2 U
1	Aroclor 1016 (ug/kg)	9	0	0						10 U	10 UG	10	10 U	10 U
1	Aroclor 1221 (ug/kg)	9	0	0						10 U	10 UG	10	10 U	10 U
1	Aroclor 1232 (ug/kg)	9	0	0						10 U	10 UG	10	10 U	10 U
1	Aroclor 1248 (ug/kg)	9	0	0						10 U	10 UG	10	10 U	10 U
1	alpha-Endosulfan (ug/kg)	9	0	0						2 U	2 U	2	2 U	2 U
1	alpha-Hexachlorocyclohexane (ug/kg)	9	0	0						2 U	2 U	2	2 U	2 U
1	beta-Endosulfan (ug/kg)	9	0	0						2 U	2 U	2	2 U	2 U
1	beta-Hexachlorocyclohexane (ug/kg)	9	0	0						2 U	2 U	2	2 U	2 U
1	Chlordane (cis & trans) (ug/kg)	9	0	0						10 U	10 U	10	10 U	10 U
1	delta-Hexachlorocyclohexane (ug/kg)	9	0	0						2 U	2 UG	2	2 U	2 U
1	Dieldrin (ug/kg)	9	0	0						2 U	5 U	2	2 U	2 U
1	Endosulfan sulfate (ug/kg)	9	0	0						2 U	2 UG	2	2 U	2 U
1	Endrin (ug/kg)	9	0	0						2 U	2 UG	2	2 U	2 U
1	Endrin aldehyde (ug/kg)	9	0	0						2 U	2 UG	2	2 U	2 U
1	gamma-Hexachlorocyclohexane (ug/kg)	9	0	0						2 U	2 UG	2	2 U	2 U
1	Heptachlor (ug/kg)	9	0	0						2 U	2 UG	2	2 U	2 U
1	Heptachlor epoxide (ug/kg)	9	0	0						2 U	2 UG	2	2 U	2 U
1	Methoxychlor (ug/kg)	9	0	0						4 U	4 UG	4	4 U	4 U
1	Toxaphene (ug/kg)	9	0	0						30 U	65 U	34	30 U	30 UG
1	Aroclor 1242 (ug/kg)	9	1	11	29	29	29	29	29	10 U	29	12	10 U	10 U
1	Aroclor 1254 (ug/kg)	9	1	11	43	43	43	43	43	10 U	43	14	10 U	10 U
1	Aldrin (ug/kg)	9	1	11	0.2 J	0.2 J	0.2	0.2 J	0.2 J	0.2 J	2 U	1.8	2 U	2 UG
1	Aroclor 1260 (ug/kg)	9	2	22	5	7	6	5	5	5	10 U	9	10 U	10 U
1	Polychlorinated biphenyls (ug/kg)	9	3	33	5 A	72 A	28	5 A	7 A	5 A	72 A	16	10 UA	10 UA
1	Gravel (%)	5	2	40	0.1	5.7	2.9	0.1	0.1	0.1	5.7	1.2	0.1 U	0.1 U
1	4,4'-DDD (ug/kg)	9	4	44	0.7	7	3.4	1	5	0.7	7	2.6	2 U	5
1	4,4'-DDE (ug/kg)	9	4	44	0.4	7	3.0	0.7	4	0.4	7	2.5	2 U	4
1	Total of 3 isomers: pp-DDT,-DDD,-DDE (ug/kg)	9	4	44	1.1 A	12 A	6.5	1.7 A	11 A	1.1 A	12 A	4.0	2 UA	11 A
1	Dibenzofuran (ug/kg)	9	6	67	0.5 G	8 G	2.5	1 G	4 G	0.5 G	8 G	3.4	1 G	5 UG
1	Clay (%)	11	8	73	1.8	8.9	5.1	4.2	7.5	0.1 U	8.9	4.1	3.1	7.5
1	Acenaphthene (ug/kg)	9	7	78	0.7 G	16 G	4.2	1 G	7 G	0.7 G	16 G	4.4	1 G	7 G
1	Acid Volatile Sulfides (mg/kg)	9	8	89	0.8	53	14.4	4.8	30	0.8 U	53	12.9	1.9	30
1	Anthracene (ug/kg)	9	8	89	0.6 G	27 G	7.3	2 G	18 G	0.6 G	27 G	7.1	2 G	18 G
1	Benz(a)anthracene (ug/kg)	9	8	89	1 G	86 G	22	4 G	44 G	1 G	86 G	20	3 G	44 G
1	Benzo(b)fluoranthene (ug/kg)	9	8	89	2 G	81 G	23	4 G	59 G	2 G	81 G	21	4 G	59 G
1	Benzo(k)fluoranthene (ug/kg)	9	8	89	1 G	79 G	23	3 G	63 G	1 G	79 G	21	3 G	63 G
1	Sand (%)	5	5	100	6.1	91.9	31.5	7.3	26.9	6.1	91.9	31.5	7.3	26.9
1	2-Methylnaphthalene (ug/kg)	9	9	100	2 GB	27 G	6	2 GB	12 G	2 GB	27 G	6	2 GB	12 G
1	Acenaphthylene (ug/kg)	9	9	100	0.3 G	11 G	2.7	0.7 G	5 G	0.3 G	11 G	2.7	0.7 G	5 G
1	Arsenic (mg/kg)	9	9	100	0.6 E	5.8 E	2.7	1.3 E	5.6 E	0.6 E	5.8 E	2.7	1.3 E	5.6 E
1	Benzo(a)pyrene (ug/kg)	9	9	100	0.9 GB	123 G	32.0	4 GB	103 G	0.9 GB	123 G	32.0	4 GB	103 G
1	Benzo(b+k)fluoranthene (ug/kg)	9	9	100	3 A	160 A	42	7 A	122 A	3 A	160 A	42	7 A	122 A
1	Benzo(g,h,i)perylene (ug/kg)	9	9	100	1 GB	115 GB	29	5 GB	77 GB	1 GB	115 GB	29	5 GB	77 GB
1	Cadmium (mg/kg)	9	9	100	0.03	1.62	0.50	0.16	1.36	0.03	1.62	0.50	0.16	1.36

Table 4-6. Historical Subsurface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detects	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
1	Chromium (mg/kg)	9	9	100	6.6	26.8	18.3	15.9	25.2	6.6	26.8	18.3	15.9	25.2
1	Chrysene (ug/kg)	9	9	100	0.7 G	112 G	24.7	2 G	52 G	0.7 G	112 G	24.7	2 G	52 G
1	Copper (mg/kg)	9	9	100	8.9	26.4	18.0	14.5	24.6	8.9	26.4	18.0	14.5	24.6
1	Dibenz(a,h)anthracene (ug/kg)	9	9	100	0.8 GB	19 G	5.4	1 GB	13 GB	0.8 GB	19 G	5.4	1 GB	13 GB
1	Fluoranthene (ug/kg)	9	9	100	0.7 G	158 G	37.5	4 G	83 G	0.7 G	158 G	37.5	4 G	83 G
1	Fluorene (ug/kg)	9	9	100	0.7 G	19 G	4.4	1 G	10 G	0.7 G	19 G	4.4	1 G	10 G
1	High Molecular Weight PAH (ug/kg)	9	9	100	6 A	1079 A	263	38 A	654 A	6 A	1079 A	263	38 A	654 A
1	Indeno(1,2,3-cd)pyrene (ug/kg)	9	9	100	1 GB	108 G	28	5 GB	76 G	1 GB	108 G	28	5 GB	76 G
1	Lead (mg/kg)	9	9	100	1.2	27	10.6	7.1	23.7	1.2	27	10.6	7.1	23.7
1	Low Molecular Weight PAH (ug/kg)	9	9	100	6.7 A	227 A	53.8	12.4 A	140 A	6.7 A	227 A	53.8	12.4 A	140 A
1	Mercury (mg/kg)	9	9	100	0.01	0.13	0.06	0.03	0.12	0.01	0.13	0.06	0.03	0.12
1	Naphthalene (ug/kg)	9	9	100	0.6 GB	31 G	7.6	2 GB	24 G	0.6 GB	31 G	7.6	2 GB	24 G
1	Nickel (mg/kg)	9	9	100	4.4	19.8	14.2	12.8	19.3	4.4	19.8	14.2	12.8	19.3
1	Phenanthrene (ug/kg)	9	9	100	2 GB	96 G	23	4 G	65 G	2 GB	96 G	23	4 G	65 G
1	Polycyclic Aromatic Hydrocarbons (ug/kg)	9	9	100	19 A	1306 A	317	48.6 A	699 A	19 A	1306 A	317	48.6 A	699 A
1	Pyrene (ug/kg)	9	9	100	0.9 G	198 G	47.5	5 G	101 G	0.9 G	198 G	47.5	5 G	101 G
1	Silver (mg/kg)	9	9	100	0.03	0.18	0.11	0.08	0.16	0.03	0.18	0.11	0.08	0.16
1	Total organic carbon (%)	9	9	100	0.06	0.99	0.58	0.38	0.99	0.06	0.99	0.58	0.38	0.99
1	Total solids (%)	9	9	100	53.4	77	64.7	63.7	69.1	53.4	77	64.7	63.7	69.1
1	Zinc (mg/kg)	9	9	100	10.8	166	75.1	53.6	138	10.8	166	75.1	53.6	138
1	Fines (%)	11	11	100	2.4	100.5	58.7	64.8	93.9	2.4	100.5	58.7	64.8	93.9
1	Mean grain size (mm)	11	11	100	0.02	0.48	0.11	0.05	0.24	0.02	0.48	0.11	0.05	0.24
1	Median grain size (mm)	11	11	100	0.01	0.3	0.08	0.03	0.21	0.01	0.3	0.08	0.03	0.21
1	Silt (%)	11	11	100	2.4	91.6	54.6	60.6	90.8	2.4	91.6	54.6	60.6	90.8
1	Total volatile solids (%)	11	11	100	0.7	3.6	2.6	2.5	3.6	0.7	3.6	2.6	2.5	3.6
2	4,4'-DDD (ug/kg)	2	2	100	3.9	9.9	6.9	3.9	3.9	3.9	9.9	6.9	3.9	3.9
2	4,4'-DDE (ug/kg)	2	2	100	2.6	5	3.8	2.6	2.6	2.6	5	3.8	2.6	2.6
2	Acenaphthene (ug/kg)	2	2	100	28	33	30.5	28	28	28	33	30.5	28	28
2	Ammonia (mg/kg)	2	2	100	70.5	119	94.8	70.5	70.5	70.5	119	94.8	70.5	70.5
2	Antimony (mg/kg)	2	2	100	0.03 G	0.05 G	0.04	0.03 G	0.03 G	0.03 G	0.05 G	0.04	0.03 G	0.03 G
2	Aroclor 1260 (ug/kg)	2	2	100	13	14	14	13	13	13	14	14	13	13
2	Arsenic (mg/kg)	2	2	100	1.2	2.6	1.9	1.2	1.2	1.2	2.6	1.9	1.2	1.2
2	Benz(a)anthracene (ug/kg)	2	2	100	34	130	82	34	34	34	130	82	34	34
2	Benzo(a)pyrene (ug/kg)	2	2	100	38	180	109	38	38	38	180	109	38	38
2	Benzo(b)fluoranthene (ug/kg)	2	2	100	32	120	76	32	32	32	120	76	32	32
2	Benzo(b+k)fluoranthene (ug/kg)	2	2	100	58 A	220 A	139	58 A	58 A	58 A	220 A	139	58 A	58 A
2	Benzo(g,h,i)perylene (ug/kg)	2	2	100	23	100	62	23	23	23	100	62	23	23
2	Benzo(k)fluoranthene (ug/kg)	2	2	100	26	100	63	26	26	26	100	63	26	26
2	Cadmium (mg/kg)	2	2	100	0.44	0.85	0.65	0.44	0.44	0.44	0.85	0.65	0.44	0.44
2	Chromium (mg/kg)	2	2	100	13.3	16.3	14.8	13.3	13.3	13.3	16.3	14.8	13.3	13.3
2	Chrysene (ug/kg)	2	2	100	42	160	101	42	42	42	160	101	42	42
2	Copper (mg/kg)	2	2	100	14.7	19.7	17.2	14.7	14.7	14.7	19.7	17.2	14.7	14.7
2	Fluoranthene (ug/kg)	2	2	100	93	300	197	93	93	93	300	197	93	93
2	High Molecular Weight PAH (ug/kg)	2	2	100	438 A	1630 A	1034	438 A	438 A	438 A	1630 A	1034	438 A	438 A
2	Indeno(1,2,3-cd)pyrene (ug/kg)	2	2	100	30	130	80	30	30	30	130	80	30	30
2	Lead (mg/kg)	2	2	100	11.1	18.2	14.7	11.1	11.1	11.1	18.2	14.7	11.1	11.1

Table 4-6. Historical Subsurface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detects	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
2	Low Molecular Weight PAH (ug/kg)	2	2	100	190 A	368 A	279	190 A	190 A	190 A	368 A	279	190 A	190 A
2	Mercury (mg/kg)	2	2	100	0.05	0.11	0.08	0.05	0.05	0.05	0.11	0.08	0.05	0.05
2	Nickel (mg/kg)	2	2	100	16.1	16.2	16.2	16.1	16.1	16.1	16.2	16.2	16.1	16.1
2	Phenanthrene (ug/kg)	2	2	100	140	250	195	140	140	140	250	195	140	140
2	Polychlorinated biphenyls (ug/kg)	2	2	100	14 A	35 A	25	14 A	14 A	14 A	35 A	25	14 A	14 A
2	Polycyclic Aromatic Hydrocarbons (ug/kg)	2	2	100	628 A	1998 A	1313	628 A	628 A	628 A	1998 A	1313	628 A	628 A
2	Pyrene (ug/kg)	2	2	100	120	390	255	120	120	120	390	255	120	120
2	Silver (mg/kg)	2	2	100	0.16	0.18	0.17	0.16	0.16	0.16	0.18	0.17	0.16	0.16
2	Total of 3 isomers: pp-DDT,-DDD,-DDE (ug/kg)	2	2	100	6.5 A	14.9 A	10.7	6.5 A	6.5 A	6.5 A	14.9 A	10.7	6.5 A	6.5 A
2	Total organic carbon (%)	2	2	100	0.52	0.54	0.53	0.52	0.52	0.52	0.54	0.53	0.52	0.52
2	Total solids (%)	2	2	100	62.1	69.6	65.9	62.1	62.1	62.1	69.6	65.9	62.1	62.1
2	Total sulfides (mg/kg)	2	2	100	41	45	43	41	41	41	45	43	41	41
2	Total volatile solids (%)	2	2	100	2.79	5.72	4.26	2.79	2.79	2.79	5.72	4.26	2.79	2.79
2	Zinc (mg/kg)	2	2	100	75.5	112	93.8	75.5	75.5	75.5	112	93.8	75.5	75.5
2	Tributyltin ion (ug/l)	1	1	100	0.03 G	0.03 G	0.03	0.03 G	0.03 G	0.03 G	0.03 G	0.03	0.03 G	0.03 G
2	Anthracene (ug/kg)	2	1	50	35	35	35	35	35	20 U	35	27.5	20 U	20 U
2	Aroclor 1242 (ug/kg)	2	1	50	22	22	22	22	22	10 U	22	16	10 U	10 U
2	Dibenz(a,h)anthracene (ug/kg)	2	1	50	20	20	20	20	20	20	20 U	20	20	20
2	Fluorene (ug/kg)	2	1	50	22	22	22	22	22	20 U	22	21	20 U	20 U
2	Naphthalene (ug/kg)	2	1	50	50	50	50	50	50	20 U	50	35	20 U	20 U
2	4-Methylphenol (ug/kg)	2	1	50	77	77	77	77	77	20 U	77	49	20 U	20 U
2	Bis(2-ethylhexyl) phthalate (ug/kg)	2	1	50	56	56	56	56	56	36 U	56	46	36 U	36 U
2	4,4'-DDT (ug/kg)	2	0	0						6.7 U	6.7 U	6.7	6.7 U	6.7 U
2	Acenaphthylene (ug/kg)	2	0	0						20 U	20 U	20	20 U	20 U
2	Aroclor 1016 (ug/kg)	2	0	0						10 U	10 U	10	10 U	10 U
2	Aroclor 1221 (ug/kg)	2	0	0						10 U	10 U	10	10 U	10 U
2	Aroclor 1232 (ug/kg)	2	0	0						10 U	20 U	15	10 U	10 U
2	Aroclor 1248 (ug/kg)	2	0	0						10 U	20 U	15	10 U	10 U
2	Aroclor 1254 (ug/kg)	2	0	0						15 U	20 U	17.5	15 U	15 U
2	Benzoic acid (ug/kg)	2	0	0						100 U	100 U	100	100 U	100 U
2	Benzyl alcohol (ug/kg)	2	0	0						6 U	6 U	6	6 U	6 U
2	Dibenzofuran (ug/kg)	2	0	0						20 U	20 U	20	20 U	20 U
2	Hexachlorobutadiene (ug/kg)	2	0	0						20 U	20 U	20	20 U	20 U
2	N-Nitrosodiphenylamine (ug/kg)	2	0	0						12 U	12 U	12	12 U	12 U
2	1,2-Dichlorobenzene (ug/kg)	2	0	0						1 U	1 U	1	1 U	1 U
2	1,3-Dichlorobenzene (ug/kg)	2	0	0						1 U	1 U	1	1 U	1 U
2	1,4-Dichlorobenzene (ug/kg)	2	0	0						1 U	1 U	1	1 U	1 U
2	2,4-Dimethylphenol (ug/kg)	2	0	0						6 U	6 U	6	6 U	6 U
2	2-Methylphenol (ug/kg)	2	0	0						6 U	6 U	6	6 U	6 U
2	Aldrin (ug/kg)	2	0	0						1.7 U	1.7 U	1.7	1.7 U	1.7 U
2	alpha-Chlordane (ug/kg)	2	0	0						1.7 U	1.7 U	1.7	1.7 U	1.7 U
2	Butylbenzyl phthalate (ug/kg)	2	0	0						20 U	20 U	20	20 U	20 U
2	Dibutyl phthalate (ug/kg)	2	0	0						20 U	20 U	20	20 U	20 U
2	Dieldrin (ug/kg)	2	0	0						2.3 U	2.3 U	2.3	2.3 U	2.3 U
2	Diethyl phthalate (ug/kg)	2	0	0						20 U	20 U	20	20 U	20 U
2	Dimethyl phthalate (ug/kg)	2	0	0						20 U	20 U	20	20 U	20 U

Table 4-6. Historical Subsurface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detects	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
2	Di-n-octyl phthalate (ug/kg)	2	0	0						20 U	20 U	20	20 U	20 U
2	gamma-Chlordane (ug/kg)	2	0	0						1.7 U	1.7 U	1.7	1.7 U	1.7 U
2	gamma-Hexachlorocyclohexane (ug/kg)	2	0	0						1.7 U	1.7 U	1.7	1.7 U	1.7 U
2	Heptachlor (ug/kg)	2	0	0						1.7 U	1.7 U	1.7	1.7 U	1.7 U
2	Hexachlorobenzene (ug/kg)	2	0	0						20 U	20 U	20	20 U	20 U
2	Pentachlorophenol (ug/kg)	2	0	0						61 U	61 U	61	61 U	61 U
2	Phenol (ug/kg)	2	0	0						20 U	20 U	20	20 U	20 U
3	Arsenic (mg/kg)	5	5	100	2.2	4.9	3.34	2.5 E	3.8	2.2	4.9	3.3	2.5 E	3.8
3	Benz(a)anthracene (ug/kg)	5	5	100	11	373 G	97	17	56	11	373 G	97	17	56
3	Benzo(a)pyrene (ug/kg)	5	5	100	20	530 G	144	27	96	20	530 G	144	27	96
3	Benzo(b)fluoranthene (ug/kg)	5	5	100	22	517 G	136	27	76	22	517 G	136	27	76
3	Benzo(b+k)fluoranthene (ug/kg)	5	5	100	34.3 A	1061 A	258.7	43 A	99 A	34.3 A	1061 A	258.7	43 A	99 A
3	Benzo(g,h,i)perylene (ug/kg)	5	5	100	17	832 G	193	25	50	17	832 G	193	25	50
3	Benzo(k)fluoranthene (ug/kg)	5	5	100	7.3	544 G	122.5	17	23	7.3	544 G	122.5	17	23
3	Chrysene (ug/kg)	5	5	100	17	452 G	118	26	65	17	452 G	118	26	65
3	Clay (%)	5	5	100	4.1	14.7	8.14	6.6	8.7	4.1	14.7	8.14	6.6	8.7
3	Copper (mg/kg)	5	5	100	30.2	40	35.0	31.6	39	30.2	40	35.0	31.6	39
3	Fines (%)	5	5	100	56.2	81.3	71.9	67.5	80.43	56.2	81.3	71.9	67.5	80.43
3	High Molecular Weight PAH (ug/kg)	5	5	100	167 A	5654 A	1424	209.3 A	699 A	167 A	5654 A	1424	209.3 A	699 A
3	Indeno(1,2,3-cd)pyrene (ug/kg)	5	5	100	17	802 G	180	22	35	17	802 G	180	22	35
3	Mean grain size (mm)	5	5	100	0.03	0.2	0.10	0.05	0.16	0.03	0.2	0.10	0.05	0.16
3	Median grain size (mm)	5	5	100	0.02	0.06	0.03	0.02	0.03	0.02	0.06	0.03	0.02	0.03
3	Nickel (mg/kg)	5	5	100	17	24	20	17.2	21.7	17	24	20	17.2	21.7
3	Polycyclic Aromatic Hydrocarbons (ug/kg)	5	5	100	167 A	7138 A	1838	294.6 A	1021 A	167 A	7138 A	1838	294.6 A	1021 A
3	Pyrene (ug/kg)	5	5	100	13	789 G	219	47	160	13	789 G	219	47	160
3	Silt (%)	5	5	100	52.1	74.7	63.7	60.9	65.7	52.1	74.7	63.7	60.9	65.7
3	Total solids (%)	5	5	100	52.7	79.7	59.5	54.4	55.3	52.7	79.7	59.5	54.4	55.3
3	Total volatile solids (%)	5	5	100	4.1	8.24	6.56	4.7	7.96	4.1	8.24	6.56	4.7	7.96
3	Zinc (mg/kg)	5	5	100	87	234	148	120	170	87	234	148	120	170
3	Sand (%)	4	4	100	18.7	31.4	23.6	19.57	24.9	18.7	31.4	23.6	19.57	24.9
3	Total organic carbon (%)	4	4	100	1.62	2.4	1.98	1.9	2	1.62	2.4	1.98	1.9	2
3	Chromium (mg/kg)	2	2	100	28.1	199 J	113.6	28.1	28.1	28.1	199 J	113.6	28.1	28.1
3	1,2,3,4,6,7,8-Heptachlorodibenzofuran (ng/kg)	1	1	100	25 B	25 B	25	25 B	25 B	25 B	25 B	25	25 B	25 B
3	1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin (ng/kg	1	1	100	190 B	190 B	190	190 B	190 B	190 B	190 B	190	190 B	190 B
3	1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin (ng/kg)	1	1	100	11 B	11 B	11	11 B	11 B	11 B	11 B	11	11 B	11 B
3	1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin (ng/kg)	1	1	100	5.2 J	5.2 J	5.2	5.2 J	5.2 J	5.2 J	5.2 J	5.2	5.2 J	5.2 J
3	2,3,7,8-Tetrachlorodibenzofuran (ng/kg)	1	1	100	3 B	3 B	3	3 B	3 B	3 B	3 B	3	3 B	3 B
3	Acid Volatile Sulfides (mg/kg)	1	1	100	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2
3	Octachlorodibenzofuran (ng/kg)	1	1	100	73 B	73 B	73	73 B	73 B	73 B	73 B	73	73 B	73 B
3	Octachlorodibenzo-p-dioxin (ng/kg)	1	1	100	1800 B	1800 B	1800	1800 B	1800 B	1800 B	1800 B	1800	1800 B	1800 B
3	Lube Oil (mg/kg)	1	1	100	79	79	79	79	79	79	79	79	79	79
3	Acenaphthene (ug/kg)	5	4	80	12	122 G	58	44	52	9.7 U	122 G	48	12	52
3	Acenaphthylene (ug/kg)	5	4	80	6.3	62 G	26	12	23	6.3	62 G	23	9.7 U	23
3	Anthracene (ug/kg)	5	4	80	11	160 G	57	17	40	9.7 U	160 G	48	11	40
3	Fluoranthene (ug/kg)	5	4	80	40	673 G	233	67	150	9.7 U	673 G	188	40	150
3	Fluorene (ug/kg)	5	4	80	6.9	105 G	41	26	27	6.9	105 G	35	9.7 U	27

Table 4-6. Historical Subsurface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detects	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
3	Low Molecular Weight PAH (ug/kg)	5	4	80	85.3 A	1484 A	518	181.3 A	322 A	9.7 UA	1484 A	416	85.3 A	322 A
3	Naphthalene (ug/kg)	5	4	80	4.1	221 G	66	9.3	30	4.1	221 G	55	9.3	30
3	Phenanthrene (ug/kg)	5	4	80	45	684 G	238	73	150	9.7 U	684 G	192.3	45	150
3	4,4'-DDD (ug/kg)	4	3	75	2	5.4	3.4	2	2.9 J	2	5.4	3.4	2.9 J	3.4 U
3	4,4'-DDE (ug/kg)	4	3	75	2	5.9	3.5	2	2.5 J	2	5.9	3.5	2.5 J	3.4 U
3	Total of 3 isomers: pp-DDT,-DDD,-DDE (ug/kg)	4	3	75	4 A	11.3 A	6.9	4 A	5.4 A	3.4 UA	11.3 A	6.0	4 A	5.4 A
3	3- and 4-Methylphenol Coelution (ug/kg)	4	3	75	24	28	27	24	28	24	190 U	68	28	28
3	Bis(2-ethylhexyl) phthalate (ug/kg)	4	3	75	27 B	34 B	31	27 B	31	27 B	190 U	71	31	34 B
3	Gravel (%)	3	2	67	1	1.08	1.04	1	1	0.1 U	1.08	0.73	0.1 U	1
3	2-Methylnaphthalene (ug/kg)	5	3	60	23	130 G	66	23	45	3.2 U	130 G	42.2	9.7 U	45
3	Dibenzofuran (ug/kg)	5	3	60	9.7 J	33 G	18.2	9.7 J	12 J	9.7 U	33 G	16.1	9.7 J	16 U
3	Lead (mg/kg)	5	3	60	19	40.9	27.3	19	22	19	62 U	35	22	40.9
3	Mercury (mg/kg)	5	3	60	0.04	0.16	0.10	0.04	0.09	0.04	0.19 U	0.128	0.09	0.16 U
3	Silver (mg/kg)	5	3	60	0.25	2.09	0.90	0.25	0.36 J	0.25	2.09	0.90	0.36 J	0.93 U
3	Aroclor 1260 (ug/kg)	4	2	50	21	200	111	21	21	17 U	200	64	19 U	21
3	Polychlorinated biphenyls (ug/kg)	4	2	50	28 A	1620 A	824	28 A	28 A	28 A	1620 A	430	34 UA	37 UA
3	Pentachlorophenol (ug/kg)	4	2	50	19	21	20	19	19	15 U	290 U	86	19	21
3	Cadmium (mg/kg)	5	2	40	0.41 J	0.43	0.42	0.41 J	0.41 J	0.41 J	1.9 U	1.10	0.43	1.7 U
3	Antimony (mg/kg)	4	1	25	1.6 JB	1.6 JB	1.6	1.6 JB	1.6 JB	1.6 JB	150 U	75.5	10.5 U	140 U
3	Aroclor 1242 (ug/kg)	4	1	25	7	7	7	7	7	7	100 U	36	17 U	19 U
3	Aroclor 1248 (ug/kg)	4	1	25	1420	1420	1420	1420	1420	10 U	1420	367	17 U	19 U
3	Benzoic acid (ug/kg)	4	1	25	11 J	11 J	11	11 J	11 J	11 J	390 U	108	15 U	16 U
3	Benzyl alcohol (ug/kg)	4	1	25	7.3 J	7.3 J	7.3	7.3 J	7.3 J	6 U	49 U	19	7.3 J	15 U
3	Aldrin (ug/kg)	4	1	25	0.36 J	0.36 J	0.36	0.36 J	0.36 J	0.36 J	2 U	1.49	1.7 U	1.9 U
3	beta-Endosulfan (ug/kg)	4	1	25	1 J	1 J	1	1 J	1 J	1 J	3.7 U	2.9	3.4 U	3.4 U
3	Dibutyl phthalate (ug/kg)	4	1	25	4.6 JB	4.6 JB	4.6	4.6 JB	4.6 JB	4.6 JB	19 U	13.7	15 U	16 U
3	Endrin aldehyde (ug/kg)	4	1	25	0.5 J	0.5 J	0.5	0.5 J	0.5 J	0.5 J	3.7 U	2.75	3.4 U	3.4 U
3	Heptachlor (ug/kg)	4	1	25	0.34 J	0.34 J	0.34	0.34 J	0.34 J	0.34 J	2 U	1.49	1.7 U	1.9 U
3	Dibenz(a,h)anthracene (ug/kg)	5	1	20	142 G	142 G	142	142 G	142 G	2.9 U	142 G	34.0	2.9 U	19 U
3	4,4'-DDT (ug/kg)	4	0	0						2 U	3.7 U	3.1	3.4 U	3.4 U
3	Aroclor 1016 (ug/kg)	4	0	0						10 U	100 U	37	17 U	19 U
3	Aroclor 1221 (ug/kg)	4	0	0						10 U	200 U	70	34 U	37 U
3	Aroclor 1232 (ug/kg)	4	0	0						10 U	100 U	37	17 U	19 U
3	Aroclor 1254 (ug/kg)	4	0	0						10 U	100 U	37	17 U	19 U
3	Hexachlorobutadiene (ug/kg)	4	0	0						9.7 U	16 U	13.9	15 U	15 U
3	Hexachloroethane (ug/kg)	4	0	0						15 U	39 U	21	15 U	16 U
3	N-Nitrosodiphenylamine (ug/kg)	4	0	0						9.7 U	16 U	13.9	15 U	15 U
3	1,2,4-Trichlorobenzene (ug/kg)	4	0	0						9.7 U	16 U	13.9	15 U	15 U
3	1,2-Dichlorobenzene (ug/kg)	4	0	0						9.7 U	16 U	13.9	15 U	15 U
3	1,3-Dichlorobenzene (ug/kg)	4	0	0						9.7 U	16 U	13.9	15 U	15 U
3	1,4-Dichlorobenzene (ug/kg)	4	0	0						9.7 U	16 U	13.9	15 U	15 U
3	2,4-Dimethylphenol (ug/kg)	4	0	0						15 U	190 U	59	15 U	16 U
3	2-Methylphenol (ug/kg)	4	0	0						15 U	190 U	59	15 U	16 U
3	alpha-Endosulfan (ug/kg)	4	0	0						1.7 U	2 U	1.8	1.7 U	1.9 U
3	alpha-Hexachlorocyclohexane (ug/kg)	4	0	0						1.7 U	2 U	1.8	1.7 U	1.9 U
3	beta-Hexachlorocyclohexane (ug/kg)	4	0	0						1.7 U	2 U	1.8	1.7 U	1.9 U

Table 4-6. Historical Subsurface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detects	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
3	Butylbenzyl phthalate (ug/kg)	4	0	0						15 U	19 U	16	15 U	16 U
3	Chlordane (cis & trans) (ug/kg)	4	0	0						10 U	19 U	16	17 U	17 U
3	delta-Hexachlorocyclohexane (ug/kg)	4	0	0						1.7 U	2 U	1.8	1.7 U	1.9 U
3	Dieldrin (ug/kg)	4	0	0						2 U	3.7 U	3.1	3.4 U	3.4 U
3	Diethyl phthalate (ug/kg)	4	0	0						9.7 U	16 U	13.9	15 U	15 U
3	Dimethyl phthalate (ug/kg)	4	0	0						9.7 U	16 U	13.9	15 U	15 U
3	Di-n-octyl phthalate (ug/kg)	4	0	0						15 U	190 U	59	15 U	16 U
3	Endosulfan sulfate (ug/kg)	4	0	0						2 U	3.7 U	3.1	3.4 U	3.4 U
3	Endrin (ug/kg)	4	0	0						2 U	3.7 U	3.1	3.4 U	3.4 U
3	gamma-Hexachlorocyclohexane (ug/kg)	4	0	0						1.7 U	2 U	1.8	1.7 U	1.9 U
3	Heptachlor epoxide (ug/kg)	4	0	0						1.7 U	2 U	1.8	1.7 U	1.9 U
3	Hexachlorobenzene (ug/kg)	4	0	0						9.7 U	16 U	13.9	15 U	15 U
3	Methoxychlor (ug/kg)	4	0	0						4 U	19 U	14	17 U	17 U
3	Phenol (ug/kg)	4	0	0						15 U	49 U	24	15 U	16 U
3	Toxaphene (ug/kg)	4	0	0						40 U	190 U	143	170 U	170 U
3	2,4-Dinitrotoluene (ug/kg)	3	0	0						15 U	49 U	27	15 U	16 U
3	2,6-Dinitrotoluene (ug/kg)	3	0	0						15 U	19 U	17	15 U	16 U
3	2-Chloronaphthalene (ug/kg)	3	0	0						2.9 U	9.7 U	5.3	2.9 U	3.2 U
3	2-Nitroaniline (ug/kg)	3	0	0						15 U	19 U	17	15 U	16 U
3	3,3'-Dichlorobenzidine (ug/kg)	3	0	0						15 U	80 UJ	37	15 U	16 U
3	3-Nitroaniline (ug/kg)	3	0	0						15 U	190 U	74	15 U	16 U
3	4-Bromophenyl phenyl ether (ug/kg)	3	0	0						9.7 U	16 U	13.6	9.7 U	15 U
3	4-Chloroaniline (ug/kg)	3	0	0						15 U	49 UJ	27	15 U	16 U
3	4-Chlorophenyl phenyl ether (ug/kg)	3	0	0						9.7 U	16 U	13.6	9.7 U	15 U
3	4-Nitroaniline (ug/kg)	3	0	0						15 U	97 U	43	15 U	16 U
3	Bis(2-chloroethoxy) methane (ug/kg)	3	0	0						15 U	19 U	17	15 U	16 U
3	Bis(2-chloroethyl) ether (ug/kg)	3	0	0						9.7 U	16 U	13.6	9.7 U	15 U
3	Hexachlorocyclopentadiene (ug/kg)	3	0	0						15 U	190 U	74	15 U	16 U
3	Isophorone (ug/kg)	3	0	0						9.7 U	16 U	13.6	9.7 U	15 U
3	Nitrobenzene (ug/kg)	3	0	0						9.7 U	16 U	13.6	9.7 U	15 U
3	N-Nitrosodipropylamine (ug/kg)	3	0	0						9.7 U	16 U	13.6	9.7 U	15 U
3	2,4,5-Trichlorophenol (ug/kg)	3	0	0						15 U	49 U	27	15 U	16 U
3	2,4,6-Trichlorophenol (ug/kg)	3	0	0						15 U	49 U	27	15 U	16 U
3	2,4-Dichlorophenol (ug/kg)	3	0	0						15 U	97 U	43	15 U	16 U
3	2,4-Dinitrophenol (ug/kg)	3	0	0						15 U	290 U	107	15 U	16 U
3	2-Chlorophenol (ug/kg)	3	0	0						15 U	49 U	27	15 U	16 U
3	2-Nitrophenol (ug/kg)	3	0	0						15 U	49 U	27	15 U	16 U
3	4,6-Dinitro-2-methylphenol (ug/kg)	3	0	0						15 U	190 U	74	15 U	16 U
3	4-Chloro-3-methylphenol (ug/kg)	3	0	0						15 U	49 U	27	15 U	16 U
3	4-Nitrophenol (ug/kg)	3	0	0						15 U	97 U	43	15 U	16 U
3	Endrin ketone (ug/kg)	3	0	0						3.4 U	3.7 U	3.5	3.4 U	3.4 U
3	Bis(2-chloro-1-methylethyl) ether (ug/kg)	2	0	0						15 U	16 U	15.5	15 U	15 U
3	Butyltin ion (ug/l)	2	0	0						0.02 U	0.03 U	0.025	0.02 U	0.02 U
3	Dibutyltin ion (ug/l)	2	0	0						0.02 U	0.03 U	0.025	0.02 U	0.02 U
3	Tetrabutyltin (ug/l)	2	0	0						0.02 U	0.03 U	0.025	0.02 U	0.02 U
3	Tributyltin ion (ug/l)	2	0	0						0.02 U	0.03 U	0.025	0.02 U	0.02 U

Table 4-6. Historical Subsurface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detects	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
3	2,4,5-T (ug/kg)	2	0	0						18 U	19 U	18.5	18 U	18 U
3	2,4-D (ug/kg)	2	0	0						18 U	19 U	18.5	18 U	18 U
3	2,4-DB (ug/kg)	2	0	0						18 U	19 U	18.5	18 U	18 U
3	Dalapon (ug/kg)	2	0	0						88 U	96 U	92	88 U	88 U
3	Dicamba (ug/kg)	2	0	0						35 U	38 U	36.5	35 U	35 U
3	Dichloroprop (ug/kg)	2	0	0						18 U	19 U	18.5	18 U	18 U
3	Dinoseb (ug/kg)	2	0	0						18 U	19 U	18.5	18 U	18 U
3	MCPA (ug/kg)	2	0	0						18 U	19 U	18.5	18 U	18 U
3	MCPP (ug/kg)	2	0	0						18 U	19 U	18.5	18 U	18 U
3	Silvex (ug/kg)	2	0	0						18 U	19 U	18.5	18 U	18 U
3	1,2,3,4,7,8,9-Heptachlorodibenzofuran (ng/kg)	1	0	0						2.8 U	2.8 U	2.8	2.8 U	2.8 U
3	1,2,3,4,7,8-Hexachlorodibenzofuran (ng/kg)	1	0	0						4.4 U	4.4 U	4.4	4.4 U	4.4 U
3	1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin (ng/kg)	1	0	0						1.7 U	1.7 U	1.7	1.7 U	1.7 U
3	1,2,3,6,7,8-Hexachlorodibenzofuran (ng/kg)	1	0	0						2.1 U	2.1 U	2.1	2.1 U	2.1 U
3	1,2,3,7,8,9-Hexachlorodibenzofuran (ng/kg)	1	0	0						0.19 U	0.19 U	0.19	0.19 U	0.19 U
3	1,2,3,7,8-Pentachlorodibenzofuran (ng/kg)	1	0	0						1.9 U	1.9 U	1.9	1.9 U	1.9 U
3	1,2,3,7,8-Pentachlorodibenzo-p-dioxin (ng/kg)	1	0	0						0.89 U	0.89 U	0.89	0.89 U	0.89 U
3	2,3,4,6,7,8-Hexachlorodibenzofuran (ng/kg)	1	0	0						1.1 U	1.1 U	1.1	1.1 U	1.1 U
3	2,3,4,7,8-Pentachlorodibenzofuran (ng/kg)	1	0	0						1.3 U	1.3 U	1.3	1.3 U	1.3 U
3	2,3,7,8-Tetrachlorodibenzo-p-dioxin (ng/kg)	1	0	0						0.68 U	0.68 U	0.68	0.68 U	0.68 U
3	Beryllium (mg/kg)	1	0	0						1.05 U	1.05 U	1.05	1.05 U	1.05 U
3	Bis(2-chloroisopropyl) ether (ug/kg)	1	0	0						9.7 U	9.7 U	9.7	9.7 U	9.7 U
3	Selenium (mg/kg)	1	0	0						1 U	1 U	1	1 U	1 U
3	Thallium (mg/kg)	1	0	0						1 U	1 U	1	1 U	1 U
3	Carbazole (ug/kg)	1	0	0						9.7 U	9.7 U	9.7	9.7 U	9.7 U
3	Diesel fuels (mg/kg)	1	0	0						10 U	10 U	10	10 U	10 U
3	Gasoline (mg/kg)	1	0	0						10 U	10 U	10	10 U	10 U
3	Heavy oil (mg/kg)	1	0	0						25 U	25 U	25	25 U	25 U
3	Jet fuel A (mg/kg)	1	0	0						10 U	10 U	10	10 U	10 U
3	JP-4 jet fuel (mg/kg)	1	0	0						10 U	10 U	10	10 U	10 U
3	Kerosene (mg/kg)	1	0	0						10 U	10 U	10	10 U	10 U
3	Mineral spirits (mg/kg)	1	0	0						10 U	10 U	10	10 U	10 U
3	Naphtha distillate (mg/kg)	1	0	0						10 U	10 U	10	10 U	10 U
4	2-Methylnaphthalene (ug/kg)	3	3	100	360	1400	717	360	390	360	1400	717	360	390
4	Acenaphthene (ug/kg)	3	3	100	600	4100	1780	600	640	600	4100	1780	600	640
4	Acenaphthylene (ug/kg)	3	3	100	71	400	188	71	94	71	400	188	71	94
4	Aluminum (mg/kg)	3	3	100	38300	41300	39967	38300	40300	38300	41300	39967	38300	40300
4	Anthracene (ug/kg)	3	3	100	360	3000	1303	360	550	360	3000	1303	360	550
4	Barium (mg/kg)	3	3	100	175	192	186	175	191	175	192	186	175	191
4	Benz(a)anthracene (ug/kg)	3	3	100	600	4200	1897	600	890	600	4200	1897	600	890
4	Benzo(a)pyrene (ug/kg)	3	3	100	770	5700	2467	770	930	770	5700	2467	770	930
4	Benzo(b)fluoranthene (ug/kg)	3	3	100	620	4200	1870	620	790	620	4200	1870	620	790
4	Benzo(b+k)fluoranthene (ug/kg)	3	3	100	1030 A	7100 A	3117	1030 A	1220 A	1030 A	7100 A	3117	1030 A	1220 A
4	Benzo(g,h,i)perylene (ug/kg)	3	3	100	770	4600	2097	770	920	770	4600	2097	770	920
4	Benzo(k)fluoranthene (ug/kg)	3	3	100	410	2900	1247	410	430	410	2900	1247	410	430
4	Beryllium (mg/kg)	3	3	100	0.59	0.65	0.62	0.59	0.63	0.59	0.65	0.62	0.59	0.63

Table 4-6. Historical Subsurface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detects	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
4	Cadmium (mg/kg)	3	3	100	0.7	0.8	0.73	0.7	0.7	0.7	0.8	0.7	0.7	0.7
4	Calcium (mg/kg)	3	3	100	8240	8860	8607	8240	8720	8240	8860	8607	8240	8720
4	Chromium (mg/kg)	3	3	100	37.7	39.3	38.3	37.7	37.8	37.7	39.3	38.3	37.7	37.8
4	Chrysene (ug/kg)	3	3	100	800	5300	2400	800	1100	800	5300	2400	800	1100
4	Clay (%)	3	3	100	16.56	17.88	17.3	16.56	17.36	16.56	17.88	17.27	16.56	17.36
4	Cobalt (mg/kg)	3	3	100	16.3	18.4	17.4	16.3	17.4	16.3	18.4	17.4	16.3	17.4
4	Copper (mg/kg)	3	3	100	48.4	57.5	52.1	48.4	50.5	48.4	57.5	52.1	48.4	50.5
4	Dibenz(a,h)anthracene (ug/kg)	3	3	100	150	830	400	150	220	150	830	400	150	220
4	Dibenzofuran (ug/kg)	3	3	100	150	290	227	150	240	150	290	227	150	240
4	Fines (%)	3	3	100	63.41	77.45	72.45	63.41	76.49	63.41	77.45	72.45	63.41	76.49
4	Fluoranthene (ug/kg)	3	3	100	1400	14000	5833	1400	2100	1400	14000	5833	1400	2100
4	Fluorene (ug/kg)	3	3	100	360	2600	1160	360	520	360	2600	1160	360	520
4	Gravel (%)	3	3	100	0.17	1.8	0.74	0.17	0.24	0.17	1.8	0.74	0.17	0.24
4	High Molecular Weight PAH (ug/kg)	3	3	100	8060 A	63930 A	27550	8060 A	10660 A	8060 A	63930 A	27550	8060 A	10660 A
4	Indeno(1,2,3-cd)pyrene (ug/kg)	3	3	100	540	3200	1473	540	680	540	3200	1473	540	680
4	Iron (mg/kg)	3	3	100	39900	42100	41133	39900	41400	39900	42100	41133	39900	41400
4	Lead (mg/kg)	3	3	100	27	41	34	27	34	27	41	34	27	34
4	Low Molecular Weight PAH (ug/kg)	3	3	100	3891 A	31000 A	13465	3891 A	5504 A	3891 A	31000 A	13465	3891 A	5504 A
4	Magnesium (mg/kg)	3	3	100	6630	7150	6947	6630	7060	6630	7150	6947	6630	7060
4	Manganese (mg/kg)	3	3	100	495	587	542	495	545	495	587	542	495	545
4	Mercury (mg/kg)	3	3	100	0.23	0.34	0.28	0.23	0.27	0.23	0.34	0.28	0.23	0.27
4	Naphthalene (ug/kg)	3	3	100	1000	2900	1633	1000	1000	1000	2900	1633	1000	1000
4	Nickel (mg/kg)	3	3	100	30	32.6	31.4	30	31.5	30	32.6	31.4	30	31.5
4	Phenanthrene (ug/kg)	3	3	100	1500	18000	7400	1500	2700	1500	18000	7400	1500	2700
4	Polycyclic Aromatic Hydrocarbons (ug/kg)	3	3	100	11951 A	94930 A	41015	11951 A	16164 A	11951 A	94930 A	41015	11951 A	16164 A
4	Potassium (mg/kg)	3	3	100	1330	1400	1367	1330	1370	1330	1400	1367	1330	1370
4	Pyrene (ug/kg)	3	3	100	2000	19000	7867	2000	2600	2000	19000	7867	2000	2600
4	Sand (%)	3	3	100	22.38	34.79	26.81	22.38	23.27	22.38	34.79	26.8	22.38	23.27
4	Selenium (mg/kg)	3	3	100	8	11	9	8	8	8	11	9	8	8
4	Silt (%)	3	3	100	46.85	60.09	55.18	46.85	58.61	46.85	60.09	55.18	46.85	58.61
4	Silver (mg/kg)	3	3	100	1.3	1.5	1.4	1.3	1.4	1.3	1.5	1.4	1.3	1.4
4	Sodium (mg/kg)	3	3	100	1120 J	1230 J	1167	1120 J	1150 J	1120 J	1230 J	1167	1120 J	1150 J
4	Total organic carbon (%)	3	3	100	2.3	3	2.6	2.3	2.4	2.3	3	2.6	2.3	2.4
4	Vanadium (mg/kg)	3	3	100	98.7	103	101.6	98.7	103	98.7	103	101.6	98.7	103
4	Zinc (mg/kg)	3	3	100	152	255	201	152	196	152	255	201	152	196
4	4-Methylphenol (ug/kg)	3	3	100	230	450	307	230	240	230	450	307	230	240
4	Carbazole (ug/kg)	3	3	100	73 J	370 J	179	73 J	93 J	73 J	370 J	179	73 J	93 J
4	4,4'-DDD (ug/kg)	1	1	100	36 J	36 J	36	36 J	36 J	36 J	36 J	36	36 J	36 J
4	4,4'-DDE (ug/kg)	1	1	100	9.4 J	9.4 J	9.4	9.4 J	9.4 J	9.4 J	9.4 J	9.4	9.4 J	9.4 J
4	4,4'-DDT (ug/kg)	1	1	100	62 J	62 J	62	62 J	62 J	62 J	62 J	62	62 J	62 J
4	Titanium (mg/kg)	1	1	100	1970	1970	1970	1970	1970	1970	1970	1970	1970	1970
4	Total of 3 isomers: pp-DDT,-DDD,-DDE (ug/kg)	1	1	100	107.4 A	107.4 A	107.4	107.4 A	107.4 A	107.4 A	107.4 A	107.4	107.4 A	107.4 A
4	Bis(2-ethylhexyl) phthalate (ug/kg)	3	2	67	37	220	128.5	37	37	37	220	110	37	73 U
4	Antimony (mg/kg)	3	1	33	5 J	5 J	5	5 J	5 J	4 UJ	5 J	4	4 UJ	4 UJ
4	Arsenic (mg/kg)	3	1	33	5	5	5	5	5	4 U	5 U	5	4 U	5
4	Thallium (mg/kg)	3	1	33	5	5	5	5	5	4 U	5	5	4 U	5 U

Table 4-6. Historical Subsurface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detects	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
4	2,4-Dinitrotoluene (ug/kg)	3	0	0						98 U	370 U	189	98 U	98 U
4	2,6-Dinitrotoluene (ug/kg)	3	0	0						98 U	370 U	189	98 U	98 U
4	2-Chloronaphthalene (ug/kg)	3	0	0						20 U	73 U	38	20 U	20 U
4	2-Nitroaniline (ug/kg)	3	0	0						98 U	370 U	189	98 U	98 U
4	3,3'-Dichlorobenzidine (ug/kg)	3	0	0						98 U	370 U	189	98 U	98 U
4	3-Nitroaniline (ug/kg)	3	0	0						120 UJ	440 UJ	227	120 UJ	120 UJ
4	4-Bromophenyl phenyl ether (ug/kg)	3	0	0						20 U	73 U	38	20 U	20 U
4	4-Chloroaniline (ug/kg)	3	0	0						59 U	220 U	113	59 U	59 U
4	4-Chlorophenyl phenyl ether (ug/kg)	3	0	0						20 U	73 U	38	20 U	20 U
4	4-Nitroaniline (ug/kg)	3	0	0						98 UJ	370 UJ	189	98 UJ	98 UJ
4	Benzoic acid (ug/kg)	3	0	0						200 U	730 U	377	200 U	200 U
4	Benzyl alcohol (ug/kg)	3	0	0						20 UJ	73 UJ	38	20 UJ	20 UJ
4	Bis(2-chloro-1-methylethyl) ether (ug/kg)	3	0	0						20 U	73 U	38	20 U	20 U
4	Bis(2-chloroethoxy) methane (ug/kg)	3	0	0						20 U	73 U	38	20 U	20 U
4	Bis(2-chloroethyl) ether (ug/kg)	3	0	0						39 U	150 U	76	39 U	39 U
4	Hexachlorobutadiene (ug/kg)	3	0	0						20 U	73 U	38	20 U	20 U
4	Hexachlorocyclopentadiene (ug/kg)	3	0	0						98 UJ	370 UJ	189	98 UJ	98 UJ
4	Hexachloroethane (ug/kg)	3	0	0						20 U	73 U	38	20 U	20 U
4	Isophorone (ug/kg)	3	0	0						20 U	73 U	38	20 U	20 U
4	Nitrobenzene (ug/kg)	3	0	0						20 U	73 U	38	20 U	20 U
4	N-Nitrosodiphenylamine (ug/kg)	3	0	0						20 UJ	73 UJ	38	20 UJ	20 UJ
4	N-Nitrosodipropylamine (ug/kg)	3	0	0						39 U	150 U	76	39 U	39 U
4	1,2,4-Trichlorobenzene (ug/kg)	3	0	0						20 U	73 U	38	20 U	20 U
4	1,2-Dichlorobenzene (ug/kg)	3	0	0						20 U	73 U	38	20 U	20 U
4	1,3-Dichlorobenzene (ug/kg)	3	0	0						20 U	73 U	38	20 U	20 U
4	1,4-Dichlorobenzene (ug/kg)	3	0	0						20 U	73 U	38	20 U	20 U
4	2,4,5-Trichlorophenol (ug/kg)	3	0	0						98 U	370 U	189	98 U	98 U
4	2,4,6-Trichlorophenol (ug/kg)	3	0	0						98 U	370 U	189	98 U	98 U
4	2,4-Dichlorophenol (ug/kg)	3	0	0						59 U	220 U	113	59 U	59 U
4	2,4-Dimethylphenol (ug/kg)	3	0	0						20 U	73 U	38	20 U	20 U
4	2,4-Dinitrophenol (ug/kg)	3	0	0						200 UJ	730 UJ	377	200 UJ	200 UJ
4	2-Chlorophenol (ug/kg)	3	0	0						20 U	73 U	38	20 U	20 U
4	2-Methylphenol (ug/kg)	3	0	0						20 U	73 U	38	20 U	20 U
4	2-Nitrophenol (ug/kg)	3	0	0						98 U	370 U	189	98 U	98 U
4	4,6-Dinitro-2-methylphenol (ug/kg)	3	0	0						200 UJ	730 UJ	377	200 UJ	200 UJ
4	4-Chloro-3-methylphenol (ug/kg)	3	0	0						39 U	150 U	76	39 U	39 U
4	4-Nitrophenol (ug/kg)	3	0	0						98 U	370 U	189	98 U	98 U
4	Butylbenzyl phthalate (ug/kg)	3	0	0						20 U	73 U	38	20 U	20 U
4	Dibutyl phthalate (ug/kg)	3	0	0						20 U	73 U	38	20 U	20 U
4	Diethyl phthalate (ug/kg)	3	0	0						20 U	73 U	38	20 U	20 U
4	Dimethyl phthalate (ug/kg)	3	0	0						20 U	73 U	38	20 U	20 U
4	Di-n-octyl phthalate (ug/kg)	3	0	0						20 U	73 U	38	20 U	20 U
4	Hexachlorobenzene (ug/kg)	3	0	0						20 U	73 U	38	20 U	20 U
4	Pentachlorophenol (ug/kg)	3	0	0						98 UJ	370 UJ	189	98 UJ	98 UJ
4	Phenol (ug/kg)	3	0	0						20 U	73 U	38	20 U	20 U
4	Aroclor 1016 (ug/kg)	1	0	0						19 UJ	19 UJ	19	19 UJ	19 UJ

Table 4-6. Historical Subsurface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detects	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
4	Aroclor 1221 (ug/kg)	1	0	0						39 UJ	39 UJ	39	39 UJ	39 UJ
4	Aroclor 1232 (ug/kg)	1	0	0						19 UJ	19 UJ	19	19 UJ	19 UJ
4	Aroclor 1242 (ug/kg)	1	0	0						19 UJ	19 UJ	19	19 UJ	19 UJ
4	Aroclor 1248 (ug/kg)	1	0	0						19 UJ	19 UJ	19	19 UJ	19 UJ
4	Aroclor 1254 (ug/kg)	1	0	0						19 UJ	19 UJ	19	19 UJ	19 UJ
4	Aroclor 1260 (ug/kg)	1	0	0						19 UJ	19 UJ	19	19 UJ	19 UJ
4	Butyltin ion (ug/kg)	1	0	0						11 U	11 U	11	11 U	11 U
4	Dibutyltin ion (ug/kg)	1	0	0						11 U	11 U	11	11 U	11 U
4	Polychlorinated biphenyls (ug/kg)	1	0	0						39 UA	39 UA	39	39 UA	39 UA
4	Tetrabutyltin (ug/kg)	1	0	0						11 U	11 U	11	11 U	11 U
4	Tributyltin ion (ug/kg)	1	0	0						11 U	11 U	11	11 U	11 U
4	Aldrin (ug/kg)	1	0	0						0.96 UJ	0.96 UJ	0.96	0.96 UJ	0.96 UJ
4	alpha-Chlordane (ug/kg)	1	0	0						0.96 UJ	0.96 UJ	0.96	0.96 UJ	0.96 UJ
4	alpha-Endosulfan (ug/kg)	1	0	0						0.96 UJ	0.96 UJ	0.96	0.96 UJ	0.96 UJ
4	alpha-Hexachlorocyclohexane (ug/kg)	1	0	0						0.96 UJ	0.96 UJ	0.96	0.96 UJ	0.96 UJ
4	beta-Endosulfan (ug/kg)	1	0	0						1.9 UJ	1.9 UJ	1.9	1.9 UJ	1.9 UJ
4	beta-Hexachlorocyclohexane (ug/kg)	1	0	0						0.96 UJ	0.96 UJ	0.96	0.96 UJ	0.96 UJ
4	delta-Hexachlorocyclohexane (ug/kg)	1	0	0						0.96 UJ	0.96 UJ	0.96	0.96 UJ	0.96 UJ
4	Dieldrin (ug/kg)	1	0	0						1.9 UJ	1.9 UJ	1.9	1.9 UJ	1.9 UJ
4	Endosulfan sulfate (ug/kg)	1	0	0						1.9 UJ	1.9 UJ	1.9	1.9 UJ	1.9 UJ
4	Endrin (ug/kg)	1	0	0						1.9 UJ	1.9 UJ	1.9	1.9 UJ	1.9 UJ
4	Endrin aldehyde (ug/kg)	1	0	0						1.9 UJ	1.9 UJ	1.9	1.9 UJ	1.9 UJ
4	Endrin ketone (ug/kg)	1	0	0						1.9 UJ	1.9 UJ	1.9	1.9 UJ	1.9 UJ
4	gamma-Chlordane (ug/kg)	1	0	0						0.96 UJ	0.96 UJ	0.96	0.96 UJ	0.96 UJ
4	gamma-Hexachlorocyclohexane (ug/kg)	1	0	0						0.96 UJ	0.96 UJ	0.96	0.96 UJ	0.96 UJ
4	Heptachlor (ug/kg)	1	0	0						0.96 UJ	0.96 UJ	0.96	0.96 UJ	0.96 UJ
4	Heptachlor epoxide (ug/kg)	1	0	0						0.96 UJ	0.96 UJ	0.96	0.96 UJ	0.96 UJ
4	Methoxychlor (ug/kg)	1	0	0						9.6 UJ	9.6 UJ	9.6	9.6 UJ	9.6 UJ
4	Toxaphene (ug/kg)	1	0	0						96 UJ	96 UJ	96	96 UJ	96 UJ
5	Total organic carbon (%)	30	30	100	0.03	3.3	1.47	1.67	2.6	0.03	3.3	1.47	1.67	2.6
5	Chromium (mg/kg)	25	25	100	9	41.4	25.1	25.3	38.2	9	41.4	25.1	25.3	38.2
5	Copper (mg/kg)	25	25	100	13.3	103	42.7	38.4	78.3	13.3	103	42.7	38.4	78.3
5	Lead (mg/kg)	25	25	100	3	576	117.18	27	364	3	576	117	27	364
5	Total solids (%)	25	25	100	46.5	81.4	61.7	57.4	78.3	46.5	81.4	61.7	57.4	78.3
5	Zinc (mg/kg)	25	25	100	37 G	656 G	210	123	535	37 G	656 G	210	123	535
5	Ammonia (mg/kg)	24	24	100	1.4	327	136	142	239	1.4	327	136.0	142	239
5	Total volatile solids (%)	23	23	100	1.73	10.5	5.5	6.13	7.95	1.73	10.5	5.5	6.13	7.95
5	Nickel (mg/kg)	21	21	100	15 G	37.4	23.0	23 G	30	15 G	37.4	23.0	23 G	30
5	Pencil pitch (mg/kg)	16	16	100	21	2300	703	385	2000	21	2300	703	385	2000
5	Total sulfides (mg/kg)	14	14	100	2 G	796 G	120	31.4 G	276 G	2 G	796 G	120	31.4 G	276 G
5	Clay (%)	12	12	100	0.9	17.97	10.0	12.5	17.43	0.9	17.97	10.0	12.5	17.43
5	Fines (%)	12	12	100	3	80.1	51.0	62.9	76.54	3	80.1	51.0	62.9	76.54
5	Silt (%)	12	12	100	2.1	73.4	41.1	50.41	62.4	2.1	73.4	41.1	50.41	62.4
5	Sand (%)	11	11	100	22.98	96.9	51.39	34.24	96.8	22.98	96.9	51.39	34.24	96.8
5	Barium (mg/kg)	8	8	100	129	197	172	175	191	129	197	172	175	191
5	Gravel (%)	7	7	100	0.01	1.14	0.35	0.1	0.55	0.01	1.14	0.35	0.1	0.55

Table 4-6. Historical Subsurface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detects	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
5	>10 Phi clay (%)	4	4	100	0	6.8	1.7	0	0	0	6.8	1.7	0	0
5	8-9 Phi clay (%)	4	4	100	0	6.8	2.6	0	3.7	0	6.8	2.6	0	3.7
5	9-10 Phi clay (%)	4	4	100	0	6.8	2.6	0	3.7	0	6.8	2.6	0	3.7
5	Aluminum (mg/kg)	4	4	100	37100	40900	39875	40700	40800	37100	40900	39875	40700	40800
5	Beryllium (mg/kg)	4	4	100	0.54	0.66	0.59	0.56	0.6	0.54	0.66	0.59	0.56	0.6
5	Calcium (mg/kg)	4	4	100	7490	8330	8013	7930	8300	7490	8330	8013	7930	8300
5	Coarse silt (%)	4	4	100	10.7	33.2	23.8	18.4	33	10.7	33.2	23.8	18.4	33
5	Cobalt (mg/kg)	4	4	100	17.2	20.3	18.5	17.3	19.1	17.2	20.3	18.5	17.3	19.1
5	Fine silt (%)	4	4	100	0	7.4	5.3	6.8	6.8	0	7.4	5.3	6.8	6.8
5	Iron (mg/kg)	4	4	100	40200	44100	42000	41100	42600	40200	44100	42000	41100	42600
5	Magnesium (mg/kg)	4	4	100	6510	7100	6845	6760	7010	6510	7100	6845	6760	7010
5	Manganese (mg/kg)	4	4	100	495	684	582	529	619	495	684	582	529	619
5	Medium silt (%)	4	4	100	0	13.6	5.1	0	6.8	0	13.6	5.1	0	6.8
5	Potassium (mg/kg)	4	4	100	1300	1410	1343	1330	1330	1300	1410	1343	1330	1330
5	Sieve 10 (%)	4	4	100	0	1.1	0.45	0.3	0.4	0	1.1	0.45	0.3	0.4
5	Sieve 140 (%)	4	4	100	3	51.7	24.2	14.4	27.7	3	51.7	24.2	14.4	27.7
5	Sieve 20 (%)	4	4	100	0.2	0.4	0.3	0.3	0.4	0.2	0.4	0.3	0.3	0.4
5	Sieve 200 (%)	4	4	100	0.6	5.6	3.0	0.7	5.2	0.6	5.6	3.0	0.7	5.2
5	Sieve 230 (%)	4	4	100	5.6	21.9	12.5	6.8	15.5	5.6	21.9	12.5	6.8	15.5
5	Sieve 4 (%)	4	4	100	0	6	2	0	0.2	0	6	2	0	0.2
5	Sieve 40 (%)	4	4	100	0.5	1.6	0.8	0.5	0.6	0.5	1.6	0.8	0.5	0.6
5	Sieve 60 (%)	4	4	100	0.7	10.7	3.9	1.9	2.3	0.7	10.7	3.9	1.9	2.3
5	Sodium (mg/kg)	4	4	100	1060 J	1230 J	1155	1130 J	1200 J	1060 J	1230 J	1155	1130 J	1200 J
5	Vanadium (mg/kg)	4	4	100	98.2	107	103.6	103	106	98.2	107	103.6	103	106
5	Very fine silt (%)	4	4	100	0	6.8	3.4	0	6.8	0	6.8	3.4	0	6.8
5	Carbazole (ug/kg)	4	4	100	99	1800	622	280 J	310 J	99	1800	622	280 J	310 J
5	Mean grain size (mm)	2	2	100	0.05	0.07	0.06	0.05	0.05	0.05	0.07	0.06	0.05	0.05
5	Median grain size (mm)	2	2	100	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
5	1,2,3,4,6,7,8-Heptachlorodibenzofuran (ng/kg)	1	1	100	67	67	67	67	67	67	67	67	67	67
5	1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin (ng/kg	1	1	100	380	380	380	380	380	380	380	380	380	380
5	1,2,3,4,7,8,9-Heptachlorodibenzofuran (ng/kg)	1	1	100	12	12	12	12	12	12	12	12	12	12
5	1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin (ng/kg)	1	1	100	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
5	1,2,3,6,7,8-Hexachlorodibenzofuran (ng/kg)	1	1	100	11	11	11	11	11	11	11	11	11	11
5	1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin (ng/kg)	1	1	100	21	21	21	21	21	21	21	21	21	21
5	1,2,3,7,8,9-Hexachlorodibenzofuran (ng/kg)	1	1	100	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3
5	1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin (ng/kg)	1	1	100	11	11	11	11	11	11	11	11	11	11
5	1,2,3,7,8-Pentachlorodibenzofuran (ng/kg)	1	1	100	24	24	24	24	24	24	24	24	24	24
5	2,3,4,6,7,8-Hexachlorodibenzofuran (ng/kg)	1	1	100	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
5	2,3,4,7,8-Pentachlorodibenzofuran (ng/kg)	1	1	100	10	10	10	10	10	10	10	10	10	10
5	2,3,7,8-Tetrachlorodibenzofuran (ng/kg)	1	1	100	19	19	19	19	19	19	19	19	19	19
5	Acid Volatile Sulfides (mg/kg)	1	1	100	17.9 G	17.9 G	17.9	17.9 G	17.9 G	17.9 G	17.9 G	17.9	17.9 G	17.9 G
5	Bromine (ug/kg)	1	1	100	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5
5	Chlorine (ug/kg)	1	1	100	610	610	610	610	610	610	610	610	610	610
5	Heptachlorodibenzofuran (ng/kg)	1	1	100	260	260	260	260	260	260	260	260	260	260
5	Heptachlorodibenzo-p-dioxin (ng/kg)	1	1	100	710	710	710	710	710	710	710	710	710	710
5	Hexachlorodibenzofuran (ng/kg)	1	1	100	140	140	140	140	140	140	140	140	140	140

Table 4-6. Historical Subsurface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detects	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
5	Hexachlorodibenzo-p-dioxin (ng/kg)	1	1	100	140	140	140	140	140	140	140	140	140	140
5	Mean grain size (%)	1	1	100	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
5	Median grain size (%)	1	1	100	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
5	Octachlorodibenzofuran (ng/kg)	1	1	100	230	230	230	230	230	230	230	230	230	230
5	Octachlorodibenzo-p-dioxin (ng/kg)	1	1	100	2700	2700	2700	2700	2700	2700	2700	2700	2700	2700
5	Pentachlorodibenzofuran (ng/kg)	1	1	100	84	84	84	84	84	84	84	84	84	84
5	Tetrachlorodibenzofuran (ng/kg)	1	1	100	49	49	49	49	49	49	49	49	49	49
5	Tetrachlorodibenzo-p-dioxin (ng/kg)	1	1	100	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3
5	Titanium (mg/kg)	1	1	100	1960	1960	1960	1960	1960	1960	1960	1960	1960	1960
5	Tributyltin ion (ug/l)	1	1	100	0.04 G	0.04 G	0.04	0.04 G	0.04 G	0.04 G	0.04 G	0.04	0.04 G	0.04 G
5	Mercury (mg/kg)	25	23	92	0.02	0.33	0.13	0.09	0.21	0.02	0.33	0.12	0.09	0.21
5	Arsenic (mg/kg)	25	22	88	1	15 G	5	4.5	8 G	1	15 G	5	4.5	8 G
5	High Molecular Weight PAH (ug/kg)	29	25	86	920 A	198000 A	51541	8740 A	152700 A	20 UA	198000 A	44567	7360 A	152700 A
5	Polycyclic Aromatic Hydrocarbons (ug/kg)	29	25	86	2003 A	214890 A	57575	10590 A	190000 A	20 UA	214890 A	49769	8485 A	190000 A
5	Pyrene (ug/kg)	29	25	86	215 G	48000	8241	1900	24000	20 U	48000	7239	1840	24000
5	Fluoranthene (ug/kg)	29	24	83	217 G	34000	8413	2300	27000	20 U	34000	7154	1650 U	27000
5	Low Molecular Weight PAH (ug/kg)	29	24	83	108 A	62190 A	6285	1670 A	12770 A	20 UA	62190 A	5475	1290 A	12770 A
5	Phenanthrene (ug/kg)	29	24	83	87	42000	4727	1290	10000	20 U	42000	4185	1100	10000
5	Cadmium (mg/kg)	25	20	80	0.1 G	3.3 G	1.1	0.4	3.2 G	0.1 UG	3.3 G	0.9	0.5 U	2.8
5	Benz(a)anthracene (ug/kg)	29	23	79	74 G	20000	5283	1600	15000	20 U	20000	4405	790 G	15000
5	Benzo(a)pyrene (ug/kg)	29	23	79	81 G	24000	6484	1900	18000	20 U	24000	5357	960	18000
5	Benzo(b)fluoranthene (ug/kg)	29	23	79	63 G	21000	5226	1800	14000	20 U	21000	4360	960 G	14000
5	Benzo(b+k)fluoranthene (ug/kg)	29	23	79	121 A	36000 A	9596	3400 A	26000 A	20 UA	36000 A	7826	1520 A	26000 A
5	Benzo(g,h,i)perylene (ug/kg)	29	23	79	56 G	16000	4362	1300	13000	20 U	16000	3674	660 U	13000
5	Benzo(k)fluoranthene (ug/kg)	29	23	79	58 G	17000	4370	1600	12000	20 U	17000	3681	670	12000
5	Chrysene (ug/kg)	29	23	79	90 G	20000	5411	1800	14000	20 U	20000	4507	860	14000
5	Indeno(1,2,3-cd)pyrene (ug/kg)	29	23	79	55 G	32000	6826	2200	18000	20 U	32000	5628	1100 G	18000
5	4,4'-DDD (ug/kg)	8	6	75	2	32	16	14	23 J	2	43.3 U	18.2	14	32
5	Total of 3 isomers: pp-DDT,-DDD,-DDE (ug/kg)	8	6	75	4.8 A	479.8 A	99.3	32 A	41 A	4.8 A	479.8 A	80.7	32 A	43.3 UA
5	Silver (mg/kg)	25	18	72	0.12	1.6	0.75	0.4	1.4	0.1 U	2.15 U	0.72	0.4	1.4
5	Polychlorinated biphenyls (ug/kg)	8	5	63	12 A	194 A	69	19 A	85.9 A	12 A	288 UA	106	78 UA	194 A
5	Selenium (mg/kg)	8	5	63	0.93	11	6.6	6	9	0.5 U	11	4.4	1.08 U	9
5	2-Methylnaphthalene (ug/kg)	9	5	56	53	860	411	170 G	730	53	3550 U	916	330 U	1650 U
5	Antimony (mg/kg)	20	10	50	0.03 G	8 J	1.81	0.3 G	6 J	0.02 UG	8 J	1.44	0.2 G	6 J
5	Anthracene (ug/kg)	29	12	41	21	7800	1117	150	1800	20 U	7800	1453	330 U	4000 U
5	4,4'-DDE (ug/kg)	8	3	38	2	13.9	7.2	2	5.8	2	43.3 U	12.7	6.7 U	20.1 U
5	4,4'-DDT (ug/kg)	8	3	38	0.8	460	159.6	0.8	18 J	0.8	460	70.288	6.7 U	43.3 U
5	Aroclor 1260 (ug/kg)	8	3	38	12	32	21	12	19	12	144 U	60.75	67 U	78 UIJ
5	Acenaphthene (ug/kg)	29	9	31	30	5400	1241	148 G	2500	20 U	5400	1412	330 U	4000 U
5	Dibenz(a,h)anthracene (ug/kg)	29	8	28	11 G	4400	937	43	2100	11 G	4400	1305	330 U	4000 U
5	Aroclor 1254 (ug/kg)	8	2	25	85.9	194	140	85.9	85.9	10 U	194	77	67 U	144 U
5	Naphthalene (ug/kg)	29	7	24	84	1900	648	230 G	1500	20 U	4000 U	1198	330 U	4000 U
5	Fluorene (ug/kg)	29	6	21	27	4600	1230	133 G	1700	20 U	4600	1302	330 U	4000 U
5	Bis(2-ethylhexyl) phthalate (ug/kg)	28	5	18	36	420	227	120	380	20 U	21500 U	2245	380	4000 U
5	Dibenzofuran (ug/kg)	29	5	17	42	470	231	85 G	340	20 U	4000 U	1089	220	4000 U
5	4-Methylphenol (ug/kg)	24	4	17	23	280	122	26	160	20 U	4000 U	1031	160	4000 U

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River Mile	Analyte	N	N Detected	% Detects	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
5	Methoxychlor (ug/kg)	6	1	17	1 J	1 J	1	1 J	1 J	1 J	43.3 U	16.8	6.7 U	23 UIJ
5	Acenaphthylene (ug/kg)	29	3	10	10 G	490	240	10 G	220	10 G	4000 U	1076	200 U	4000 U
5	m,p-Xylene (ug/kg)	18	1	6	5	5	5	5	5	5 U	10 U	6	5 U	10 U
5	Butylbenzyl phthalate (ug/kg)	28	1	4	240	240	240	240	240	19 U	4000 U	1096	200 U	4000 U
5	Benzoic acid (ug/kg)	28	0	0						100 U	20000 U	5079	1000 U	20000 U
5	Benzyl alcohol (ug/kg)	28	0	0						6 U	3550 U	489	60 U	1200 U
5	Hexachlorobutadiene (ug/kg)	28	0	0						19 U	10800 U	1545	200 U	4000 U
5	N-Nitrosodiphenylamine (ug/kg)	28	0	0						12 U	3550 U	748	120 U	2400 U
5	2,4-Dimethylphenol (ug/kg)	28	0	0						6 U	10800 U	939	60 U	2000 U
5	2-Methylphenol (ug/kg)	28	0	0						6 U	3550 U	489	60 U	1200 U
5	Dibutyl phthalate (ug/kg)	28	0	0						19 U	10800 U	1545	200 U	4000 U
5	Diethyl phthalate (ug/kg)	28	0	0						19 U	4000 U	1094	200 U	4000 U
5	Dimethyl phthalate (ug/kg)	28	0	0						19 U	4000 U	1094	200 U	4000 U
5	Di-n-octyl phthalate (ug/kg)	28	0	0						19 U	4000 U	1094	200 U	4000 U
5	Hexachlorobenzene (ug/kg)	28	0	0						19 U	4000 U	1094	200 U	4000 U
5	Phenol (ug/kg)	28	0	0						19 U	4000 U	1094	200 U	4000 U
5	Pentachlorophenol (ug/kg)	27	0	0						60 U	12000 U	3407	600 U	12000 U
5	1,2-Dichlorobenzene (ug/kg)	24	0	0						1 U	130 U	14	5 U	35 U
5	1,3-Dichlorobenzene (ug/kg)	24	0	0						1 U	130 U	14	5 U	35 U
5	1,4-Dichlorobenzene (ug/kg)	24	0	0						1 U	130 U	14	5 U	35 U
5	Benzene (ug/kg)	18	0	0						5 U	10 U	6	5 U	10 U
5	Ethylbenzene (ug/kg)	18	0	0						5 U	10 U	6	5 U	10 U
5	o-Xylene (ug/kg)	18	0	0						5 U	10 U	6	5 U	10 U
5	Tetrachloroethene (ug/kg)	18	0	0						5 U	10 U	6	5 U	10 U
5	Toluene (ug/kg)	18	0	0						5 U	10 U	6	5 U	10 U
5	Trichloroethene (ug/kg)	18	0	0						5 U	10 U	6	5 U	10 U
5	2,4-Dinitrotoluene (ug/kg)	8	0	0						97 U	21500 U	4831	640 U	10000 U
5	2,6-Dinitrotoluene (ug/kg)	8	0	0						97 U	5380 U	1316	500 U	2500 U
5	2-Chloronaphthalene (ug/kg)	8	0	0						19 U	3550 U	803	130 U	1650 U
5	2-Nitroaniline (ug/kg)	8	0	0						97 U	3550 U	917	330 U	1650 U
5	3,3'-Dichlorobenzidine (ug/kg)	8	0	0						97 U	10800 U	2493	640 U	5000 U
5	3-Nitroaniline (ug/kg)	8	0	0						120 U	10800 U	2524	770 UJ	5000 U
5	4-Bromophenyl phenyl ether (ug/kg)	8	0	0						19 U	3550 U	803	130 U	1650 U
5	4-Chloroaniline (ug/kg)	8	0	0						58 U	21500 U	4774	390 U	10000 U
5	4-Chlorophenyl phenyl ether (ug/kg)	8	0	0						19 U	3550 U	803	130 U	1650 U
5	4-Nitroaniline (ug/kg)	8	0	0						97 U	3550 U	917	330 U	1650 U
5	Aroclor 1016 (ug/kg)	8	0	0						10 U	144 U	49	19 UJ	67 U
5	Aroclor 1221 (ug/kg)	8	0	0						10 U	288 U	95	39 UJ	137 U
5	Aroclor 1232 (ug/kg)	8	0	0						10 U	144 U	49	19 UJ	67 U
5	Aroclor 1242 (ug/kg)	8	0	0						10 U	144 U	49	19 UJ	67 U
5	Aroclor 1248 (ug/kg)	8	0	0						10 U	144 U	49	19 UJ	67 U
5	Bis(2-chloroethoxy) methane (ug/kg)	8	0	0						19 U	3550 U	803	130 U	1650 U
5	Bis(2-chloroethyl) ether (ug/kg)	8	0	0						39 U	3550 U	832	260 U	1650 U
5	Hexachlorocyclopentadiene (ug/kg)	8	0	0						97 UJ	10800 U	2493	640 UJ	5000 U
5	Hexachloroethane (ug/kg)	8	0	0						19 U	10800 U	2379	130 U	5000 U
5	Isophorone (ug/kg)	8	0	0						19 U	3550 U	803	130 U	1650 U

Table 4-6. Historical Subsurface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detects	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
5	Nitrobenzene (ug/kg)	8	0	0						19 U	3550 U	803	130 U	1650 U
5	N-Nitrosodipropylamine (ug/kg)	8	0	0						39 U	3550 U	832	260 U	1650 U
5	2,4,5-Trichlorophenol (ug/kg)	8	0	0						97 U	3550 U	917	330 U	1650 U
5	2,4,6-Trichlorophenol (ug/kg)	8	0	0						97 U	3550 U	917	330 U	1650 U
5	2,4-Dichlorophenol (ug/kg)	8	0	0						58 U	3550 U	860	330 U	1650 U
5	2,4-Dinitrophenol (ug/kg)	8	0	0						190 UJ	3550 U	1064	480 UJ	1650 U
5	2-Chlorophenol (ug/kg)	8	0	0						19 U	3550 U	803	130 U	1650 U
5	2-Nitrophenol (ug/kg)	8	0	0						97 U	3550 U	917	330 U	1650 U
5	4,6-Dinitro-2-methylphenol (ug/kg)	8	0	0						190 U	10800 U	2640	1000 U	5000 U
5	4-Chloro-3-methylphenol (ug/kg)	8	0	0						39 U	3550 U	832	260 U	1650 U
5	4-Nitrophenol (ug/kg)	8	0	0						97 U	10800 U	2493	640 U	5000 U
5	Aldrin (ug/kg)	8	0	0						0.97 UJ	43.3 U	10.40	2 U	20.1 U
5	Dieldrin (ug/kg)	8	0	0						1.9 UJ	43.3 U	10.7	2.3 U	20.1 U
5	gamma-Hexachlorocyclohexane (ug/kg)	8	0	0						0.97 UJ	43.3 U	10.40	2 U	20.1 U
5	Heptachlor (ug/kg)	8	0	0						0.97 UJ	43.3 U	10.40	2 U	20.1 U
5	alpha-Chlordane (ug/kg)	7	0	0						0.97 UJ	43.3 U	11.60	1.7 U	20.1 U
5	alpha-Endosulfan (ug/kg)	6	0	0						0.97 UJ	43.3 U	13.30	6.7 U	20.1 U
5	alpha-Hexachlorocyclohexane (ug/kg)	6	0	0						0.97 UJ	43.3 U	13.30	6.7 U	20.1 U
5	beta-Endosulfan (ug/kg)	6	0	0						1.9 UJ	43.3 U	13.5	6.7 U	20.1 U
5	beta-Hexachlorocyclohexane (ug/kg)	6	0	0						0.97 UJ	43.3 U	13.30	6.7 U	20.1 U
5	delta-Hexachlorocyclohexane (ug/kg)	6	0	0						0.97 UJ	43.3 U	13.30	6.7 U	20.1 U
5	Endosulfan sulfate (ug/kg)	6	0	0						1.9 UJ	43.3 U	13.5	6.7 U	20.1 U
5	Endrin (ug/kg)	6	0	0						1.9 UJ	43.3 U	13.5	6.7 U	20.1 U
5	Endrin aldehyde (ug/kg)	6	0	0						1.9 UJ	43.3 U	13.5	6.7 U	20.1 U
5	Heptachlor epoxide (ug/kg)	6	0	0						0.97 UJ	43.3 U	13.30	6.7 U	20.1 U
5	Toxaphene (ug/kg)	6	0	0						40 U	1290 U	405	200 U	600 U
5	Endrin ketone (ug/kg)	5	0	0						1.9 UJ	43.3 U	15.7	6.7 U	20.1 U
5	Bis(2-chloro-1-methylethyl) ether (ug/kg)	4	0	0						19 U	130 U	58	35 U	48 U
5	Bis(2-chloroisopropyl) ether (ug/kg)	4	0	0						330 U	3550 U	1548	660 U	1650 U
5	Thallium (mg/kg)	4	0	0						4 U	5 U	5	5 U	5 U
5	1,2,4-Trichlorobenzene (ug/kg)	4	0	0						19 U	130 U	58	35 U	48 U
5	3- and 4-Methylphenol Coelution (ug/kg)	4	0	0						330 U	3550 U	1548	660 U	1650 U
5	Chlordane (technical) (ug/kg)	4	0	0						150 U	968 U	430	150 U	450 U
5	trans-Chlordane (ug/kg)	4	0	0						6.7 U	43.3 U	19.2	6.7 U	20.1 U
5	Diesel fuels (mg/kg)	3	0	0						25 U	100 U	75	25 U	100 U
5	gamma-Chlordane (ug/kg)	3	0	0						0.97 UJ	1.7 U	1.46	0.97 UJ	1.7 U
5	Lube Oil (mg/kg)	3	0	0						100 U	100 U	100	100 U	100 U
5	Phytane (mg/kg)	3	0	0						0.5 U	0.5 U	0.5	0.5 U	0.5 U
5	Pristane (mg/kg)	3	0	0						0.5 U	0.5 U	0.5	0.5 U	0.5 U
5	1,2,3,4,7,8-Hexachlorodibenzofuran (ng/kg)	1	0	0						62 U	62 U	62	62 U	62 U
5	1,2,3,7,8-Pentachlorodibenzo-p-dioxin (ng/kg)	1	0	0						1.5 U	1.5 U	1.5	1.5 U	1.5 U
5	2,3,7,8-Tetrachlorodibenzo-p-dioxin (ng/kg)	1	0	0						0.58 U	0.58 U	0.58	0.58 U	0.58 U
5	Butyltin ion (ug/kg)	1	0	0						19 U	19 U	19	19 U	19 U
5	Dibutyltin ion (ug/kg)	1	0	0						19 U	19 U	19	19 U	19 U
5	Pentachlorodibenzo-p-dioxin (ng/kg)	1	0	0						1.5 U	1.5 U	1.5	1.5 U	1.5 U
5	Tetrabutyltin (ug/kg)	1	0	0						19 U	19 U	19	19 U	19 U

Table 4-6. Historical Subsurface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detects	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
5	Tributyltin ion (ug/kg)	1	0	0						19 U	19 U	19	19 U	19 U
5	Chlordane (cis & trans) (ug/kg)	1	0	0						10 U	10 U	10	10 U	10 U
6	Benzo(a)pyrene (ug/kg)	9	9	100	0.5 G	30000	5103	740	11000	0.5 G	30000	5103	740	11000
6	Benzo(b)fluoranthene (ug/kg)	9	9	100	5 G	25000	4312	930	8000	5 G	25000	4312	930	8000
6	Benzo(b+k)fluoranthene (ug/kg)	9	9	100	10 A	32900 A	6273	1440 A	14800 A	10 A	32900 A	6273	1440 A	14800 A
6	Benzo(g,h,i)perylene (ug/kg)	9	9	100	0.7 G	25000	4226	300	9800	0.7 G	25000	4226	300	9800
6	Benzo(k)fluoranthene (ug/kg)	9	9	100	5 G	7900	1962	490	6800	5 G	7900	1962	490	6800
6	Cadmium (mg/kg)	9	9	100	0.05	0.6	0.34	0.3	0.6	0.05	0.6	0.34	0.3	0.6
6	Chromium (mg/kg)	9	9	100	15.1	67.5	32.6	24.3	36.9	15.1	67.5	32.6	24.3	36.9
6	Copper (mg/kg)	9	9	100	13.5	151	49.8	36.5	64	13.5	151	49.8	36.5	64
6	Dibenzofuran (ug/kg)	9	9	100	2 J	1500	496	32	1300	2 J	1500	496	32	1300
6	Fluoranthene (ug/kg)	9	9	100	0.7 G	100000	16706.7	3000 J	33000	0.7 G	100000	16706.7	3000 J	33000
6	High Molecular Weight PAH (ug/kg)	9	9	100	3 A	402800 A	66888	9650 A	134900 A	3 A	402800 A	66888	9650 A	134900 A
6	Lead (mg/kg)	9	9	100	2.8	131	33.9	16	46	2.8	131	33.9	16	46
6	Mercury (mg/kg)	9	9	100	0.03	0.5	0.15	0.07	0.18	0.03	0.5	0.15	0.07	0.18
6	Nickel (mg/kg)	9	9	100	19.2	37 J	27.1	25.1	33 J	19.2	37 J	27.1	25.1	33 J
6	Polycyclic Aromatic Hydrocarbons (ug/kg)	9	9	100	3 A	583600 A	97420	13974 A	204310 A	3 A	583600 A	97420	13974 A	204310 A
6	Pyrene (ug/kg)	9	9	100	0.9 G	130000	20705.7	1500	40000	0.9 G	130000	20705.7	1500	40000
6	Silver (mg/kg)	9	9	100	0.06 E	1.3	0.75	0.49	1.2	0.06 E	1.3	0.75	0.49	1.2
6	Total organic carbon (%)	9	9	100	0.07	4.37	1.68	1.34	2.2	0.07	4.37	1.68	1.34	2.2
6	Zinc (mg/kg)	9	9	100	41.6	213	118.8	91.3	178	41.6	213	118.8	91.3	178
6	Beryllium (mg/kg)	8	8	100	0.41	0.62	0.535	0.56	0.61	0.41	0.62	0.535	0.56	0.61
6	Carbazole (ug/kg)	8	8	100	1 J	730	191.5	50	370	1 J	730	191.5	50	370
6	Fines (%)	6	6	100	0.4	82.42	54.64	61.58	67.22	0.4	82.42	54.64	61.58	67.22
6	Silt (%)	6	6	100	0.4	65.57	43.85	46.63	55.86	0.4	65.57	43.85	46.63	55.86
6	Aluminum (mg/kg)	5	5	100	33800	36700	35060	34400	35400	33800	36700	35060	34400	35400
6	Barium (mg/kg)	5	5	100	164	191	177	175	180	164	191	177	175	180
6	Calcium (mg/kg)	5	5	100	7350	12500	8880	7890	8760	7350	12500	8880	7890	8760
6	Cobalt (mg/kg)	5	5	100	16.6	18.8	18.1	17.6	18.8	16.6	18.8	18.1	17.6	18.8
6	Gravel (%)	5	5	100	0.01	5.6	1.40	0.09	1.13	0.01	5.6	1.40	0.09	1.13
6	Iron (mg/kg)	5	5	100	38900	45300	41480	40300	42100	38900	45300	41480	40300	42100
6	Magnesium (mg/kg)	5	5	100	6030	7560	6726	6610	6730	6030	7560	6726	6610	6730
6	Manganese (mg/kg)	5	5	100	524	704	633	607	668	524	704	633	607	668
6	Potassium (mg/kg)	5	5	100	1130	1270	1190	1140	1220	1130	1270	1190	1140	1220
6	Sand (%)	5	5	100	17.24	46.98	33.06	32.77	35.5	17.24	46.98	33.06	32.77	35.5
6	Sodium (mg/kg)	5	5	100	935	1040	990.2	936	1030	935	1040	990.2	936	1030
6	Titanium (mg/kg)	5	5	100	1790	1950	1870	1800	1940	1790	1950	1870	1800	1940
6	Vanadium (mg/kg)	5	5	100	94.6	102	98.2	96.3	100	94.6	102	98.2	96.3	100
6	Total solids (%)	4	4	100	64.4	77.9	68	64.7	65	64.4	77.9	68	64.7	65
6	Antimony (mg/kg)	3	3	100	0.16	0.56	0.30	0.16	0.19	0.16	0.56	0.30	0.16	0.19
6	Mean grain size (mm)	1	1	100	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36
6	Median grain size (mm)	1	1	100	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
6	Total volatile solids (%)	1	1	100	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
6	2-Methylnaphthalene (ug/kg)	9	8	89	3 J	1400	386	77 N	920	3 J	1400	344	60	920
6	Acenaphthene (ug/kg)	9	8	89	10 J	18000	3580	410	7900	5 UG	18000	3183	310	7900
6	Acenaphthylene (ug/kg)	9	8	89	10 J	610	218	74 J	600 J	5 UG	610	194	60	600 J

Table 4-6. Historical Subsurface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detects	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
6	Anthracene (ug/kg)	9	8	89	10 J	25000	4166	290	6200	5 UG	25000	3704	170 J	6200
6	Benz(a)anthracene (ug/kg)	9	8	89	100	28000	5160	950	8100	5 UG	28000	4587	870	8100
6	Chrysene (ug/kg)	9	8	89	100	34000	6183	880 N	9300	5 UG	34000	5496	840	9300
6	Fluorene (ug/kg)	9	8	89	8 J	16000	3360	370	6700	5 UG	16000	2987	310	6700
6	Indeno(1,2,3-cd)pyrene (ug/kg)	9	8	89	100 J	21000	4106	380	8900	5 UG	21000	3651	340	8900
6	Low Molecular Weight PAH (ug/kg)	9	8	89	130 A	180800 A	34349	3479 A	69410 A	5 UA	180800 A	30533	3447 A	69410 A
6	Naphthalene (ug/kg)	9	8	89	10 J	2000	574	230	1200	5 UG	2000	510	150	1200
6	Phenanthrene (ug/kg)	9	8	89	82 J	120000	22589	2300	46000	5 UG	120000	20080	2300	46000
6	Clay (%)	6	5	83	9.55	16.85	12.95	11.36	14.95	0.1 U	16.85	10.81	11.36	14.95
6	Total of 3 isomers: pp-DDT,-DDD,-DDE (ug/kg)	5	4	80	5 A	94 A	30	5.2 A	14.7 A	2 UA	94 A	24	5 A	14.7 A
6	4-Methylphenol (ug/kg)	5	4	80	54 N	120 J	81	64 JN	85	54 N	190 U	103	64 JN	120 J
6	Dibenz(a,h)anthracene (ug/kg)	9	7	78	42 N	1900	537	61 N	1400 N	5 UG	1900	452	61 N	1400 N
6	Benzoic acid (ug/kg)	8	6	75	50 J	580 J	323	240	550	50 J	24000 U	3480	470 J	1900 U
6	Diesel fuels (mg/kg)	3	2	67	570	2800	1685	570	570	97 U	2800	1156	97 U	570
6	Residual Range Organics (mg/kg)	3	2	67	730	2300	1515	730	730	390 U	2300	1140	390 U	730
6	Thallium (mg/kg)	8	5	63	0.06	9	3.24	0.07	7	0.06	9	4.53	4 U	8 U
6	Tributyltin ion (ug/kg)	8	5	63	5 J	1000	258	45	190	1 U	1000	163	6 U	190
6	4,4'-DDD (ug/kg)	5	3	60	2.5 JN	61	23.5	2.5 JN	7 JN	2 U	61	15	2 U	7 JN
6	4,4'-DDT (ug/kg)	5	3	60	4.5 J	33	14.2	4.5 J	5 J	2 U	33	9	2 UJ	5 J
6	Dibutyltin ion (ug/kg)	8	4	50	1	100 J	27	1	7.3 J	1	100 J	16	5.7 UJ	7.3 J
6	Polychlorinated biphenyls (ug/kg)	8	4	50	10 A	104 A	55	30 A	76 A	10 UA	350 UA	80	30 A	104 A
6	Selenium (mg/kg)	8	4	50	8	11	10	10	11	2.2 U	11	6.8	8	11
6	Arsenic (mg/kg)	9	4	44	1.4 E	3.8	3.1	3.6	3.7	1.4 E	8 U	4.6	3.8	8 U
6	4,4'-DDE (ug/kg)	5	2	40	2.7 JN	3.2 JN	3.0	2.7 JN	2.7 JN	2 U	17 U	5	2 U	3.2 JN
6	Aroclor 1260 (ug/kg)	8	3	38	10	76	46	10	51 J	10 U	170 U	48	20 U	76
6	Butyltin ion (ug/kg)	8	3	38	0.6 J	37	17.9	0.6 J	16	0.6 J	37	9.1	5.7 U	16
6	Bis(2-ethylhexyl) phthalate (ug/kg)	8	3	38	20 J	310	177	20 J	200 J	20 J	3000 U	500	140 U	310
6	Butylbenzyl phthalate (ug/kg)	8	3	38	26 N	100 J	51	26 N	28 N	19 U	190 U	55	28 N	100 J
6	Gasoline (mg/kg)	3	1	33	40 J	40 J	40	40 J	40 J	20 U	100 U	53	20 U	40 J
6	Aroclor 1254 (ug/kg)	8	2	25	30	53 J	42	30	30	10 U	170 U	39	10 U	53 J
6	Benzyl alcohol (ug/kg)	8	2	25	5.5 JN	9.4 JN	7.5	5.5 JN	5.5 JN	5.5 JN	3000 U	424.0	20 U	190 U
6	Diethyl phthalate (ug/kg)	8	2	25	3 J	3 J	3	3 J	3 J	3 J	990 U	158	20 U	190 U
6	Phenol (ug/kg)	8	2	25	9 J	26 J	18	9 J	9 J	9 J	3000 U	420	20 U	190 U
6	Tetrabutyltin (ug/kg)	8	1	13	8	8	8	8	8	3 U	8	5	5.7 U	6 U
6	4-Nitrophenol (ug/kg)	8	1	13	600 J	600 J	600	600 J	600 J	94 U	970 U	283	99 U	600 J
6	Dimethyl phthalate (ug/kg)	8	1	13	0.5 J	0.5 J	0.5	0.5 J	0.5 J	0.5 J	590 U	109.3	20 U	190 U
6	2,4-Dinitrotoluene (ug/kg)	8	0	0						73 U	3000 U	563	98 U	970 U
6	2,6-Dinitrotoluene (ug/kg)	8	0	0						29 U	1200 U	327	98 U	970 U
6	2-Chloronaphthalene (ug/kg)	8	0	0						15 U	590 U	111	20 U	190 U
6	2-Nitroaniline (ug/kg)	8	0	0						29 U	1200 U	327	98 U	970 U
6	3,3'-Dichlorobenzidine (ug/kg)	8	0	0						94 U	4000 U	708	99 U	970 U
6	3-Nitroaniline (ug/kg)	8	0	0						110 U	12000 U	1783	120 U	1200 U
6	4-Bromophenyl phenyl ether (ug/kg)	8	0	0						15 U	590 U	111	20 U	190 U
6	4-Chloroaniline (ug/kg)	8	0	0						57 U	3000 U	495	60 U	580 U
6	4-Chlorophenyl phenyl ether (ug/kg)	8	0	0						15 U	590 U	111	20 U	190 U
6	4-Nitroaniline (ug/kg)	8	0	0						94 U	5900 U	945	99 U	970 U

Table 4-6. Historical Subsurface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detects	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
6	Aroclor 1016 (ug/kg)	8	0	0						10 U	170 U	34	13 U	20 U
6	Aroclor 1221 (ug/kg)	8	0	0						10 U	350 U	70	38 UJ	40 U
6	Aroclor 1232 (ug/kg)	8	0	0						10 U	170 U	41	20 U	60 U
6	Aroclor 1242 (ug/kg)	8	0	0						10 U	170 U	37	19 UJ	35 U
6	Aroclor 1248 (ug/kg)	8	0	0						10 U	170 U	34	10 U	20 U
6	Bis(2-chloroethoxy) methane (ug/kg)	8	0	0						19 U	1200 U	191	20 U	190 U
6	Bis(2-chloroethyl) ether (ug/kg)	8	0	0						15 U	590 U	146	39 U	390 U
6	Hexachlorobutadiene (ug/kg)	8	0	0						15 U	590 U	111	20 U	190 U
6	Hexachlorocyclopentadiene (ug/kg)	8	0	0						94 U	12000 U	1744	99 U	970 U
6	Hexachloroethane (ug/kg)	8	0	0						19 U	2400 U	348	20 U	190 U
6	Isophorone (ug/kg)	8	0	0						15 U	590 U	111	20 U	190 U
6	Nitrobenzene (ug/kg)	8	0	0						15 U	590 U	111	20 U	190 U
6	N-Nitrosodiphenylamine (ug/kg)	8	0	0						15 U	590 U	111	20 U	190 U
6	N-Nitrosodipropylamine (ug/kg)	8	0	0						15 U	590 U	146	39 U	390 U
6	1,2,4-Trichlorobenzene (ug/kg)	8	0	0						5 U	590 U	110	20 U	190 U
6	1,2-Dichlorobenzene (ug/kg)	8	0	0						15 U	590 U	111	20 U	190 U
6	1,3-Dichlorobenzene (ug/kg)	8	0	0						15 U	590 U	111	20 U	190 U
6	1,4-Dichlorobenzene (ug/kg)	8	0	0						15 U	590 U	111	20 U	190 U
6	2,4,5-Trichlorophenol (ug/kg)	8	0	0						73 U	3000 U	563	98 U	970 U
6	2,4,6-Trichlorophenol (ug/kg)	8	0	0						73 U	3000 U	563	98 U	970 U
6	2,4-Dichlorophenol (ug/kg)	8	0	0						57 U	5900 U	877	60 U	580 U
6	2,4-Dimethylphenol (ug/kg)	8	0	0						19 U	12000 U	1607	20 U	300 U
6	2,4-Dinitrophenol (ug/kg)	8	0	0						190 UJ	18000 U	2696	200 UJ	1900 UJ
6	2-Chlorophenol (ug/kg)	8	0	0						19 U	3000 U	427	20 U	190 U
6	2-Methylphenol (ug/kg)	8	0	0						19 U	12000 U	1607	20 U	300 U
6	2-Nitrophenol (ug/kg)	8	0	0						73 U	3000 U	563	98 U	970 U
6	4,6-Dinitro-2-methylphenol (ug/kg)	8	0	0						190 U	12000 U	1910	200 UJ	1900 U
6	4-Chloro-3-methylphenol (ug/kg)	8	0	0						38 U	3000 U	462	40 U	390 U
6	Dibutyl phthalate (ug/kg)	8	0	0						19 U	1200 U	191	20 U	190 U
6	Di-n-octyl phthalate (ug/kg)	8	0	0						19 U	12000 U	1607	20 U	300 U
6	Hexachlorobenzene (ug/kg)	8	0	0						15 U	590 U	111	20 U	190 U
6	Pentachlorophenol (ug/kg)	8	0	0						94 UJ	18000 U	2530	99 UJ	970 UJ
6	Bis(2-chloro-1-methylethyl) ether (ug/kg)	5	0	0						19 U	190 U	54	20 U	20 U
6	Aldrin (ug/kg)	5	0	0						0.95 UJ	8.7 U	2.73	0.99 U	2 U
6	alpha-Endosulfan (ug/kg)	5	0	0						0.95 UJ	8.7 U	2.73	0.99 U	2 U
6	alpha-Hexachlorocyclohexane (ug/kg)	5	0	0						0.95 UJ	8.7 U	2.73	0.99 U	2 U
6	beta-Endosulfan (ug/kg)	5	0	0						1.9 UJ	17 U	5.0	2 U	2 U
6	beta-Hexachlorocyclohexane (ug/kg)	5	0	0						0.95 UJ	8.7 U	2.73	0.99 U	2 U
6	delta-Hexachlorocyclohexane (ug/kg)	5	0	0						0.95 UJ	8.7 U	2.73	0.99 UJ	2 U
6	Dieldrin (ug/kg)	5	0	0						1.9 UJ	17 U	5.0	2 U	2 U
6	Endosulfan sulfate (ug/kg)	5	0	0						1.9 UJ	17 U	5.0	2 U	2 U
6	Endrin (ug/kg)	5	0	0						1.9 UJ	17 U	5.0	2 U	2 U
6	Endrin aldehyde (ug/kg)	5	0	0						1.9 UJ	17 U	5.0	2 U	2 U
6	gamma-Hexachlorocyclohexane (ug/kg)	5	0	0						0.95 UJ	8.7 U	2.73	0.99 U	2 U
6	Heptachlor (ug/kg)	5	0	0						0.95 UJ	8.7 U	2.73	0.99 U	2 U
6	Heptachlor epoxide (ug/kg)	5	0	0						0.95 UJ	8.7 U	2.73	0.99 U	2 U

Table 4-6. Historical Subsurface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detects	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
6	Methoxychlor (ug/kg)	5	0	0						4 U	87 U	24	9.5 UJ	9.9 U
6	Toxaphene (ug/kg)	5	0	0						30 U	870 U	239	95 UJ	99 U
6	alpha-Chlordane (ug/kg)	4	0	0						0.95 UJ	8.7 U	2.91	0.99 U	0.99 U
6	Endrin ketone (ug/kg)	4	0	0						2 U	17 U	7	2 U	5.5 UIJ
6	gamma-Chlordane (ug/kg)	4	0	0						0.95 UJ	8.7 U	3.06	0.99 U	1.6 UI
6	Bis(2-chloroisopropyl) ether (ug/kg)	3	0	0						15 U	590 U	207	15 U	15 U
6	3- and 4-Methylphenol Coelution (ug/kg)	3	0	0						290 U	12000 U	4197	290 U	300 U
6	Acid Volatile Sulfides (mg/kg)	1	0	0						0.7 UG	0.7 UG	0.7	0.7 UG	0.7 UG
6	Chlordane (cis & trans) (ug/kg)	1	0	0						10 U	10 U	10	10 U	10 U
7	Total solids (%)	78	78	100	40.3	81.4	57.6	54.9	76.2	40.3	81.4	57.6	54.9	76.2
7	Lead (mg/kg)	72	72	100	2.28	416	39.10	26.1	64	2.28	416	39.10	26.1	64
7	Fines (%)	49	49	100	0	95.8	55.5	74.7	93	0	95.8	55.5	74.7	93
7	Sand (%)	47	47	100	4.2	98.3	40.2	20.9	94.9	4.2	98.3	40.2	20.9	94.9
7	Chromium (mg/kg)	41	41	100	12.1	64 J	28.4	27 J	41.3	12.1	64 J	28.4	27 J	41.3
7	Copper (mg/kg)	41	41	100	14	100	39	35 M	71.6	14	100	39	35 M	71.6
7	Zinc (mg/kg)	41	41	100	37 J	450 J	127	102 J	260 J	37 J	450 J	127	102 J	260 J
7	Gravel (%)	33	33	100	0	66.41	8.88	1	41.8	0	66.41	8.88	1	41.8
7	Silt (%)	29	29	100	1.6	85.3	52.6	63.52	78.3	1.6	85.3	52.6	63.52	78.3
7	Nickel (mg/kg)	26	26	100	14.8	36.2	25.2	25	31.3	14.8	36.2	25.2	25	31.3
7	Total volatile solids (%)	19	19	100	0.9	18.3	7.6	8.1	10	0.9	18.3	7.6	8.1	10
7	1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin (ng/kg	13	13	100	29	25000 J	3640	270	11000	29	25000 J	3640	270	11000
7	1,2,3,4,7,8,9-Heptachlorodibenzofuran (ng/kg)	13	13	100	1.8	1300	178.2	21	360	1.8	1300	178.2	21	360
7	1,2,3,7,8-Pentachlorodibenzofuran (ng/kg)	13	13	100	0.32	150	55.07	49	130	0.32	150	55.07	49	130
7	2,3,4,7,8-Pentachlorodibenzofuran (ng/kg)	13	13	100	0.76	230	52.70	36	86	0.76	230	52.70	36	86
7	Mean grain size (%)	13	13	100	0.01	0.06	0.02	0.02	0.03	0.01	0.06	0.02	0.02	0.03
7	Median grain size (%)	13	13	100	0.01	0.02	0.01	0.01	0.02	0.01	0.02	0.01	0.01	0.02
7	Octachlorodibenzofuran (ng/kg)	13	13	100	31	7600 J	1754	210	6800 J	31	7600 J	1754	210	6800 J
7	Octachlorodibenzo-p-dioxin (ng/kg)	13	13	100	180	92000 J	15161	3400 B	43000 J	180	92000 J	15161	3400 B	43000 J
7	1,2,3,4,6,7,8-Heptachlorodibenzofuran (ng/kg)	12	12	100	13	3300 J	557	85 J	2300	13	3300 J	557	85 J	2300
7	Mercury (mg/kg)	8	8	100	0.02	0.56	0.17	0.11	0.18	0.02	0.56	0.17	0.11	0.18
7	Mean grain size (mm)	6	6	100	0.02	10.01	1.96	0.12	1.24	0.02	10.01	1.96	0.12	1.24
7	Median grain size (mm)	6	6	100	0.01	1.57	0.36	0.08	0.35	0.01	1.57	0.36	0.08	0.35
7	Aluminum (mg/kg)	5	5	100	19000	43100	34860	34100	42400	19000	43100	34860	34100	42400
7	Barium (mg/kg)	5	5	100	189	200	193	190	195	189	200	193	190	195
7	Beryllium (mg/kg)	5	5	100	0.47	0.74	0.63	0.6	0.7	0.47	0.74	0.63	0.6	0.7
7	Calcium (mg/kg)	5	5	100	5900	8450	7660	7440	8380	5900	8450	7660	7440	8380
7	Cobalt (mg/kg)	5	5	100	16	24.6	19.0	16.9	20.4	16	24.6	19.0	16.9	20.4
7	Iron (mg/kg)	5	5	100	38000	53900	43620	38200	44700	38000	53900	43620	38200	44700
7	Magnesium (mg/kg)	5	5	100	4900	7160	6296	5870	7010	4900	7160	6296	5870	7010
7	Manganese (mg/kg)	5	5	100	441	863	653	552	771	441	863	653	552	771
7	Potassium (mg/kg)	5	5	100	1000	1400	1204	1070	1350	1000	1400	1204	1070	1350
7	Sodium (mg/kg)	5	5	100	380	1230 J	954	932 J	1180 J	380	1230 J	954	932 J	1180 J
7	Vanadium (mg/kg)	5	5	100	84	136	107	99.7	111	84	136	107	99.7	111
7	Heavy oil (mg/kg)	5	5	100	160	910	404	280	380	160	910	404	280	380
7	Hexachlorodibenzofuran (ng/kg)	2	2	100	210	770	490	210	210	210	770	490	210	210
7	Pentachlorodibenzofuran (ng/kg)	2	2	100	150	240	195	150	150	150	240	195	150	150

Table 4-6. Historical Subsurface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detects	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
7	Titanium (mg/kg)	2	2	100	2090	2850	2470	2090	2090	2090	2850	2470	2090	2090
7	Bromine (ug/kg)	1	1	100	12	12	12	12	12	12	12	12	12	12
7	Chlorine (ug/kg)	1	1	100	1780	1780	1780	1780	1780	1780	1780	1780	1780	1780
7	Heptachlorodibenzofuran (ng/kg)	1	1	100	1300	1300	1300	1300	1300	1300	1300	1300	1300	1300
7	Heptachlorodibenzo-p-dioxin (ng/kg)	1	1	100	3400	3400	3400	3400	3400	3400	3400	3400	3400	3400
7	Hexachlorodibenzo-p-dioxin (ng/kg)	1	1	100	340	340	340	340	340	340	340	340	340	340
7	Tetrachlorodibenzofuran (ng/kg)	1	1	100	91	91	91	91	91	91	91	91	91	91
7	Tetrachlorodibenzo-p-dioxin (ng/kg)	1	1	100	34	34	34	34	34	34	34	34	34	34
7	Total organic carbon (%)	44	43	98	0.06	37	3.53	1.9	8.76	0.05 U	37	3.45	1.9	8.76
7	Total of 3 isomers: pp-DDT,-DDD,-DDE (ug/kg)	44	41	93	2.2 A	2190 A	325.7	90 A	800 A	2.2 A	2190 A	305.9	90 A	800 A
7	Clay (%)	29	27	93	0.29	26	12.90	15.2	19.4	0.1 U	26	12.0	14.5	19.4
7	1,2,3,6,7,8-Hexachlorodibenzofuran (ng/kg)	13	12	92	0.71 J	190	52.06	26 J	130	0.71 J	190	53.05	26 J	130
7	1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin (ng/kg)	13	12	92	1.5 T	180	39.5	5.6	150 J	1.4 U	180	36.5	5.1	150 J
7	2,3,4,6,7,8-Hexachlorodibenzofuran (ng/kg)	13	12	92	2	210	49	9.5 J	160	2	210	45	9.1 J	160
7	Polycyclic Aromatic Hydrocarbons (ug/kg)	109	100	92	3.4 A	6192000 A	399731	58600 A	1E+06 A	3 UA	6192000 A	366729	44900 A	1E+06 A
7	1,2,3,4,7,8-Hexachlorodibenzofuran (ng/kg)	12	11	92	5 J	1000	253	93	650	5 J	1000	243	110 J	650
7	1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin (ng/kg)	12	11	92	3.1	990	177.2	15	500 J	3.1 U	990	162.7	15	500 J
7	2,3,7,8-Tetrachlorodibenzofuran (ng/kg)	12	11	92	2	84	37	30	62	0.3 U	84	33.6	30	62
7	4,4'-DDD (ug/kg)	44	40	91	0.2	2000	273.7	60	1200	0.2	2000	252.5	60	760
7	High Molecular Weight PAH (ug/kg)	109	99	91	2 A	2063000 A	166227	36410 A	740700 A	2 A	2063000 A	150981	27610 A	706000 A
7	Arsenic (mg/kg)	41	37	90	1.1	11 M	3.5	3.2	5.2 J	1.1	11 M	3.7	3.4	5.2 J
7	Fluoranthene (ug/kg)	109	98	90	6 J	540000	45159	8410	180000	2 U	540000	40603	6680	174000
7	Pyrene (ug/kg)	109	98	90	8.5	670000	51883	10600	213000	2 U	670000	46649	8110	210000
7	Cadmium (mg/kg)	8	7	88	0.09	0.6	0.39	0.33	0.6	0.09	0.7 U	0.43	0.4	0.6
7	Silver (mg/kg)	8	7	88	0.06 E	1.6	0.77	0.35	1.3	0.06 E	1.6	0.795	0.7	1.3
7	Benzo(b)fluoranthene (ug/kg)	91	79	87	5 G	160000	10239	2940	40300	2 U	160000	8892	2480	33000
7	2-Methylnaphthalene (ug/kg)	45	39	87	0.6 G	51000 JM	7579	2600	25600	0.6 G	51000 JM	6608.4	2090	21600
7	Low Molecular Weight PAH (ug/kg)	109	94	86	1.4 A	4977000 A	250177	25330 A	631400 A	1.4 A	4977000 A	215752	15070 A	547200 A
7	Benzo(k)fluoranthene (ug/kg)	91	78	86	4 J	92000	8056	2540	35000	3 U	92000	6910	1770	30000
7	Chrysene (ug/kg)	109	93	85	4 J	180000	15333	4330	66000	3 U	180000	13085	2990	52000
7	Phenanthrene (ug/kg)	109	93	85	5 J	1300000	94086	16000	380000	2 U	1300000	80278	8110	330000
7	1,2,3,7,8,9-Hexachlorodibenzofuran (ng/kg)	13	11	85	2.5	48	16.1	11	22	0.4 U	48	13.7	10	22
7	Chromium hexavalent (mg/kg)	6	5	83	0.1 G	0.6 G	0.302	0.14 G	0.35 G	0.1 G	0.6 G	0.3	0.14 G	0.35 G
7	Benzo(b+k)fluoranthene (ug/kg)	109	90	83	4 A	217000 A	16897	5470 A	70300 A	3 UA	217000 A	13956	2880 A	66000 A
7	Benz(a)anthracene (ug/kg)	109	88	81	3 J	150000	13516	4290	52700	2 U	150000	10917	2340	48000
7	Benzo(a)pyrene (ug/kg)	109	88	81	0.6 G	180000	13179	3330	58000	0.6 G	180000	10663	1490	39100
7	Selenium (mg/kg)	5	4	80	6	14	10.75	10	13	0.45 UJ	14	8.69	6	13
7	Bis(2-ethylhexyl) phthalate (ug/kg)	5	4	80	48	1700 M	554.5	210	260	48	1700 M	461	86 UJ	260
7	Acenaphthene (ug/kg)	109	85	78	4 J	580000 J	37331	4000	86000	2 UJ	580000 J	29119	1670	85000
7	Cyanide (mg/kg)	18	14	78	0.2 J	5.4	1.7	1	3.7	0.2 U	5.4	1.4	0.9	3.7
7	o-Xylene (ug/kg)	18	14	78	0.02 J	4	0.45	0.09 J	0.84	0.008 U	4	0.348	0.04 J	0.84
7	1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin (ng/kg)	13	10	77	0.9 T	50	14.3	3.6 T	40 J	0.6 U	50	11.3	2.1 T	40 J
7	Anthracene (ug/kg)	109	83	76	2 J	250000	20525	4980	72000	2 U	250000	15637	1490	63400
7	Naphthalene (ug/kg)	109	82	75	0.6 G	2900000 J	94231	1900 J	100000 J	0.6 G	2900000 J	70900	580	100000
7	Fluorene (ug/kg)	109	80	73	33	500000	25798	4040	81000	2 U	500000	18946	1150	70000 JM
7	Dibenzofuran (ug/kg)	45	33	73	5 G	32000 JM	1943	700	3600	5 G	32000 JM	1505	390	3120

Table 4-6. Historical Subsurface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detects	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
7	Benzo(g,h,i)perylene (ug/kg)	108	79	73	0.8 G	140000	10833	3080	47000	0.8 G	140000	8082	1500 M	39000
7	4,4'-DDE (ug/kg)	44	32	73	2 J	70	20	9 J	40	2 U	70	21	8 J	60 U
7	Indeno(1,2,3-cd)pyrene (ug/kg)	109	79	72	0.8 G	90000	8708	2860	40900	0.7 U	90000	6579	1300	32000
7	Acid Volatile Sulfides (mg/kg)	3	2	67	19	34 G	27	19	19	0.7 UG	34 G	18	0.7 UG	19
7	1,2,3,7,8-Pentachlorodibenzo-p-dioxin (ng/kg)	13	8	62	0.79 T	11	4.57	1.7 T	10	0.4 U	11	3.83	1.7 T	10
7	4-Methylphenol (ug/kg)	5	3	60	34	160	108	34	130	34	1400 U	367	110 U	160
7	m,p-Xylene (ug/kg)	18	10	56	0.03 J	5.1	0.72	0.1 J	1.2	0.02 U	5.1	0.41	0.04 U	1.2
7	Dibenz(a,h)anthracene (ug/kg)	109	60	55	3	16000	1767	850	7070	2 U	75000 U	1955	300 U	6600
7	alpha-Hexachlorocyclohexane (ug/kg)	44	23	52	1 J	30	6	3 J	10	0.94 U	30	4.01	2 J	10
7	Polychlorinated biphenyls (ug/kg)	6	3	50	21 A	78 A	52	21 A	57 A	10 UA	78 A	40	34 UJ	57 A
7	Pentachlorodibenzo-p-dioxin (ng/kg)	2	1	50	3.8	3.8	3.8	3.8	3.8	1.6 U	3.8	2.7	1.6 U	1.6 U
7	Ethylbenzene (ug/kg)	27	13	48	0.05 J	6200	578.60	0.28	1300	0.009 U	6200	356	0.28	300 U
7	4,4'-DDT (ug/kg)	44	21	48	2	690	84	40	150	1 U	690	58	40	150
7	Benzo(e)pyrene (ug/kg)	17	8	47	71	15000	3010	300	3600 M	12 U	15000	1431	19 U	3600 M
7	2,3,7,8-Tetrachlorodibenzo-p-dioxin (ng/kg)	13	6	46	0.96	4.3	2.28	1.2	3 J	0.4 U	8.7 U	2.1	0.96	4.3
7	Acenaphthylene (ug/kg)	109	45	41	0.2 G	28000	2211	700	7400	0.2 G	28000	1071	300 U	4200
7	Aroclor 1260 (ug/kg)	5	2	40	21	52	36.5	21	21	10 U	52	30.6	20 UJ	50 UI
7	Benzoic acid (ug/kg)	5	2	40	400	1000	700	400	400	200 U	3600 U	1260	400	1100 U
7	Thallium (mg/kg)	5	2	40	1.5	9	5.25	1.5	1.5	1.5	9	5.5	4 U	8 U
7	gamma-Hexachlorocyclohexane (ug/kg)	44	16	36	2 J	360	80	20	300	0.94 U	360	30	1 U	160
7	Benzene (ug/kg)	27	8	30	0.03 J	1800	226	0.04 J	6.4	0.01 U	1800	156	0.03 J	300 U
7	Aldrin (ug/kg)	44	12	27	4 J	9 J	6	5 J	9 J	0.94 U	90 U	9	2 U	30 U
7	Carbazole (ug/kg)	22	6	27	36	23000	4946	660	5000	20 U	23000	1605	36	2400 U
7	Natural gasoline (mg/kg)	8	2	25	44	110	77	44	44	10 U	110	33	20 U	44
7	Tributyltin ion (ug/kg)	9	2	22	67	360	214	67	67	3 UH	360	50	3 UH	67
7	Xylene (ug/kg)	9	2	22	1300	6000	3650	1300	1300	300 U	6000	1044	300 U	1300
7	Antimony (mg/kg)	5	1	20	5.3 J	5.3 J	5.3	5.3 J	5.3 J	4 UJ	8 UJ	5	5 UJ	5.3 J
7	Aroclor 1242 (ug/kg)	5	1	20	26	26	26	26	26	10 U	26	17	10 U	20 UJ
7	Aroclor 1254 (ug/kg)	5	1	20	57	57	57	57	57	10 U	57	21	10 U	20 UJ
7	N-Nitrosodiphenylamine (ug/kg)	5	1	20	3800 M	3800 M	3800	3800 M	3800 M	20 U	3800 M	797	20 UJ	110 U
7	Diesel fuels (mg/kg)	5	1	20	50 G	50 G	50	50 G	50 G	50 U	50 G	50	50 U	50 U
7	Heptachlor epoxide (ug/kg)	44	8	18	2 J	10	7	7 J	10	0.94 U	60 U	10	2 U	30 U
7	Toluene (ug/kg)	27	4	15	0.03 J	0.3 J	0.11	0.03 J	0.07 J	0.01 U	300 U	100.03	0.02 U	300 U
7	delta-Hexachlorocyclohexane (ug/kg)	44	6	14	2 J	8 J	4	3 J	6 J	0.94 UJ	30 U	2.89	2 U	5 J
7	Endrin (ug/kg)	44	4	9	4 J	10	7	5	9 J	0.9 UG	60 U	9	2 U	60 U
7	Heptachlor (ug/kg)	44	4	9	2 J	6 J	5	5 J	5 J	0.94 U	40 U	2.32	1 U	5 J
7	beta-Endosulfan (ug/kg)	44	3	7	6 J	30	14	6 J	7 J	1 U	60 U	11	1 U	60 U
7	Pentachlorophenol (ug/kg)	42	2	5	120 J	1700	910	120 J	120 J	2.4 U	19000 U	1372	134 U	1900 U
7	2,4-Dichlorophenol (ug/kg)	22	1	5	140	140	140	140	140	59 U	26000 UJ	2604	140	12000 U
7	alpha-Endosulfan (ug/kg)	44	1	2	6 J	6 J	6	6 J	6 J	0.94 U	60 U	5.26	1 U	6 J
7	Dieldrin (ug/kg)	44	1	2	3 J	3 J	3	3 J	3 J	1.9 U	60 U	7	2 U	60 U
7	Endrin aldehyde (ug/kg)	44	1	2	2 J	2 J	2	2 J	2 J	1 UG	60 U	10	1 U	60 U
7	beta-Hexachlorocyclohexane (ug/kg)	44	0	0						0.94 U	3.4 UJ	1.96	2 U	2 U
7	Endosulfan sulfate (ug/kg)	44	0	0						1.9 U	60 U	10.6	2 U	60 U
7	Methoxychlor (ug/kg)	44	0	0						4 UG	300 U	42	5 U	200 U
7	Toxaphene (ug/kg)	44	0	0						30 U	6000 U	1955	2000 U	4000 U

Table 4-6. Historical Subsurface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detects	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
7	Chlordane (cis & trans) (ug/kg)	40	0	0						10 U	1000 U	216	21 U	900 U
7	Hexachlorobutadiene (ug/kg)	22	0	0						20 U	13000 U	1344	68 U	6100 UJ
7	2,4,5-Trichlorophenol (ug/kg)	22	0	0						2.4 U	12000 U	888	140 U	1300 U
7	2,4,6-Trichlorophenol (ug/kg)	22	0	0						2.4 U	6100 U	467	88 U	650 U
7	Hexachlorobenzene (ug/kg)	22	0	0						20 U	5200 U	539	35 U	2400 U
7	2,3,4,5-Tetrachlorophenol (ug/kg)	18	0	0						2.4 U	6100 U	521	68 U	900 U
7	2,3,4,6-Tetrachlorophenol (ug/kg)	18	0	0						2.4 U	6100 U	521	68 U	900 U
7	2,6-Dichlorophenol (ug/kg)	18	0	0						120 U	26000 U	3151	180 U	12000 U
7	Anthanthrene (ug/kg)	17	0	0						59 U	13000 U	1373	88 U	6100 U
7	Butyltin ion (ug/kg)	9	0	0						3 UGH	5.9 U	3.9	3 UGH	5.9 U
7	Dibutyltin ion (ug/kg)	9	0	0						3 UH	5.9 U	3.9	3 UH	5.9 U
7	2,4-Dinitrotoluene (ug/kg)	5	0	0						98 U	720 U	323	98 U	530 U
7	2,6-Dinitrotoluene (ug/kg)	5	0	0						98 U	530 U	251	98 U	360 U
7	2-Chloronaphthalene (ug/kg)	5	0	0						20 U	110 U	51	20 U	72 U
7	2-Nitroaniline (ug/kg)	5	0	0						98 U	7200 U	1619	98 U	530 U
7	3,3'-Dichlorobenzidine (ug/kg)	5	0	0						98 U	530 U	207	98 U	170 U
7	3-Nitroaniline (ug/kg)	5	0	0						120 U	7200 U	1656	120 UJ	630 U
7	4-Bromophenyl phenyl ether (ug/kg)	5	0	0						20 U	360 U	109	20 U	110 U
7	4-Chloroaniline (ug/kg)	5	0	0						59 U	1400 U	388	59 U	320 U
7	4-Chlorophenyl phenyl ether (ug/kg)	5	0	0						20 U	140 U	65	20 U	110 U
7	4-Nitroaniline (ug/kg)	5	0	0						98 U	7200 U	1619	98 UJ	530 U
7	Aroclor 1016 (ug/kg)	5	0	0						10 U	20 UJ	14	10 U	19 U
7	Aroclor 1221 (ug/kg)	5	0	0						10 U	39 UJ	22	10 UG	38 U
7	Aroclor 1232 (ug/kg)	5	0	0						10 U	20 UJ	14	10 UG	19 U
7	Aroclor 1248 (ug/kg)	5	0	0						10 U	20 UJ	14	10 U	19 U
7	Benzyl alcohol (ug/kg)	5	0	0						20 U	720 U	181	20 UJ	110 U
7	Bis(2-chloroethoxy) methane (ug/kg)	5	0	0						20 U	110 U	51	20 U	72 U
7	Bis(2-chloroethyl) ether (ug/kg)	5	0	0						39 U	210 U	99	39 U	140 U
7	Hexachloroethane (ug/kg)	5	0	0						20 U	720 UJ	181	20 U	110 U
7	Isophorone (ug/kg)	5	0	0						20 U	110 U	51	20 U	72 U
7	Nitrobenzene (ug/kg)	5	0	0						20 U	360 U	109	20 U	110 U
7	N-Nitrosodipropylamine (ug/kg)	5	0	0						39 U	720 U	215	39 U	210 U
7	1,2,4-Trichlorobenzene (ug/kg)	5	0	0						20 U	360 U	109	20 U	110 U
7	1,2-Dichlorobenzene (ug/kg)	5	0	0						20 U	140 UJ	65	20 U	110 U
7	1,3-Dichlorobenzene (ug/kg)	5	0	0						20 U	140 UJ	65	20 U	110 U
7	1,4-Dichlorobenzene (ug/kg)	5	0	0						20 U	140 UJ	65	20 U	110 U
7	2,4-Dimethylphenol (ug/kg)	5	0	0						20 U	140 U	65	20 U	110 U
7	2-Chlorophenol (ug/kg)	5	0	0						20 U	360 U	109	20 U	110 U
7	2-Methylphenol (ug/kg)	5	0	0						20 U	1400 U	317	20 U	110 U
7	2-Nitrophenol (ug/kg)	5	0	0						98 U	530 U	251	98 U	360 U
7	4,6-Dinitro-2-methylphenol (ug/kg)	5	0	0						200 U	1400 U	650	200 UJ	1100 U
7	4-Chloro-3-methylphenol (ug/kg)	5	0	0						39 U	720 U	215	39 U	210 U
7	4-Nitrophenol (ug/kg)	5	0	0						98 U	720 UJ	323	98 U	530 U
7	Butylbenzyl phthalate (ug/kg)	5	0	0						20 U	110 U	51	20 U	72 U
7	Dibutyl phthalate (ug/kg)	5	0	0						20 U	110 U	51	20 U	72 U
7	Diethyl phthalate (ug/kg)	5	0	0						20 U	110 U	51	20 U	72 U

Table 4-6. Historical Subsurface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detects	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
7	Dimethyl phthalate (ug/kg)	5	0	0						20 U	110 U	51	20 U	72 U
7	Di-n-octyl phthalate (ug/kg)	5	0	0						20 U	110 U	51	20 U	72 U
7	Lube Oil (mg/kg)	5	0	0						100 U	100 U	100	100 U	100 U
7	Phenol (ug/kg)	5	0	0						20 U	720 U	181	20 U	110 U
7	Bis(2-chloro-1-methylethyl) ether (ug/kg)	4	0	0						20 U	110 U	46	20 U	35 U
7	Hexachlorocyclopentadiene (ug/kg)	4	0	0						98 UJ	530 UJ	224	98 UJ	170 UJ
7	2,4-Dinitrophenol (ug/kg)	4	0	0						200 UJ	1100 UJ	463	200 UJ	350 UJ
7	alpha-Chlordane (ug/kg)	4	0	0						0.94 UJ	3.4 UJ	1.57	0.96 U	0.98 UJ
7	Endrin ketone (ug/kg)	4	0	0						1.9 U	3.4 UJ	2.6	2 UJ	3.1 UIJ
7	gamma-Chlordane (ug/kg)	4	0	0						0.96 U	3.4 UJ	1.61	0.98 UJ	1.1 UI
7	Tetrabutyltin (ug/kg)	3	0	0						5.7 U	5.9 U	5.8	5.7 U	5.9 U
7	Bis(2-chloroisopropyl) ether (ug/kg)	1	0	0						1400 U	1400 U	1400	1400 U	1400 U
8	Total solids (%)	52	52	100	44.2	87.5	63.0	62.5	86.2	44.2	87.5	63.0	62.5	86.2
8	Chromium (mg/kg)	50	50	100	10	64 J	31	32	44	10	64 J	31	32	44
8	Fines (%)	45	45	100	0.13	93.3	51.2	65.6	89.72	0.13	93.3	51.2	65.6	89.72
8	Copper (mg/kg)	42	42	100	12	579	67	42	141	12	579	67	42	141
8	Zinc (mg/kg)	30	30	100	35	579 G	134	97.8	243	35	579 G	134	97.8	243
8	Nickel (mg/kg)	25	25	100	15.2	87	31	29	34	15.2	87	30.9	29	34
8	Total of 3 isomers: pp-DDT,-DDD,-DDE (ug/kg)	19	19	100	4.2 A	51000 A	6795	1270 A	22556 A	4.2 A	51000 A	6795	1270 A	22556 A
8	Barium (mg/kg)	13	13	100	67.1	330	191	184	281	67.1	330	191	184	281
8	Aluminum (mg/kg)	12	12	100	34400	44100	39325	37900	43900	34400	44100	39325	37900	43900
8	Calcium (mg/kg)	12	12	100	4310	13800	8524	8500	8920	4310	13800	8524	8500	8920
8	Cobalt (mg/kg)	12	12	100	16.2	19.8	17.9	17.5	19.6	16.2	19.8	17.9	17.5	19.6
8	Iron (mg/kg)	12	12	100	36100	45700	41183	39900	44200	36100	45700	41183	39900	44200
8	Magnesium (mg/kg)	12	12	100	5670	7670	7046	7300	7580	5670	7670	7046	7300	7580
8	Manganese (mg/kg)	12	12	100	344	846	634	558	836	344	846	634	558	836
8	Potassium (mg/kg)	12	12	100	1130	1420	1298	1280	1410	1130	1420	1298	1280	1410
8	Sodium (mg/kg)	12	12	100	948	57800 J	6233	1080 J	4480 J	948	57800 J	6233	1080 J	4480 J
8	Vanadium (mg/kg)	12	12	100	93.5	107	102	102	107	93.5	107	102	102	107
8	Titanium (mg/kg)	8	8	100	1800	2020	1923	1940	1960	1800	2020	1923	1940	1960
8	1,2,3,4,6,7,8-Heptachlorodibenzofuran (ng/kg)	4	4	100	1.6	5400	1463	180	270	1.6	5400	1463	180	270
8	1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin (ng/kg	4	4	100	13 J	1100 J	403	210	290	13 J	1100 J	403	210	290
8	1,2,3,4,7,8-Hexachlorodibenzofuran (ng/kg)	4	4	100	0.44	22000 J	5694	77	700	0.44	22000 J	5694	77	700
8	1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin (ng/kg)	4	4	100	0.46	22	14.62	17	19 J	0.46	22	14.62	17	19 J
8	1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin (ng/kg)	4	4	100	0.95 J	13	7.46	7.3 J	8.6	0.95 J	13	7.46	7.3 J	8.6
8	2,3,4,6,7,8-Hexachlorodibenzofuran (ng/kg)	4	4	100	0.51	1300	334	17	18	0.51	1300	334	17	18
8	2,3,4,7,8-Pentachlorodibenzofuran (ng/kg)	4	4	100	1.9	11000	2768	9.5	61	1.9	11000	2768	9.5	61
8	2,3,7,8-Tetrachlorodibenzofuran (ng/kg)	4	4	100	0.28	15000	3778	1.2 J	110	0.28	15000	3778	1.2 J	110
8	Octachlorodibenzofuran (ng/kg)	4	4	100	6.8	4900	1524	530	660	6.8	4900	1524	530	660
8	Octachlorodibenzo-p-dioxin (ng/kg)	4	4	100	92 J	4500 J	2348	2100	2700	92 J	4500 J	2348	2100	2700
8	Chromium hexavalent (mg/kg)	2	2	100	0.4 G	0.57 G	0.49	0.4 G	0.4 G	0.4 G	0.57 G	0.49	0.4 G	0.4 G
8	Bromine (ug/kg)	1	1	100	13	13	13	13	13	13	13	13	13	13
8	Chlorine (ug/kg)	1	1	100	2380	2380	2380	2380	2380	2380	2380	2380	2380	2380
8	Heptachlorodibenzofuran (ng/kg)	1	1	100	650	650	650	650	650	650	650	650	650	650
8	Heptachlorodibenzo-p-dioxin (ng/kg)	1	1	100	630	630	630	630	630	630	630	630	630	630
8	Hexachlorodibenzofuran (ng/kg)	1	1	100	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200

Table 4-6. Historical Subsurface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detects	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
8	Hexachlorodibenzo-p-dioxin (ng/kg)	1	1	100	130	130	130	130	130	130	130	130	130	130
8	Mean grain size (mm)	1	1	100	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
8	Median grain size (mm)	1	1	100	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
8	Pentachlorodibenzofuran (ng/kg)	1	1	100	680	680	680	680	680	680	680	680	680	680
8	Pentachlorodibenzo-p-dioxin (ng/kg)	1	1	100	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
8	Tetrachlorodibenzofuran (ng/kg)	1	1	100	270	270	270	270	270	270	270	270	270	270
8	Tetrachlorodibenzo-p-dioxin (ng/kg)	1	1	100	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4
8	Total volatile solids (%)	1	1	100	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6
8	p-Cymene (ug/kg)	1	1	100	253	253	253	253	253	253	253	253	253	253
8	Polycyclic Aromatic Hydrocarbons (ug/kg)	60	59	98	8 A	1E+07 A	198734	2000 A	164600 A	8 A	1E+07 A	195422	2000 A	164600 A
8	Sand (%)	45	43	96	6.7	100.16	45	30.1	94.41	6.7	100.16	47	30.37	96.8 U
8	High Molecular Weight PAH (ug/kg)	60	57	95	12 A	1866000 A	43469	1397 A	63000 A	5 UA	1866000 A	41297	1281 A	63000 A
8	Gravel (%)	39	37	95	0	14.9	1.9	0.46	5.58	0	14.9	1.9	0.46	5.58
8	4,4'-DDD (ug/kg)	19	18	95	2.2 J	29000	3391	147	16000	2.2 J	29000	3213	96	16000
8	Clay (%)	34	32	94	0.04	24.8	8.8	7.17	17.34	0.04	24.8	8.2	6.9	17.34
8	Silt (%)	34	32	94	0.12	77.3	44.9	53.73	75.79	0.08 U	77.3	42.3	53.19	75.79
8	Total organic carbon (%)	47	44	94	0.06	5.3	1.5	1.4	2.8	0.05 U	5.3	1.4	1.4	2.8
8	Selenium (mg/kg)	13	12	92	7	13	10.7	11	13	0.5 U	13	9.9	10	13
8	Pyrene (ug/kg)	60	55	92	13	530000	12134	350	18000	5 U	530000	11123	300	18000
8	Fluoranthene (ug/kg)	60	54	90	13.5 J	910000	20387	310	23000	5 U	910000	18349	240	23000
8	Benzo(b)fluoranthene (ug/kg)	46	41	89	14.5	9700	636	120	1300 G	5 U	9700	568	113	1300 G
8	Low Molecular Weight PAH (ug/kg)	60	53	88	8 A	8230000 A	174483	580 A	133000 A	5 UA	8230000 A	154127	521 A	133000 A
8	Benzo(k)fluoranthene (ug/kg)	46	40	87	11 J	16000	666	110	1380	5 U	16000	581	78.6	1000 G
8	Chrysene (ug/kg)	60	51	85	12 J	98000	3183	180	7100	5 U	98000	2717	130	7100
8	Phenanthrene (ug/kg)	60	51	85	19.3	2000000	44873	310	40000 J	5 U	2000000	38144	210	40000 J
8	Mercury (mg/kg)	19	16	84	0.06	0.32	0.13	0.09	0.28	0.05 U	0.32	0.12	0.09	0.28
8	Silver (mg/kg)	19	16	84	0.1	1.5	1.0	1.1	1.5	0.1	1.5	0.9	1.1	1.5
8	Tributyltin ion (ug/kg)	27	22	81	1	32000	4074	47	18000	1	32000	3321	28	18000
8	Benz(a)anthracene (ug/kg)	60	48	80	14.5 J	120000	3539	170	5000	5 U	120000	2844	111 J	5000
8	4,4'-DDT (ug/kg)	19	15	79	22	22000	4249	1100	17000	2 UJ	22000	3376	590	17000
8	Benzo(b+k)fluoranthene (ug/kg)	60	47	78	20 A	57000 J	2856	270 A	8600 A	5 UA	57000 J	2250	174 A	8600 A
8	Benzo(a)pyrene (ug/kg)	60	46	77	13 J	17000	853	150	1300 G	5 U	17000	695	86.7	1400
8	Thallium (mg/kg)	12	9	75	5	12	7	6	9	4 U	12	7	6	9
8	1,2,3,4,7,8,9-Heptachlorodibenzofuran (ng/kg)	4	3	75	26	2200	792	26	150	0.4 U	2200	594	26	150
8	1,2,3,7,8,9-Hexachlorodibenzofuran (ng/kg)	4	3	75	14	2700	913	14	25	0.3 U	2700	685	14	25
8	Bis(2-ethylhexyl) phthalate (ug/kg)	30	22	73	11 B	16000 G	1390	350	3040 G	11 B	16000 G	1036	260	3040 G
8	Arsenic (mg/kg)	50	36	72	1.69	35	6	4	21	1 U	35	6	4	21
8	Lead (mg/kg)	39	28	72	2.3 E	204	36	27	66	2.3 E	204	31	20 U	66
8	Acenaphthene (ug/kg)	60	43	72	6 GH	1200000	31464	92	23000	5 U	1200000	22556	53.9 U	23000
8	Fluorene (ug/kg)	60	43	72	8 GH	1100000 J	29293	110	24000 J	5 U	1100000 J	21000	50 U	24000 J
8	Diesel fuels (mg/kg)	13	9	69	153	12400	6713	6850	11600	50 U	12400	4663	703	11600
8	4,4'-DDE (ug/kg)	19	13	68	2 J	1840	332	100	1180	2 J	7500 U	672	100	1840
8	Anthracene (ug/kg)	60	41	68	11 J	430000	12650	90	9200	5 U	430000	8676	56	9200
8	Benzo(g,h,i)perylene (ug/kg)	60	41	68	7 J	4300	277	87	640	5 U	87000 U	1879	67 U	3200 U
8	Indeno(1,2,3-cd)pyrene (ug/kg)	60	40	67	7 J	87000	2545	97.2	1400	5 U	87000	1936	67 U	3200 U
8	4-Methylphenol (ug/kg)	18	12	67	45	410	167	120 J	370	45	410	145	100 U	370

Table 4-6. Historical Subsurface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detects	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
8	2-Methylnaphthalene (ug/kg)	36	23	64	8 J	610	93	40	220	5 U	610	64	20 U	220
8	Naphthalene (ug/kg)	63	40	63	8	3500000 J	95759	100	45000 J	5 U	3500000 J	60810	41 U	22000
8	Beryllium (mg/kg)	19	12	63	0.49	0.7	0.60	0.56	0.7	0.49	1 U	0.75	0.66	1 U
8	Dibutyltin ion (ug/kg)	27	16	59	1	830	145	52 J	470	1	830	88	5.6 UJ	320
8	Dibenzofuran (ug/kg)	36	21	58	7 J	630	111	21	350	5 U	630	69	16	350
8	Cadmium (mg/kg)	26	15	58	0.2	0.8	0.5	0.5	0.7	0.1 U	1 U	0.6	0.5	1 U
8	1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin (ng/kg)	4	2	50	1.2	1.7 J	1.45	1.2	1.2	0.5 U	11 U	3.6	1.2	1.7 J
8	1,2,3,6,7,8-Hexachlorodibenzofuran (ng/kg)	4	2	50	9.8	150	79.9	9.8	9.8	0.2 U	5600 UJ	1440	9.8	150
8	1,2,3,7,8-Pentachlorodibenzofuran (ng/kg)	4	2	50	3.3	360	181.7	3.3	3.3	0.2 U	18000 U	4591	3.3	360
8	1,2,3,7,8-Pentachlorodibenzo-p-dioxin (ng/kg)	4	2	50	0.3 J	1.2	0.8	0.3 J	0.3 J	0.3 J	6.9 U	2.2	0.4 U	1.2
8	Dibenz(a,h)anthracene (ug/kg)	60	24	40	6 J	87000	3789	40	990	5 U	87000	1768	36	1800 G
8	Carbazole (ug/kg)	37	14	38	14	60000	4863	57	2900	10 U	60000	1945	22	2900
8	Butyltin ion (ug/kg)	27	10	37	1 G	240	50	8	66 G	1 UG	240	21	3 U	63
8	Aroclor 1254 (ug/kg)	22	8	36	15 J	443	97	40	72	10 U	75000 U	3919	72	1600 U
8	Polychlorinated biphenyls (ug/kg)	22	8	36	15 A	605 A	152	72 A	230 A	10 UA	150000 UA	7758	101 A	3100 UA
8	Acenaphthylene (ug/kg)	60	20	33	11	190	48	33	170	5 U	17000 U	403	19 U	640 U
8	Tetrabutyltin (ug/kg)	20	6	30	1 H	130	33	12	28	1 U	130	12	5 U	28
8	Benzo(e)pyrene (ug/kg)	14	4	29	38	1300	717	430	1100	12 U	17000 U	1595	38	1700 U
8	Aroclor 1260 (ug/kg)	22	6	27	24	160	72	33	152	10 U	75000 U	3908	100 U	1600 U
8	Hexachloroethane (ug/kg)	24	6	25	31	20000	3407	95	160	19 U	20000	874	40 U	120
8	Benzoic acid (ug/kg)	20	5	25	230	2600	950	430	770	190 U	2600	406	250 U	770
8	2,3,7,8-Tetrachlorodibenzo-p-dioxin (ng/kg)	4	1	25	0.63	0.63	0.63	0.63	0.63	0.1 U	6.9 U	2.0	0.3 U	0.63
8	Butylbenzyl phthalate (ug/kg)	30	7	23	10	42	21	18 G	24	10 U	47 U	17	18 G	24
8	Dibutyl phthalate (ug/kg)	30	6	20	12 G	1500	301	22	198 G	10 U	1500	73	19 U	53 G
8	Chlorobenzene (ug/kg)	13	2	15	1900	18000	9950	1900	1900	5 U	18000	1544	5 U	1900
8	1,2,4-Trichlorobenzene (ug/kg)	27	4	15	12	530	156	40 G	41	10 U	530	42	19 U	47 U
8	Phenol (ug/kg)	30	4	13	19	300	100	27	52	19 U	300	48	50 UG	50 UG
8	Hexachlorobenzene (ug/kg)	38	4	11	25	14000	3897	61	1500	10 U	35000 U	1491	20 U	3400 U
8	Hexachlorobutadiene (ug/kg)	41	4	10	19	34000	15019	57	26000	10 U	87000 UJ	3955	20 U	8600 UJ
8	1,3,5-Trimethylbenzene (ug/kg)	13	1	8	630	630	630	630	630	20 U	630	88	20 U	200 U
8	Isopropylbenzene (ug/kg)	13	1	8	588	588	588	588	588	20 U	588	85	20 U	200 U
8	m,p-Xylene (ug/kg)	13	1	8	740	740	740	740	740	5 U	740	67	5 U	50 U
8	n-Butylbenzene (ug/kg)	13	1	8	3190	3190	3190	3190	3190	20 U	3190	285	20 U	200 U
8	n-Propylbenzene (ug/kg)	13	1	8	1840	1840	1840	1840	1840	20 U	1840	181	20 U	200 U
8	o-Xylene (ug/kg)	13	1	8	513	513	513	513	513	5 U	513	49	5 U	50 U
8	Pseudocumene (ug/kg)	13	1	8	2210	2210	2210	2210	2210	20 U	2210	210	20 U	200 U
8	Sec-butylbenzene (ug/kg)	13	1	8	1640	1640	1640	1640	1640	20 U	1640	166	20 U	200 U
8	tert-Butylbenzene (ug/kg)	13	1	8	128	128	128	128	128	20 U	200 U	50	20 U	128
8	Tetrachloroethene (ug/kg)	13	1	8	8	8	8	8	8	5 U	100 U	18	8	50 U
8	2,3,4,6-Tetrachlorophenol (ug/kg)	14	1	7	26	26	26	26	26	17 U	700 U	163	64 U	470 U
8	Ethylbenzene (ug/kg)	14	1	7	244	244	244	244	244	5 U	300 U	48	9 U	244
8	Heavy oil (mg/kg)	14	1	7	100 G	100 G	100	100 G	100 G	75 U	500 U	204	100 G	300 U
8	Toluene (ug/kg)	14	1	7	21	21	21	21	21	5 U	300 U	39	9 U	100 U
8	2-Chlorophenol (ug/kg)	30	2	7	51	93	72	51	51	19 U	93	40	50 U	50 U
8	Antimony (mg/kg)	19	1	5	0.8 G	0.8 G	0.8	0.8 G	0.8 G	0.1 UG	10 U	5	5 UJ	10 U
8	gamma-Hexachlorocyclohexane (ug/kg)	19	1	5	45.9	45.9	45.9	45.9	45.9	0.94 U	3800 U	257	10 U	400 U

Table 4-6. Historical Subsurface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detects	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
8	2,4,5-Trichlorophenol (ug/kg)	44	2	5	35	73	54	35	35	13 U	1400 U	149	94 U	410 U
8	2,4,6-Trichlorophenol (ug/kg)	44	2	5	57	100	78.5	57	57	13 U	700 U	96	63 U	230 U
8	Aroclor 1232 (ug/kg)	22	1	5	10	10	10	10	10	10 U	75000 U	3890	20 UJ	1600 U
8	2,4-Dinitrophenol (ug/kg)	22	1	5	18 J	18 J	18	18 J	18 J	18 J	470 UJ	243	200 UJ	300 UG
8	Isophorone (ug/kg)	24	1	4	43	43	43	43	43	10 U	47 U	17	19 U	20 U
8	Dimethyl phthalate (ug/kg)	30	1	3	10 G	10 G	10	10 G	10 G	10 U	47 U	15	10 U	20 U
8	Pentachlorophenol (ug/kg)	45	1	2	100	100	100	100	100	13 U	15100 U	721	100 UG	1340 U
8	2,4-Dichlorophenol (ug/kg)	42	0	0						56 U	6400 U	320	100 U	780 U
8	2,4-Dimethylphenol (ug/kg)	30	0	0						19 U	200 UJ	93	20 U	200 UJ
8	2-Methylphenol (ug/kg)	30	0	0						19 U	100 UJ	69	100 U	100 U
8	4,6-Dinitro-2-methylphenol (ug/kg)	30	0	0						100 U	470 U	147	100 U	200 UJ
8	4-Chloro-3-methylphenol (ug/kg)	30	0	0						38 U	93 U	47	50 UG	50 U
8	Diethyl phthalate (ug/kg)	30	0	0						10 U	47 U	15	10 U	20 U
8	Di-n-octyl phthalate (ug/kg)	30	0	0						10 U	47 U	15	10 UG	20 U
8	4-Nitrophenol (ug/kg)	28	0	0						94 U	230 U	104	100 UG	100 U
8	1,2-Dichlorobenzene (ug/kg)	27	0	0						5 U	100 U	19	11 UG	47 U
8	1,3-Dichlorobenzene (ug/kg)	27	0	0						5 U	100 U	19	11 UG	47 U
8	1,4-Dichlorobenzene (ug/kg)	27	0	0						5 U	100 U	19	11 UG	47 U
8	2,4-Dinitrotoluene (ug/kg)	24	0	0						20 U	230 U	64	20 U	99 U
8	2,6-Dinitrotoluene (ug/kg)	24	0	0						10 U	230 U	59	10 U	99 U
8	2-Chloronaphthalene (ug/kg)	24	0	0						5 U	47 U	13	5 U	20 U
8	2-Nitroaniline (ug/kg)	24	0	0						10 U	230 U	59	10 U	99 U
8	3,3'-Dichlorobenzidine (ug/kg)	24	0	0						40 U	230 U	74	40 UJ	99 U
8	3-Nitroaniline (ug/kg)	24	0	0						110 U	280 U	166	200 U	200 U
8	4-Bromophenyl phenyl ether (ug/kg)	24	0	0						10 U	47 U	16	10 U	20 U
8	4-Chloroaniline (ug/kg)	24	0	0						50 U	140 U	58	50 UJ	60 U
8	4-Chlorophenyl phenyl ether (ug/kg)	24	0	0						10 U	47 U	16	10 U	20 U
8	4-Nitroaniline (ug/kg)	24	0	0						10 U	230 U	59	10 U	99 U
8	Benzyl alcohol (ug/kg)	24	0	0						19 U	50 U	36	47 U	50 U
8	Bis(2-chloro-1-methylethyl) ether (ug/kg)	24	0	0						10 U	47 U	16	10 U	20 U
8	Bis(2-chloroethoxy) methane (ug/kg)	24	0	0						10 U	47 U	16	10 U	20 U
8	Bis(2-chloroethyl) ether (ug/kg)	24	0	0						10 U	93 U	27	10 U	40 U
8	Nitrobenzene (ug/kg)	24	0	0						10 U	47 U	16	10 UG	20 U
8	N-Nitrosodiphenylamine (ug/kg)	24	0	0						10 U	47 U	16	10 U	20 U
8	N-Nitrosodipropylamine (ug/kg)	24	0	0						10 U	93 U	27	10 U	40 U
8	Aroclor 1016 (ug/kg)	22	0	0						10 U	75000 U	3890	20 U	1600 U
8	Aroclor 1221 (ug/kg)	22	0	0						10 U	150000 U	7713	39 UJ	3100 U
8	Aroclor 1242 (ug/kg)	22	0	0						10 U	75000 U	3890	20 UJ	1600 U
8	Aroclor 1248 (ug/kg)	22	0	0						10 U	75000 U	3890	20 UJ	1600 U
8	Aldrin (ug/kg)	19	0	0						0.94 U	3800 U	427	10 U	3600 U
8	alpha-Chlordane (ug/kg)	19	0	0						0.94 U	3800 UJ	257	10 U	400 U
8	alpha-Endosulfan (ug/kg)	19	0	0						0.94 U	3800 U	257	10 U	400 U
8	beta-Endosulfan (ug/kg)	19	0	0						1.9 U	7500 U	475	10 U	750 U
8	beta-Hexachlorocyclohexane (ug/kg)	19	0	0						0.94 U	3800 U	257	10 U	400 U
8	delta-Hexachlorocyclohexane (ug/kg)	19	0	0						0.94 UJ	3800 UJ	257	10 U	400 U
8	Dieldrin (ug/kg)	19	0	0						1.9 U	7500 U	476	10 U	750 U

Table 4-6. Historical Subsurface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detects	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
8	Endosulfan sulfate (ug/kg)	19	0	0						1.9 UJ	7500 UJ	475	10 U	750 UJ
8	Endrin (ug/kg)	19	0	0						1.9 U	7500 U	476	10 U	750 U
8	Endrin aldehyde (ug/kg)	19	0	0						1.9 U	7500 U	476	10 U	750 U
8	Endrin ketone (ug/kg)	19	0	0						1.9 UJ	7500 UJ	476	10 U	750 UJ
8	gamma-Chlordane (ug/kg)	19	0	0						0.95 U	3800 U	257	10 U	400 U
8	Heptachlor (ug/kg)	19	0	0						0.94 U	3800 U	257	10 U	400 U
8	Heptachlor epoxide (ug/kg)	19	0	0						0.94 U	3800 U	257	10 U	400 U
8	Methoxychlor (ug/kg)	19	0	0						9.4 U	38000 U	2280	20 U	3800 U
8	Toxaphene (ug/kg)	19	0	0						94 U	380000 U	26002	300 U	50000 U
8	2-Nitrophenol (ug/kg)	18	0	0						40 UG	230 U	86	96 U	99 U
8	Hexachlorocyclopentadiene (ug/kg)	16	0	0						94 U	230 UJ	131	98 UJ	200 U
8	Anthanthrene (ug/kg)	14	0	0						62 U	87000 U	7249	67 U	8600 U
8	Benzene (ug/kg)	14	0	0						5 U	300 U	38	9 U	100 U
8	1,1,1,2-Tetrachloroethane (ug/kg)	13	0	0						5 U	100 U	18	5 U	50 U
8	1,1,1-Trichloroethane (ug/kg)	13	0	0						5 U	100 U	18	5 U	50 U
8	1,1,2,2-Tetrachloroethane (ug/kg)	13	0	0						5 U	100 U	18	5 U	50 U
8	1,1,2-Trichloroethane (ug/kg)	13	0	0						5 U	100 U	18	5 U	50 U
8	1,1-Dichloroethane (ug/kg)	13	0	0						5 U	100 U	18	5 U	50 U
8	1,1-Dichloropropene (ug/kg)	13	0	0						5 U	100 U	18	5 U	50 U
8	1,2,3-Trichlorobenzene (ug/kg)	13	0	0						20 U	200 U	48	20 U	100 U
8	1,2,3-Trichloropropane (ug/kg)	13	0	0						5 U	100 U	18	5 U	50 U
8	1,2-Dibromo-3-chloropropane (ug/kg)	13	0	0						20 U	500 U	78	20 U	200 U
8	1,2-Dichloroethane (ug/kg)	13	0	0						5 U	100 U	18	5 U	50 U
8	1,2-Dichloropropane (ug/kg)	13	0	0						5 U	100 U	18	5 U	50 U
8	1,3-Dichloropropane (ug/kg)	13	0	0						5 U	100 U	18	5 U	50 U
8	2,2-Dichloropropane (ug/kg)	13	0	0						5 U	100 U	18	5 U	50 U
8	2,3,4,5-Tetrachlorophenol (ug/kg)	13	0	0						13 U	700 U	173	64 U	470 U
8	2-Chlorotoluene (ug/kg)	13	0	0						20 U	200 U	48	20 U	100 U
8	4-Chlorotoluene (ug/kg)	13	0	0						20 U	200 U	48	20 U	100 U
8	Bromobenzene (ug/kg)	13	0	0						5 U	100 U	18	5 U	50 U
8	Bromochloromethane (ug/kg)	13	0	0						5 U	100 U	18	5 U	50 U
8	Bromodichloromethane (ug/kg)	13	0	0						5 U	100 U	18	5 U	50 U
8	Bromoform (ug/kg)	13	0	0						5 U	100 U	18	5 U	50 U
8	Bromomethane (ug/kg)	13	0	0						5 UJ	500 U	48	5 UJ	50 U
8	Carbon disulfide (ug/kg)	13	0	0						5 U	1000 U	87	5 U	50 U
8	Carbon tetrachloride (ug/kg)	13	0	0						5 U	100 U	18	5 U	50 U
8	Chlorodibromomethane (ug/kg)	13	0	0						5 U	100 U	18	5 U	50 U
8	Chloroethane (ug/kg)	13	0	0						5 U	100 U	18	5 U	50 U
8	Chloroform (ug/kg)	13	0	0						5 U	100 U	18	5 U	50 U
8	Chloromethane (ug/kg)	13	0	0						5 U	500 U	48	5 UJ	50 U
8	cis-1,2-Dichloroethene (ug/kg)	13	0	0						5 U	100 U	18	5 U	50 U
8	cis-1,3-Dichloropropene (ug/kg)	13	0	0						5 U	100 U	18	5 U	50 U
8	Dichlorodifluoromethane (ug/kg)	13	0	0						5 U	500 U	48	5 UJ	50 U
8	Ethylene dibromide (ug/kg)	13	0	0						20 U	200 U	48	20 U	100 U
8	Gasoline (mg/kg)	13	0	0						20 U	20 U	20	20 U	20 U
8	Methyl N-butyl ketone (ug/kg)	13	0	0						20 U	1000 U	117	20 U	200 U

Table 4-6. Historical Subsurface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detects	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
8	Methylene bromide (ug/kg)	13	0	0						5 U	100 U	18	5 U	50 U
8	Methylene chloride (ug/kg)	13	0	0						10 U	500 U	58	10 U	100 U
8	Styrene (ug/kg)	13	0	0						5 U	100 U	18	5 U	50 U
8	trans-1,2-Dichloroethene (ug/kg)	13	0	0						5 U	100 U	18	5 U	50 U
8	trans-1,3-Dichloropropene (ug/kg)	13	0	0						5 U	100 U	18	5 U	50 U
8	Trichloroethene (ug/kg)	13	0	0						5 U	100 U	18	5 U	50 U
8	Trichlorofluoromethane (ug/kg)	13	0	0						5 UJ	100 U	18	5 UJ	50 U
8	Vinyl chloride (ug/kg)	13	0	0						5 U	100 U	18	5 U	50 U
8	Vinylidene chloride (ug/kg)	13	0	0						5 U	100 U	18	5 U	50 U
8	2,6-Dichlorophenol (ug/kg)	12	0	0						120 U	6400 U	903	130 U	1400 U
8	Cymene (ug/kg)	12	0	0						20 U	200 U	43	20 U	45 U
8	Hexachlorocyclohexanes (ug/kg)	12	0	0						10 U	400 U	51	10 U	40 U
8	alpha-Hexachlorocyclohexane (ug/kg)	7	0	0						0.94 U	3800 U	609	0.97 UJ	380 U
8	3- and 4-Methylphenol Coelution (ug/kg)	6	0	0						200 U	200 UJ	200	200 U	200 U
8	Acetone (ug/kg)	1	0	0						1000 U	1000 U	1000	1000 U	1000 U
8	Methyl isobutyl ketone (ug/kg)	1	0	0						500 U	500 U	500	500 U	500 U
8	Methyl tert-butyl ether (ug/kg)	1	0	0						100 U	100 U	100	100 U	100 U
8	Methylethyl ketone (ug/kg)	1	0	0						1000 U	1000 U	1000	1000 U	1000 U
8	Xylene (ug/kg)	1	0	0						300 U	300 U	300	300 U	300 U
9	Clay (%)	81	81	100	0.31	24.94	10.60	10.17	20.15	0.31	24.94	10.60	10.17	20.15
9	Fines (%)	81	81	100	1.11	98.15	57.99	61.54	90.34	1.11	98.15	57.99	61.54	90.34
9	Sand (%)	81	81	100	3.4	98.32	40.25	32.5	91.23	3.4	98.32	40.25	32.5	91.23
9	Silt (%)	81	81	100	0.83	86.3	47.39	50.2	75.21	0.83	86.3	47.39	50.2	75.21
9	Copper (mg/kg)	77	77	100	10.5	2200	166	34.8 G	729	10.5	2200	166	34.8 G	729
9	Nickel (mg/kg)	77	77	100	13	43 J	24	24	34	13	43 J	24	24	34
9	Zinc (mg/kg)	77	77	100	24	1500 L	205	93	872	24	1500 L	205	93	872
9	Chromium (mg/kg)	68	68	100	7	157	31	25	54 G	7	157	31	25	54 G
9	Total solids (%)	66	66	100	44.3	87	64	65.3	80.6	44.3	87	64	65.3	80.6
9	Gravel (%)	49	49	100	0.01	15.9	1.75	0.18	9.1	0.01	15.9	1.75	0.18	9.1
9	Iron (mg/kg)	10	10	100	34700	53300	42250	41400	49300	34700	53300	42250	41400	49300
9	Manganese (mg/kg)	10	10	100	419	872	621	506	817	419	872	621	506	817
9	3- and 4-Methylphenol Coelution (ug/kg)	9	9	100	4.8 J	300	82	29	180	4.8 J	300	82	29	180
9	Mean grain size (mm)	8	8	100	0.03	0.26	0.12	0.08	0.22	0.03	0.26	0.12	0.08	0.22
9	Median grain size (mm)	8	8	100	0.02	0.05	0.04	0.04	0.04	0.02	0.05	0.04	0.04	0.04
9	Titanium (mg/kg)	8	8	100	1870	3490	2255	1950	2590	1870	3490	2255	1950	2590
9	Total volatile solids (%)	8	8	100	4.79	8.22	7.13	7.12	7.89	4.79	8.22	7.13	7.12	7.89
9	Aluminum (mg/kg)	7	7	100	29200	44200	38614	40600	42100	29200	44200	38614	40600	42100
9	Barium (mg/kg)	7	7	100	168	281	222	203	274	168	281	222	203	274
9	Calcium (mg/kg)	7	7	100	6420	16000	10144	8590	14200	6420	16000	10144	8590	14200
9	Cobalt (mg/kg)	7	7	100	16.4	20.8	19	18	20.6	16.4	20.8	19	18	20.6
9	Magnesium (mg/kg)	7	7	100	5550	8510	7039	7150	7630	5550	8510	7039	7150	7630
9	Potassium (mg/kg)	7	7	100	1060	1550	1343	1310	1510	1060	1550	1343	1310	1510
9	Sodium (mg/kg)	7	7	100	714 J	1320 J	1089	1100	1170 J	714 J	1320 J	1089	1100	1170 J
9	Vanadium (mg/kg)	7	7	100	89.9	113	103	103	109	89.9	113	103	103	109
9	Tin (mg/kg)	3	3	100	2.28 G	4.46 G	3.72	2.28 G	4.42 G	2.28 G	4.46 G	3.72	2.28 G	4.42 G
9	1,2,3,4,6,7,8-Heptachlorodibenzofuran (ng/kg)	2	2	100	33 B	36	35	33 B	33 B	33 B	36	35	33 B	33 B

Table 4-6. Historical Subsurface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detects	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
9	1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin (ng/kg	2	2	100	220 B	440	330	220 B	220 B	220 B	440	330	220 B	220 B
9	1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin (ng/kg)	2	2	100	11	15 B	13	11	11	11	15 B	13	11	11
9	1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin (ng/kg)	2	2	100	5.2	7.5 J	6.4	5.2	5.2	5.2	7.5 J	6.4	5.2	5.2
9	2,3,7,8-Tetrachlorodibenzofuran (ng/kg)	2	2	100	1.5	3.2 B	2.4	1.5	1.5	1.5	3.2 B	2.4	1.5	1.5
9	Octachlorodibenzofuran (ng/kg)	2	2	100	94 B	130	112	94 B	94 B	94 B	130	112	94 B	94 B
9	Octachlorodibenzo-p-dioxin (ng/kg)	2	2	100	2000 B	5400	3700	2000 B	2000 B	2000 B	5400	3700	2000 B	2000 B
9	Bromine (ug/kg)	1	1	100	10	10	10	10	10	10	10	10	10	10
9	Chlorine (ug/kg)	1	1	100	424	424	424	424	424	424	424	424	424	424
9	Heptachlorodibenzofuran (ng/kg)	1	1	100	140	140	140	140	140	140	140	140	140	140
9	Heptachlorodibenzo-p-dioxin (ng/kg)	1	1	100	1700	1700	1700	1700	1700	1700	1700	1700	1700	1700
9	Hexachlorodibenzofuran (ng/kg)	1	1	100	78	78	78	78	78	78	78	78	78	78
9	Hexachlorodibenzo-p-dioxin (ng/kg)	1	1	100	200	200	200	200	200	200	200	200	200	200
9	Pentachlorodibenzofuran (ng/kg)	1	1	100	22	22	22	22	22	22	22	22	22	22
9	Pentachlorodibenzo-p-dioxin (ng/kg)	1	1	100	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
9	Tetrachlorodibenzofuran (ng/kg)	1	1	100	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
9	Tetrachlorodibenzo-p-dioxin (ng/kg)	1	1	100	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2
9	Total organic carbon (%)	72	69	96	0.06	5.6	1.4	1.43	2.75	0.05 U	5.6	1.4	1.3	2.75
9	Bis(2-ethylhexyl) phthalate (ug/kg)	60	55	92	10 B	5000	454	107	1520	10 U	5000	430	107	1520
9	Arsenic (mg/kg)	77	67	87	2	140	8	3.46	14	2 U	140	8	3.3	14
9	Lead (mg/kg)	77	67	87	2.1	1080	55	20.1 E	140 G	2.1	1080	53	23.9	140 G
9	Butyltin ion (ug/kg)	5	4	80	8.4	260	106	16 J	140	8.4	270 U	139	16 J	260
9	Beryllium (mg/kg)	9	7	78	0.44	0.7	0.59	0.56	0.7	0.44	1 U	0.68	0.6	1 U
9	Selenium (mg/kg)	9	7	78	8	14	10	9	11	1 U	14	8	8	11
9	Polycyclic Aromatic Hydrocarbons (ug/kg)	59	43	73	8.9 A	16890 A	2457	1100 A	5839 A	6.7 UA	16890 A	1798	528 A	5839 A
9	Tributyltin ion (ug/kg)	22	16	73	1	90000	9340	570	17000	1 U	90000	6805	28	15000
9	High Molecular Weight PAH (ug/kg)	59	42	71	8.9 A	12880 A	1930	894 A	4872 A	6.7 UA	12880 A	1397	465 A	4872 A
9	Pyrene (ug/kg)	59	42	71	5.1	2800 G	433	263	930	5.1	2800 G	331	95	930
9	Mercury (mg/kg)	77	54	70	0.02	2.1	0.27	0.15	0.73	0.02	2.1	0.21	0.1	0.72
9	Low Molecular Weight PAH (ug/kg)	59	41	69	7.3 A	4490 A	600	255 A	1157 A	3.2 UA	4490 A	433	124 A	1157 A
9	Phenanthrene (ug/kg)	59	41	69	6.7	2600 G	375	127	1100	3.2 U	2600 G	277	61	1100
9	Benzo(b)fluoranthene (ug/kg)	59	40	68	5.3	1400	197	89	1000	3.2 U	1400	165	43	910 U
9	Benzo(b+k)fluoranthene (ug/kg)	59	40	68	7.9 A	2180 A	342	162 A	1440 A	3.2 UA	2180 A	263	80 A	1231 A
9	Chrysene (ug/kg)	59	40	68	6.9	1400 G	213	106	1000	3.2 U	1400 G	176	51 G	910 U
9	Fluoranthene (ug/kg)	59	40	68	3.8	2900	446	231	2200	3.8	2900	336	112	1200
9	Benz(a)anthracene (ug/kg)	59	39	66	4.7	1300	181	81	880	3.2 U	1300	152	40	880
9	Benzo(a)pyrene (ug/kg)	59	39	66	4.7	1100	173	81	770	2.8 U	1100	146	40	770
9	Benzo(k)fluoranthene (ug/kg)	59	38	64	3.3	780	129	76	440	2.8 U	910 U	114	39	500 U
9	Benzo(g,h,i)perylene (ug/kg)	59	36	61	6.3	740	121	65	430	2.8 U	910 U	106	27	500 U
9	Carbazole (ug/kg)	10	6	60	19 J	260 G	120	71	230	19 UJ	910 UJ	169	31 J	260 G
9	Dibutyltin ion (ug/kg)	5	3	60	26	1300 J	515	26	220 J	5.7 U	1300 J	364	26	270 U
9	Indeno(1,2,3-cd)pyrene (ug/kg)	59	35	59	5.5	970	137	79	450	2.3 U	970	113	32	500 U
9	Anthracene (ug/kg)	59	33	56	3	630 G	86	42	320	2.8 U	910 U	85	16	500 U
9	Cadmium (mg/kg)	77	40	52	0.1	5.3	0.7	0.4	1.6	0.1 U	5.3	0.6	0.3	1.6 U
9	Silver (mg/kg)	77	40	52	0.06 J	3.4	0.6	0.5	1.5	0.06 J	3.4	0.5	0.3	1.5
9	Naphthalene (ug/kg)	59	30	51	3.7	260 G	57	31	120	2.8 U	910 U	62	11	260 G
9	Dibutyl phthalate (ug/kg)	60	30	50	4.4 JB	135	29	19	88	4.4 JB	910 U	56	10 U	250 UG

Table 4-6. Historical Subsurface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detects	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
9	1,2,3,4,7,8-Hexachlorodibenzofuran (ng/kg)	2	1	50	4	4	4	4	4	3.5 U	4	3.75	3.5 U	3.5 U
9	1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin (ng/kg)	2	1	50	3.6	3.6	3.6	3.6	3.6	2 U	3.6	2.8	2 U	2 U
9	1,2,3,7,8-Pentachlorodibenzo-p-dioxin (ng/kg)	2	1	50	0.92	0.92	0.92	0.92	0.92	0.92	1.4 U	1.16	0.92	0.92
9	Acetone (ug/kg)	2	1	50	200	200	200	200	200	200 U	200	200	200 U	200 U
9	Aroclor 1254 (ug/kg)	52	25	48	10	1800	307	84	1200	10 U	1800	159	22	567
9	Polychlorinated biphenyls (ug/kg)	52	25	48	10 A	2379 A	440	150 A	1640 A	10 UA	2379 A	227	40 UA	799 A
9	Butylbenzyl phthalate (ug/kg)	60	27	45	3.4 J	260	43	19	140	3.4 J	910 U	56	12 U	260
9	Fluorene (ug/kg)	59	25	42	3.9	570 G	98	39	340	2.3 U	910 U	76	10 U	430
9	2-Methylnaphthalene (ug/kg)	56	23	41	10	2000	134	23	210	2.3 U	2000	74	10 U	220 G
9	Aroclor 1260 (ug/kg)	52	21	40	18	810	156	77	440	10 U	810	75	20 U	232
9	Tetrabutyltin (ug/kg)	5	2	40	44	100	72	44	44	5.7 U	270 U	85	5.8 U	100
9	Acenaphthene (ug/kg)	59	23	39	3.1	430 G	86	36	320	2.3 U	910 U	67	10 UG	380
9	Total of 3 isomers: pp-DDT,-DDD,-DDE (ug/kg)	13	5	38	3 A	7.1 A	5	3.3 A	5.9 A	2.7 UA	10 UA	5.0	3.5 UA	10 UA
9	Dibenzofuran (ug/kg)	57	19	33	11	360 G	64	18	270	10 U	910 U	59	14 U	300 UH
9	Thallium (mg/kg)	9	3	33	4	6	5	4	5	1 U	10 U	5	5 U	9 U
9	Dibutyltin ion (ug/l)	3	1	33	0.32	0.32	0.32	0.32	0.32	0.03 U	0.32	0.13	0.03 U	0.03 U
9	Tetrabutyltin (ug/l)	3	1	33	0.15	0.15	0.15	0.15	0.15	0.03 U	0.15	0.07	0.03 U	0.03 U
9	Tributyltin ion (ug/l)	3	1	33	0.13	0.13	0.13	0.13	0.13	0.03 U	0.13	0.06	0.03 U	0.03 U
9	4,4'-DDD (ug/kg)	13	4	31	1.2 J	3.3 J	2.45	2.2 J	3.1	1.2 J	10 U	4.1	3.3 J	10 U
9	4,4'-DDE (ug/kg)	13	4	31	1.8 J	5.9	3.8	3.5	4	1.8 J	10 U	4.4	3.5 U	10 U
9	Dibenz(a,h)anthracene (ug/kg)	59	18	31	14	290	54	26	150 G	2.3 U	910 U	52	10 U	290
9	Acenaphthylene (ug/kg)	59	15	25	4.3	32	16.5	14	30	2.8 U	910 U	42	10 UG	50 UG
9	Benzoic acid (ug/kg)	21	5	24	8.7 J	860	364	9.7 J	560	8.7 J	9100 U	826	190 U	2000 UH
9	Antimony (mg/kg)	72	15	21	0.1 G	4.4	1.1	0.2 X	4	0.1 UG	140 U	13	0.1 UG	120 U
9	4-Methylphenol (ug/kg)	48	9	19	50	290	133	90	230	19 U	910 U	133	100 U	290
9	Benzyl alcohol (ug/kg)	21	3	14	5.7 J	9 J	7.3	5.7 J	7.3 J	5.7 J	910 U	99	19 U	300 UH
9	Di-n-octyl phthalate (ug/kg)	60	8	13	11	3180	538	18	851	10 U	3180	112	10 U	500 U
9	Pentachlorophenol (ug/kg)	57	7	12	9.4 J	47	20	15 J	22	9.4 J	4500 U	256	100 U	250 UG
9	Dimethyl phthalate (ug/kg)	60	5	8	3.1 J	99 G	36	10	59 N	3.1 J	910 U	43	10 U	99 G
9	Endrin (ug/kg)	13	1	8	0.62 J	0.62 J	0.62	0.62 J	0.62 J	0.62 J	10 U	4.0	3.4 U	10 U
9	Phenol (ug/kg)	57	4	7	5.1 J	22	14	8.4 J	20	5.1 J	910 U	68	50 U	50 UG
9	Diethyl phthalate (ug/kg)	60	3	5	15 J	16.3 J	16	15 J	16 J	10 U	910 U	42	10 U	50 U
9	Aroclor 1242 (ug/kg)	52	1	2	69 J	69 J	69	69 J	69 J	10 U	100 U	17	10 U	20 UB
9	2,4-Dimethylphenol (ug/kg)	57	0	0						12 U	910 U	50	20 U	50 UG
9	2-Methylphenol (ug/kg)	57	0	0						12 U	910 U	100	100 U	100 UG
9	2,4,5-Trichlorophenol (ug/kg)	55	0	0						12 U	4500 U	149	40 U	250 UG
9	2,4,6-Trichlorophenol (ug/kg)	55	0	0						12 U	4500 U	131	30 U	100 U
9	2,4-Dichlorophenol (ug/kg)	55	0	0						12 U	2700 U	140	100 UG	100 UG
9	2,4-Dinitrophenol (ug/kg)	55	0	0						12 U	9100 UJ	489	300 UG	300 UG
9	2-Chlorophenol (ug/kg)	55	0	0						12 U	910 U	70	50 UG	50 UG
9	2-Nitrophenol (ug/kg)	55	0	0						12 U	4500 U	138	40 U	100 U
9	4,6-Dinitro-2-methylphenol (ug/kg)	55	0	0						12 U	9100 UJ	358	100 U	250 UG
9	4-Chloro-3-methylphenol (ug/kg)	55	0	0						12 U	1800 U	89	50 U	50 UG
9	4-Nitrophenol (ug/kg)	55	0	0						12 U	4500 U	264	100 U	250 UG
9	Aroclor 1016 (ug/kg)	52	0	0						10 U	100 U	16	10 U	20 U
9	Aroclor 1221 (ug/kg)	52	0	0						10 U	100 U	21	10 U	40 U

Table 4-6. Historical Subsurface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detects	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
9	Aroclor 1232 (ug/kg)	52	0	0						10 U	100 U	16	10 U	20 U
9	Aroclor 1248 (ug/kg)	52	0	0						10 U	100 U	16	10 U	20 UB
9	Hexachlorobutadiene (ug/kg)	21	0	0						12 U	910 U	100	19 U	300 UH
9	Hexachloroethane (ug/kg)	21	0	0						12 U	910 U	100	19 U	300 UH
9	N-Nitrosodiphenylamine (ug/kg)	21	0	0						12 U	910 U	100	19 U	300 UH
9	1,2,4-Trichlorobenzene (ug/kg)	21	0	0						12 U	910 U	100	19 U	300 UH
9	1,2-Dichlorobenzene (ug/kg)	21	0	0						10 U	910 U	63	15 U	50 U
9	1,3-Dichlorobenzene (ug/kg)	21	0	0						10 U	910 U	63	15 U	50 U
9	1,4-Dichlorobenzene (ug/kg)	21	0	0						10 U	910 U	63	15 U	50 U
9	Hexachlorobenzene (ug/kg)	21	0	0						12 U	910 U	100	19 U	300 UH
9	2,4-Dinitrotoluene (ug/kg)	19	0	0						12 U	4500 U	323	50 U	500 U
9	2,6-Dinitrotoluene (ug/kg)	19	0	0						12 U	4500 U	323	50 U	500 U
9	2-Chloronaphthalene (ug/kg)	19	0	0						2.8 U	910 U	105	19 U	500 U
9	2-Nitroaniline (ug/kg)	19	0	0						12 U	4500 U	575	96 U	3000 U
9	3,3'-Dichlorobenzidine (ug/kg)	19	0	0						12 U	4500 U	575	96 U	3000 U
9	3-Nitroaniline (ug/kg)	19	0	0						12 U	5500 U	635	120 U	3000 U
9	4-Bromophenyl phenyl ether (ug/kg)	19	0	0						12 U	910 U	109	19 U	500 U
9	4-Chloroaniline (ug/kg)	19	0	0						12 U	2700 U	216	50 U	500 U
9	4-Chlorophenyl phenyl ether (ug/kg)	19	0	0						12 U	910 U	109	19 U	500 U
9	4-Nitroaniline (ug/kg)	19	0	0						12 U	4500 UJ	575	96 UJ	3000 U
9	Bis(2-chloro-1-methylethyl) ether (ug/kg)	19	0	0						12 U	910 U	109	19 U	500 U
9	Bis(2-chloroethoxy) methane (ug/kg)	19	0	0						12 U	910 U	109	19 U	500 U
9	Bis(2-chloroethyl) ether (ug/kg)	19	0	0						12 U	1800 U	162	38 U	500 U
9	Hexachlorocyclopentadiene (ug/kg)	19	0	0						12 U	4500 U	323	50 U	500 U
9	Isophorone (ug/kg)	19	0	0						12 U	910 U	109	19 U	500 U
9	Nitrobenzene (ug/kg)	19	0	0						12 U	910 U	109	19 U	500 U
9	N-Nitrosodipropylamine (ug/kg)	19	0	0						12 U	1800 U	162	38 U	500 U
9	4,4'-DDT (ug/kg)	13	0	0						2.7 UIJ	10 U	4.4	3.4 U	10 U
9	Aldrin (ug/kg)	13	0	0						0.96 UJ	10 U	2.87	1.7 U	10 U
9	alpha-Endosulfan (ug/kg)	13	0	0						0.96 UJ	10 U	2.87	1.7 U	10 U
9	alpha-Hexachlorocyclohexane (ug/kg)	13	0	0						0.96 UJ	10 U	2.87	1.7 U	10 U
9	beta-Endosulfan (ug/kg)	13	0	0						1.9 UJ	10 U	4.2	3.4 U	10 U
9	beta-Hexachlorocyclohexane (ug/kg)	13	0	0						0.96 UJ	30 U	5.95	1.7 U	30 U
9	delta-Hexachlorocyclohexane (ug/kg)	13	0	0						0.96 UJ	10 U	2.87	1.7 U	10 U
9	Dieldrin (ug/kg)	13	0	0						1.9 UJ	10 U	4.2	3.4 U	10 U
9	Endosulfan sulfate (ug/kg)	13	0	0						1.9 UJ	10 U	4.2	3.4 U	10 U
9	Endrin aldehyde (ug/kg)	13	0	0						1.9 UJ	10 U	4.3	3.5 U	10 U
9	gamma-Hexachlorocyclohexane (ug/kg)	13	0	0						0.96 UJ	10 U	2.87	1.7 U	10 U
9	Heptachlor (ug/kg)	13	0	0						0.96 UJ	10 U	2.87	1.7 U	10 U
9	Heptachlor epoxide (ug/kg)	13	0	0						0.96 UJ	10 U	2.87	1.7 U	10 U
9	Methoxychlor (ug/kg)	13	0	0						9.6 UJ	20 U	16	17 U	20 U
9	Toxaphene (ug/kg)	13	0	0						96 UJ	300 U	179	170 U	300 U
9	Chlordane (cis & trans) (ug/kg)	11	0	0						14 U	100 U	32	17 U	100 U
9	Endrin ketone (ug/kg)	11	0	0						2.8 U	7.3 UIJ	3.8	3.5 U	3.9 UIJ
9	2,4,5-T (ug/kg)	7	0	0						14 U	19 U	17	17 U	17 U
9	2,4-D (ug/kg)	7	0	0						14 U	19 U	17	17 U	17 U

Table 4-6. Historical Subsurface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detects	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
9	2,4-DB (ug/kg)	7	0	0						14 U	19 U	17	17 U	17 U
9	Dalapon (ug/kg)	7	0	0						69 U	94 U	84	84 U	87 U
9	Dicamba (ug/kg)	7	0	0						27 U	38 U	34	34 U	35 U
9	Dichloroprop (ug/kg)	7	0	0						14 U	19 U	17	17 U	17 U
9	Dinoseb (ug/kg)	7	0	0						14 U	19 U	17	17 U	17 U
9	MCPA (ug/kg)	7	0	0						14 U	19 U	17	17 U	17 U
9	MCPP (ug/kg)	7	0	0						14 U	19 U	17	17 U	17 U
9	Silvex (ug/kg)	7	0	0						14 U	19 U	17	17 U	17 U
9	Aniline (ug/kg)	5	0	0						50 U	2000 U	630	50 U	1000 UH
9	Benzidine (ug/kg)	3	0	0						250 U	250 UG	250	250 U	250 U
9	Butyltin ion (ug/l)	3	0	0						0.02 U	0.03 U	0.03	0.02 U	0.03 U
9	1,2,3,4,7,8,9-Heptachlorodibenzofuran (ng/kg)	2	0	0						3.4 U	3.9 U	4	3.4 U	3.4 U
9	1,2,3,6,7,8-Hexachlorodibenzofuran (ng/kg)	2	0	0						2.4 U	6.6 U	5	2.4 U	2.4 U
9	1,2,3,7,8,9-Hexachlorodibenzofuran (ng/kg)	2	0	0						0.17 U	1.2 U	0.69	0.17 U	0.17 U
9	1,2,3,7,8-Pentachlorodibenzofuran (ng/kg)	2	0	0						0.51 U	1.2 U	0.86	0.51 U	0.51 U
9	2,3,4,6,7,8-Hexachlorodibenzofuran (ng/kg)	2	0	0						0.95 U	1.5 U	1.23	0.95 U	0.95 U
9	2,3,4,7,8-Pentachlorodibenzofuran (ng/kg)	2	0	0						1.8 U	1.9 U	1.9	1.8 U	1.8 U
9	2,3,7,8-Tetrachlorodibenzo-p-dioxin (ng/kg)	2	0	0						0.76 U	1.4 U	1.08	0.76 U	0.76 U
9	N-Nitrosodimethylamine (ug/kg)	2	0	0						2000 UH	3000 U	2500	2000 UH	2000 UH
9	1,1,1-Trichloroethane (ug/kg)	2	0	0						10 U	10 U	10	10 U	10 U
9	1,1,2,2-Tetrachloroethane (ug/kg)	2	0	0						10 U	10 U	10	10 U	10 U
9	1,1,2-Trichloroethane (ug/kg)	2	0	0						10 U	10 U	10	10 U	10 U
9	1,1-Dichloroethane (ug/kg)	2	0	0						10 U	10 U	10	10 U	10 U
9	1,2-Dichloroethane (ug/kg)	2	0	0						10 U	10 U	10	10 U	10 U
9	1,2-Dichloropropane (ug/kg)	2	0	0						10 U	10 U	10	10 U	10 U
9	2-Chloroethyl vinyl ether (ug/kg)	2	0	0						20 U	20 U	20	20 U	20 U
9	alpha-Chlordane (ug/kg)	2	0	0						0.96 UJ	0.96 UJ	0.96	0.96 UJ	0.96 UJ
9	Benzene (ug/kg)	2	0	0						10 U	10 U	10	10 U	10 U
9	Bromodichloromethane (ug/kg)	2	0	0						10 U	10 U	10	10 U	10 U
9	Bromoform (ug/kg)	2	0	0						10 U	10 U	10	10 U	10 U
9	Bromomethane (ug/kg)	2	0	0						20 U	20 U	20	20 U	20 U
9	Carbon disulfide (ug/kg)	2	0	0						200 U	200 U	200	200 U	200 U
9	Carbon tetrachloride (ug/kg)	2	0	0						10 U	10 U	10	10 U	10 U
9	Chlorobenzene (ug/kg)	2	0	0						10 U	10 U	10	10 U	10 U
9	Chlorodibromomethane (ug/kg)	2	0	0						10 U	10 U	10	10 U	10 U
9	Chloroethane (ug/kg)	2	0	0						20 U	20 U	20	20 U	20 U
9	Chloroform (ug/kg)	2	0	0						10 U	10 U	10	10 U	10 U
9	Chloromethane (ug/kg)	2	0	0						20 U	20 U	20	20 U	20 U
9	cis-1,2-Dichloroethene (ug/kg)	2	0	0						10 U	10 U	10	10 U	10 U
9	cis-1,3-Dichloropropene (ug/kg)	2	0	0						10 U	10 U	10	10 U	10 U
9	Ethylbenzene (ug/kg)	2	0	0						10 U	10 U	10	10 U	10 U
9	gamma-Chlordane (ug/kg)	2	0	0						1.3 UIJ	1.5 UIJ	1.4	1.3 UIJ	1.3 UIJ
9	Methyl isobutyl ketone (ug/kg)	2	0	0						100 U	100 U	100	100 U	100 U
9	Methyl N-butyl ketone (ug/kg)	2	0	0						100 U	100 U	100	100 U	100 U
9	Methylene chloride (ug/kg)	2	0	0						10 U	10 U	10	10 U	10 U
9	Methylethyl ketone (ug/kg)	2	0	0						200 U	200 U	200	200 U	200 U

Table 4-6. Historical Subsurface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detects	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
9	Styrene (ug/kg)	2	0	0						10 UH	10 U	10	10 UH	10 UH
9	Tetrachloroethene (ug/kg)	2	0	0						10 U	10 U	10	10 U	10 U
9	Toluene (ug/kg)	2	0	0						10 U	10 U	10	10 U	10 U
9	trans-1,2-Dichloroethene (ug/kg)	2	0	0						10 U	10 U	10	10 U	10 U
9	trans-1,3-Dichloropropene (ug/kg)	2	0	0						10 U	10 U	10	10 U	10 U
9	Trichloroethene (ug/kg)	2	0	0						10 U	10 U	10	10 U	10 U
9	Trichlorofluoromethane (ug/kg)	2	0	0						20 U	20 U	20	20 U	20 U
9	Trichlorotrifluoroethane (ug/kg)	2	0	0						20 U	20 U	20	20 U	20 U
9	Vinyl acetate (ug/kg)	2	0	0						100 U	100 U	100	100 U	100 U
9	Vinyl chloride (ug/kg)	2	0	0						20 U	20 U	20	20 U	20 U
9	Vinylidene chloride (ug/kg)	2	0	0						10 U	10 U	10	10 U	10 U
9	Xylene (ug/kg)	2	0	0						10 U	10 U	10	10 U	10 U
10	Total organic carbon (%)	8	8	100	0.9	2.5	1.8	1.9	2.2	0.9	2.5	1.8	1.9	2.2
10	Clay (%)	7	7	100	4.9	14.56	8.8	6.5	11.5	4.9	14.56	8.8	6.5	11.5
10	Copper (mg/kg)	7	7	100	26	52.6	39	33	50	26	52.6	39	33	50
10	Fines (%)	7	7	100	17.4	78	56.4	56.4	70.3	17.4	78	56.4	56.4	70.3
10	Nickel (mg/kg)	7	7	100	12	31.6	21.5	20	27.7	12	31.6	21.5	20	27.7
10	Sand (%)	7	7	100	21.87	82.6	42.5	31.2	54.77	21.87	82.6	42.5	31.2	54.77
10	Silt (%)	7	7	100	12.5	63.8	47.5	50.9	63.44	12.5	63.8	47.5	50.9	63.44
10	Zinc (mg/kg)	7	7	100	88	1090	324	93	638	88	1090	324	93	638
10	Total volatile solids (%)	6	6	100	3.5	7.53	5.8	5.2	6.96	3.5	7.53	5.8	5.2	6.96
10	Gravel (%)	5	5	100	0.05	5.5	1.6	0.13	2	0.05	5.5	1.6	0.13	2
10	Mean grain size (mm)	5	5	100	0.05	0.19	0.10	0.05	0.1	0.05	0.19	0.10	0.05	0.1
10	Median grain size (mm)	5	5	100	0.03	0.15	0.06	0.03	0.04	0.03	0.15	0.06	0.03	0.04
10	Chromium (mg/kg)	4	4	100	12	40.7	28.2	26	34	12	40.7	28.2	26	34
10	1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin (ng/kg	3	3	100	91	200	140	91	130	91	200	140.3	91	130
10	1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin (ng/kg)	3	3	100	0.86	2	1.26	0.86	0.92	0.86	2	1.26	0.86	0.92
10	1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin (ng/kg)	3	3	100	2.9	11	6.9	2.9	6.8	2.9	11	6.9	2.9	6.8
10	1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin (ng/kg)	3	3	100	1.8	7.1	3.7	1.8	2.2	1.8	7.1	3.7	1.8	2.2
10	2,3,7,8-Tetrachlorodibenzofuran (ng/kg)	3	3	100	0.73	3.5	2.2	0.73	2.3	0.73	3.5	2.2	0.73	2.3
10	Heptachlorodibenzofuran (ng/kg)	3	3	100	10	77	34	10	15	10	77	34	10	15
10	Heptachlorodibenzo-p-dioxin (ng/kg)	3	3	100	180	410	287	180	270	180	410	287	180	270
10	Hexachlorodibenzofuran (ng/kg)	3	3	100	25	52	35	25	29	25	52	35	25	29
10	Hexachlorodibenzo-p-dioxin (ng/kg)	3	3	100	27	89	52	27	40	27	89	52	27	40
10	Octachlorodibenzofuran (ng/kg)	3	3	100	28	110	70	28	72	28	110	70	28	72
10	Octachlorodibenzo-p-dioxin (ng/kg)	3	3	100	670	1800	1323	670	1500	670	1800	1323	670	1500
10	Pentachlorodibenzofuran (ng/kg)	3	3	100	5.9	18	10.3	5.9	7	5.9	18	10.3	5.9	7
10	Tetrachlorodibenzofuran (ng/kg)	3	3	100	4.4	13	7.4	4.4	4.7	4.4	13	7.4	4.4	4.7
10	Tetrachlorodibenzo-p-dioxin (ng/kg)	3	3	100	1	4.5	2.7	1	2.7	1	4.5	2.7	1	2.7
10	Total solids (%)	3	3	100	52.5	62	57	52.5	57.9	52.5	62	57	52.5	57.9
10	3- and 4-Methylphenol Coelution (ug/kg)	3	3	100	20	190	87	20	52	20	190	87	20	52
10	Aluminum (mg/kg)	2	2	100	34100	45900	40000	34100	34100	34100	45900	40000	34100	34100
10	Barium (mg/kg)	2	2	100	171	199	185	171	171	171	199	185	171	171
10	Bromine (ug/kg)	2	2	100	6.1	15	10.6	6.1	6.1	6.1	15	10.6	6.1	6.1
10	Calcium (mg/kg)	2	2	100	7390	8700	8045	7390	7390	7390	8700	8045	7390	7390
10	Chlorine (ug/kg)	2	2	100	137	283	210	137	137	137	283	210	137	137

Table 4-6. Historical Subsurface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detects	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
10	Cobalt (mg/kg)	2	2	100	17.8	20.1	18.95	17.8	17.8	17.8	20.1	19.0	17.8	17.8
10	Iron (mg/kg)	2	2	100	38500	44600	41550	38500	38500	38500	44600	41550	38500	38500
10	Magnesium (mg/kg)	2	2	100	6390	7720	7055	6390	6390	6390	7720	7055	6390	6390
10	Manganese (mg/kg)	2	2	100	548	759	654	548	548	548	759	654	548	548
10	Potassium (mg/kg)	2	2	100	1100	1470	1285	1100	1100	1100	1470	1285	1100	1100
10	Sodium (mg/kg)	2	2	100	1000 J	1120 J	1060	1000 J	1000 J	1000 J	1120 J	1060	1000 J	1000 J
10	Titanium (mg/kg)	2	2	100	1820	1990	1905	1820	1820	1820	1990	1905	1820	1820
10	Tributyltin ion (ug/kg)	2	2	100	28	32	30	28	28	28	32	30	28	28
10	Vanadium (mg/kg)	2	2	100	93.1	108	101	93.1	93.1	93.1	108	101	93.1	93.1
10	Arsenic (mg/kg)	7	5	71	1	4.1 J	3	3	3.8	1	5 U	3	3.1 J	4.1 J
10	Benz(a)anthracene (ug/kg)	7	5	71	3.7	38	18	9.2	30	3.7	6000 U	913	9.7	300 U
10	Fluoranthene (ug/kg)	7	5	71	6.7	130	50	21	69	6.7	6000 U	935	21	300 U
10	High Molecular Weight PAH (ug/kg)	7	5	71	26.6 A	570 A	226	83.5 A	366 A	26.6 A	6000 UA	1062	85.6 A	570 A
10	Lead (mg/kg)	7	5	71	15	75	31	20	25	15	93 U	40	22	75
10	Low Molecular Weight PAH (ug/kg)	7	5	71	3.7 A	172 A	66	24.2 A	83 A	3.7 A	6000 UA	947	45.8 A	300 UA
10	Phenanthrene (ug/kg)	7	5	71	3.7	99	39	15	59	3.7	6000 U	928	17	300 U
10	Polycyclic Aromatic Hydrocarbons (ug/kg)	7	5	71	30.3 A	742 A	292	107.7 A	449 A	30.3 A	6000 UA	1109	131.4 A	742 A
10	Pyrene (ug/kg)	7	5	71	8.1	150	59	24	88	8.1	6000 U	942	25	300 U
10	Bis(2-ethylhexyl) phthalate (ug/kg)	7	5	71	22 B	400	144	40 B	210	22 B	6000 U	983	50 B	400
10	Aroclor 1260 (ug/kg)	6	4	67	25	400	139	31	100	16 U	400	99	25	100
10	Polychlorinated biphenyls (ug/kg)	6	4	67	48 A	400 A	162	100 A	101 A	32 UA	400 A	121	48 A	101 A
10	1,2,3,4,6,7,8-Heptachlorodibenzofuran (ng/kg)	3	2	67	10	14	12	10	10	1.8 U	14	8.6	1.8 U	10
10	1,2,3,4,7,8,9-Heptachlorodibenzofuran (ng/kg)	3	2	67	1.4	77	39	1.4	1.4	1.4	77	27	1.4	2.5 U
10	1,2,3,4,7,8-Hexachlorodibenzofuran (ng/kg)	3	2	67	0.81	0.9	0.86	0.81	0.81	0.81	3.8 U	1.8	0.81	0.9
10	1,2,3,7,8,9-Hexachlorodibenzofuran (ng/kg)	3	2	67	0.37	1.5	0.94	0.37	0.37	0.37	1.5	1.0	0.37	1 U
10	Pentachlorodibenzo-p-dioxin (ng/kg)	3	2	67	0.46	1.3	0.88	0.46	0.46	0.46	1.3 U	1.02	0.46	1.3
10	Benzo(b)fluoranthene (ug/kg)	7	4	57	8.1	58	28	9.2	35	2.9 U	6000 U	916	9.2	300 U
10	Benzo(b+k)fluoranthene (ug/kg)	7	4	57	8.1 A	94 A	46	13.5 A	69 A	2.9 UA	6000 UA	927	13.5 A	300 UA
10	Benzo(g,h,i)perylene (ug/kg)	7	4	57	7.3	32	20	13	26	3.4 U	6000 U	912	13	300 U
10	Chrysene (ug/kg)	7	4	57	7.5	64	33	11	50	3.4 U	6000 U	919	11	300 U
10	Mercury (mg/kg)	7	4	57	0.06	0.14 J	0.11	0.11	0.12	0.06	0.2 U	0.14	0.12	0.2 U
10	Beryllium (mg/kg)	4	2	50	0.49	0.65	0.57	0.49	0.49	0.49	1 U	0.785	0.65	1 U
10	Selenium (mg/kg)	4	2	50	7	10	8.5	7	7	1 U	10	4.75	1 U	7
10	4-Methylphenol (ug/kg)	4	2	50	46	92	69	46	46	46	6000 U	1610	92	300 U
10	Butyltin ion (ug/l)	2	1	50	0.04	0.04	0.04	0.04	0.04	0.03 U	0.04	0.035	0.03 U	0.03 U
10	Dibutyltin ion (ug/l)	2	1	50	0.19	0.19	0.19	0.19	0.19	0.03 U	0.19	0.11	0.03 U	0.03 U
10	Tetrabutyltin (ug/l)	2	1	50	0.05	0.05	0.05	0.05	0.05	0.03 U	0.05	0.04	0.03 U	0.03 U
10	Tributyltin ion (ug/l)	2	1	50	0.02	0.02	0.02	0.02	0.02	0.02	0.03 U	0.025	0.02	0.02
10	Tetrachloroethene (ug/kg)	2	1	50	19	19	19	19	19	10 U	19	14.5	10 U	10 U
10	Toluene (ug/kg)	2	1	50	66	66	66	66	66	10 U	66	38	10 U	10 U
10	Anthracene (ug/kg)	7	3	43	3.5	24	10.6	3.5	4.3	3.4 U	6000 U	908	4.3	300 U
10	Benzo(k)fluoranthene (ug/kg)	7	3	43	4.3	36	25	4.3	34	2.9 U	6000 U	912	4.3	300 U
10	Cadmium (mg/kg)	7	3	43	0.17 J	0.5	0.36	0.17 J	0.4	0.17 J	2.1 U	0.97	0.5	1.6 U
10	Naphthalene (ug/kg)	7	3	43	2.7	30	15.9	2.7	15	2.7	6000 U	910	15	300 U
10	Silver (mg/kg)	7	3	43	0.37 J	1	0.76	0.37 J	0.9	0.37 J	2 U	1.16	0.9	2 U
10	Butylbenzyl phthalate (ug/kg)	7	3	43	3 J	54	35	3 J	47	3 J	6000 U	920	19 U	300 U

Table 4-6. Historical Subsurface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detects	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
10	Aroclor 1254 (ug/kg)	6	2	33	23	70	46.5	23	23	16 U	100 U	55	23	100 U
10	1,2,3,6,7,8-Hexachlorodibenzofuran (ng/kg)	3	1	33	1.4	1.4	1.4	1.4	1.4	1.4	3.8 U	2.4	1.4	2 U
10	1,2,3,7,8-Pentachlorodibenzo-p-dioxin (ng/kg)	3	1	33	1.3	1.3	1.3	1.3	1.3	0.78 U	1.3	1.13	0.78 U	1.3 U
10	2,3,4,7,8-Pentachlorodibenzofuran (ng/kg)	3	1	33	0.77	0.77	0.77	0.77	0.77	0.39 U	0.77	0.63	0.39 U	0.72 U
10	2,3,7,8-Tetrachlorodibenzo-p-dioxin (ng/kg)	3	1	33	0.62	0.62	0.62	0.62	0.62	0.62	0.78 U	0.71	0.62	0.72 U
10	Acenaphthylene (ug/kg)	7	2	29	3	9.5	6.25	3	3	3	6000 U	907.7	9.5	300 U
10	Benzo(a)pyrene (ug/kg)	7	2	29	34	38	36	34	34	2.7 U	6000 U	912	3.4 U	300 U
10	Benzoic acid (ug/kg)	7	2	29	380	480	430	380	380	13 U	45000 U	6843	17 U	2000 U
10	Indeno(1,2,3-cd)pyrene (ug/kg)	7	2	29	6.9	24 J	15.45	6.9	6.9	2.7 U	6000 U	908	6.9	300 U
10	Total of 3 isomers: pp-DDT,-DDD,-DDE (ug/kg)	7	2	29	4.4 A	5.4 A	4.9	4.4 A	4.4 A	3.2 UA	10 UA	6	4.4 A	10 UA
10	1,4-Dichlorobenzene (ug/kg)	7	2	29	6	23	14.5	6	6	6	23	16	14 U	19 U
10	Dibutyl phthalate (ug/kg)	7	2	29	5.1 JB	5.4 JB	5.25	5.1 JB	5.1 JB	5.1 JB	6000 U	909	14 U	300 U
10	Pentachlorophenol (ug/kg)	7	2	29	3.2 J	67	35.1	3.2 J	3.2 J	3.2 J	45000 U	6754	67	2000 U
10	Thallium (mg/kg)	4	1	25	5	5	5	5	5	1 U	5	3	1 U	5 U
10	4,4'-DDD (ug/kg)	7	1	14	2.1 J	2.1 J	2.1	2.1 J	2.1 J	1.9 U	10 U	5	3.2 U	10 U
10	4,4'-DDE (ug/kg)	7	1	14	3.3	3.3	3.3	3.3	3.3	1.9 U	10 U	5	3.2 U	10 U
10	4,4'-DDT (ug/kg)	7	1	14	4.4	4.4	4.4	4.4	4.4	3.2 U	10 U	6.0	4.3 U	10 U
10	Acenaphthene (ug/kg)	7	1	14	21	21	21	21	21	2.7 U	6000 U	907	3.4 U	300 U
10	Antimony (mg/kg)	7	1	14	0.79 JB	0.79 JB	0.79	0.79 JB	0.79 JB	0.79 JB	170 U	46	5 UJ	120 U
10	Benzyl alcohol (ug/kg)	7	1	14	8.8 J	8.8 J	8.8	8.8 J	8.8 J	8.8 J	6000 U	911	14 U	300 U
10	Fluorene (ug/kg)	7	1	14	22	22	22	22	22	2.7 U	6000 U	907	3.4 U	300 U
10	delta-Hexachlorocyclohexane (ug/kg)	7	1	14	0.14 J	0.14 J	0.14	0.14 J	0.14 J	0.14 J	10 U	4	0.97 UJ	10 U
10	Di-n-octyl phthalate (ug/kg)	7	1	14	13 J	13 J	13	13 J	13 J	13 U	6000 U	911	14 U	300 U
10	Endrin (ug/kg)	7	1	14	0.64 J	0.64 J	0.64	0.64 J	0.64 J	0.64 J	10 U	5	1.9 U	10 U
10	Phenol (ug/kg)	7	1	14	4.9 J	4.9 J	4.9	4.9 J	4.9 J	4.9 J	6000 U	910	17 U	300 U
10	2-Methylnaphthalene (ug/kg)	7	0	0						2.7 U	6000 U	907	3.4 U	300 U
10	Dibenz(a,h)anthracene (ug/kg)	7	0	0						2.7 U	6000 U	907	3.4 U	300 U
10	Dibenzofuran (ug/kg)	7	0	0						13 U	6000 U	912	17 U	300 U
10	Hexachlorobutadiene (ug/kg)	7	0	0						13 U	6000 U	912	17 U	300 U
10	Hexachloroethane (ug/kg)	7	0	0						13 U	6000 U	912	17 U	300 U
10	N-Nitrosodiphenylamine (ug/kg)	7	0	0						13 U	6000 U	912	17 U	300 U
10	1,2,4-Trichlorobenzene (ug/kg)	7	0	0						13 U	6000 U	912	17 U	300 U
10	1,2-Dichlorobenzene (ug/kg)	7	0	0						10 U	19 U	15	13 U	19 U
10	1,3-Dichlorobenzene (ug/kg)	7	0	0						10 U	19 U	15	13 U	19 U
10	2,4-Dimethylphenol (ug/kg)	7	0	0						13 U	6000 U	912	17 U	300 U
10	2-Methylphenol (ug/kg)	7	0	0						13 U	6000 U	912	17 U	300 U
10	Aldrin (ug/kg)	7	0	0						0.96 U	10 U	3.89	1.6 U	10 U
10	alpha-Endosulfan (ug/kg)	7	0	0						0.96 U	10 U	3.89	1.6 U	10 U
10	alpha-Hexachlorocyclohexane (ug/kg)	7	0	0						0.96 U	10 U	3.89	1.6 U	10 U
10	beta-Endosulfan (ug/kg)	7	0	0						1.9 U	10 U	4.9	3.2 U	10 U
10	beta-Hexachlorocyclohexane (ug/kg)	7	0	0						0.96 U	30 U	9.6	1.6 U	30 U
10	Dieldrin (ug/kg)	7	0	0						1.9 U	10 U	4.9	3.2 U	10 U
10	Diethyl phthalate (ug/kg)	7	0	0						13 U	6000 U	912	17 U	300 U
10	Dimethyl phthalate (ug/kg)	7	0	0						13 U	6000 U	912	17 U	300 U
10	Endosulfan sulfate (ug/kg)	7	0	0						1.9 UJ	10 U	4.9	3.2 U	10 U
10	Endrin aldehyde (ug/kg)	7	0	0						1.9 U	10 U	4.9	3.2 U	10 U

Table 4-6. Historical Subsurface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detects	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
10	gamma-Hexachlorocyclohexane (ug/kg)	7	0	0						0.96 U	10 U	3.89	1.6 U	10 U
10	Heptachlor (ug/kg)	7	0	0						0.96 U	10 U	3.89	1.6 U	10 U
10	Heptachlor epoxide (ug/kg)	7	0	0						0.96 U	10 U	3.89	1.6 U	10 U
10	Hexachlorobenzene (ug/kg)	7	0	0						13 U	6000 U	912	17 U	300 U
10	Methoxychlor (ug/kg)	7	0	0						9.6 U	21 U	16	16 U	20 U
10	Toxaphene (ug/kg)	7	0	0						96 U	300 U	189	160 U	300 U
10	2,4-Dinitrotoluene (ug/kg)	6	0	0						14 U	6000 U	1087	96 U	300 U
10	2,6-Dinitrotoluene (ug/kg)	6	0	0						14 U	6000 U	1087	96 U	300 U
10	2-Chloronaphthalene (ug/kg)	6	0	0						2.9 U	6000 U	1057	19 U	300 U
10	2-Nitroaniline (ug/kg)	6	0	0						14 U	45000 U	7871	96 U	2000 U
10	3,3'-Dichlorobenzidine (ug/kg)	6	0	0						14 U	45000 U	7871	96 U	2000 U
10	3-Nitroaniline (ug/kg)	6	0	0						14 U	45000 U	7879	120 U	2000 U
10	4-Bromophenyl phenyl ether (ug/kg)	6	0	0						14 U	6000 U	1062	19 U	300 U
10	4-Chloroaniline (ug/kg)	6	0	0						14 U	6000 U	1075	58 U	300 U
10	4-Chlorophenyl phenyl ether (ug/kg)	6	0	0						14 U	6000 U	1062	19 U	300 U
10	4-Nitroaniline (ug/kg)	6	0	0						14 U	45000 U	7871	96 UJ	2000 U
10	Aroclor 1016 (ug/kg)	6	0	0						16 U	100 U	46	19 U	100 U
10	Aroclor 1221 (ug/kg)	6	0	0						32 U	100 U	59	39 U	100 U
10	Aroclor 1232 (ug/kg)	6	0	0						16 U	100 U	46	19 U	100 U
10	Aroclor 1242 (ug/kg)	6	0	0						16 U	100 U	46	19 U	100 U
10	Aroclor 1248 (ug/kg)	6	0	0						16 U	100 U	46	19 U	100 U
10	Bis(2-chloro-1-methylethyl) ether (ug/kg)	6	0	0						14 U	6000 U	1062	19 U	300 U
10	Bis(2-chloroethoxy) methane (ug/kg)	6	0	0						14 U	6000 U	1062	19 U	300 U
10	Bis(2-chloroethyl) ether (ug/kg)	6	0	0						14 U	6000 U	1068	39 U	300 U
10	Hexachlorocyclopentadiene (ug/kg)	6	0	0						14 U	6000 U	1087	96 UJ	300 U
10	Isophorone (ug/kg)	6	0	0						14 U	6000 U	1062	19 U	300 U
10	Nitrobenzene (ug/kg)	6	0	0						14 U	6000 U	1062	19 U	300 U
10	N-Nitrosodipropylamine (ug/kg)	6	0	0						14 U	6000 U	1068	39 U	300 U
10	2,4,5-Trichlorophenol (ug/kg)	6	0	0						14 U	6000 U	1087	96 U	300 U
10	2,4,6-Trichlorophenol (ug/kg)	6	0	0						14 U	6000 U	1087	96 U	300 U
10	2,4-Dichlorophenol (ug/kg)	6	0	0						14 U	6000 U	1075	58 U	300 U
10	2,4-Dinitrophenol (ug/kg)	6	0	0						14 U	45000 U	7902	190 UJ	2000 U
10	2-Chlorophenol (ug/kg)	6	0	0						14 U	6000 U	1062	19 U	300 U
10	2-Nitrophenol (ug/kg)	6	0	0						14 U	6000 U	1087	96 U	300 U
10	4,6-Dinitro-2-methylphenol (ug/kg)	6	0	0						14 U	45000 U	7902	190 UJ	2000 U
10	4-Chloro-3-methylphenol (ug/kg)	6	0	0						14 U	6000 U	1068	39 U	300 U
10	4-Nitrophenol (ug/kg)	6	0	0						14 U	45000 U	7871	96 U	2000 U
10	Chlordane (cis & trans) (ug/kg)	5	0	0						16 U	100 U	50.6	16 U	100 U
10	Endrin ketone (ug/kg)	5	0	0						2.2 UIJ	4.9 UIJ	3.56	3.2 U	4.3 U
10	1,2,3,7,8-Pentachlorodibenzofuran (ng/kg)	3	0	0						0.29 U	0.99 U	0.75	0.29 U	0.98 U
10	2,3,4,6,7,8-Hexachlorodibenzofuran (ng/kg)	3	0	0						0.26 U	0.37 U	0.31	0.26 U	0.31 U
10	Aniline (ug/kg)	2	0	0						1000 U	20000 U	10500	1000 U	1000 U
10	Butyltin ion (ug/kg)	2	0	0						5.8 U	5.8 U	5.8	5.8 U	5.8 U
10	Dibutyltin ion (ug/kg)	2	0	0						5.8 U	5.8 U	5.8	5.8 U	5.8 U
10	N-Nitrosodimethylamine (ug/kg)	2	0	0						2000 U	45000 U	23500	2000 U	2000 U
10	Tetrabutyltin (ug/kg)	2	0	0						5.8 U	5.8 U	5.8	5.8 U	5.8 U

Table 4-6. Historical Subsurface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detects	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
10	1,1,1-Trichloroethane (ug/kg)	2	0	0						10 U	10 U	10	10 U	10 U
10	1,1,2,2-Tetrachloroethane (ug/kg)	2	0	0						10 U	10 U	10	10 U	10 U
10	1,1,2-Trichloroethane (ug/kg)	2	0	0						10 U	10 U	10	10 U	10 U
10	1,1-Dichloroethane (ug/kg)	2	0	0						10 U	10 U	10	10 U	10 U
10	1,2-Dichloroethane (ug/kg)	2	0	0						10 U	10 U	10	10 U	10 U
10	1,2-Dichloropropane (ug/kg)	2	0	0						10 U	10 U	10	10 U	10 U
10	2,4,5-T (ug/kg)	2	0	0						16 U	21 U	19	16 U	16 U
10	2,4-D (ug/kg)	2	0	0						16 U	21 U	19	16 U	16 U
10	2,4-DB (ug/kg)	2	0	0						16 U	21 U	19	16 U	16 U
10	2-Chloroethyl vinyl ether (ug/kg)	2	0	0						20 U	20 U	20	20 U	20 U
10	Acetone (ug/kg)	2	0	0						200 U	200 U	200	200 U	200 U
10	alpha-Chlordane (ug/kg)	2	0	0						0.96 UJ	0.97 UJ	0.97	0.96 UJ	0.96 UJ
10	Benzene (ug/kg)	2	0	0						10 U	10 U	10	10 U	10 U
10	Bromodichloromethane (ug/kg)	2	0	0						10 U	10 U	10	10 U	10 U
10	Bromoform (ug/kg)	2	0	0						10 U	10 U	10	10 U	10 U
10	Bromomethane (ug/kg)	2	0	0						20 U	20 U	20	20 U	20 U
10	Carbazole (ug/kg)	2	0	0						19 U	19 U	19	19 U	19 U
10	Carbon disulfide (ug/kg)	2	0	0						200 U	200 U	200	200 U	200 U
10	Carbon tetrachloride (ug/kg)	2	0	0						10 U	10 U	10	10 U	10 U
10	Chlorobenzene (ug/kg)	2	0	0						10 U	10 U	10	10 U	10 U
10	Chlorodibromomethane (ug/kg)	2	0	0						10 U	10 U	10	10 U	10 U
10	Chloroethane (ug/kg)	2	0	0						20 U	20 U	20	20 U	20 U
10	Chloroform (ug/kg)	2	0	0						10 U	10 U	10	10 U	10 U
10	Chloromethane (ug/kg)	2	0	0						20 U	20 U	20	20 U	20 U
10	cis-1,2-Dichloroethene (ug/kg)	2	0	0						10 U	10 U	10	10 U	10 U
10	cis-1,3-Dichloropropene (ug/kg)	2	0	0						10 U	10 U	10	10 U	10 U
10	Dalapon (ug/kg)	2	0	0						81 U	110 U	96	81 U	81 U
10	Dicamba (ug/kg)	2	0	0						32 U	42 U	37	32 U	32 U
10	Dichloroprop (ug/kg)	2	0	0						16 U	21 U	19	16 U	16 U
10	Dinoseb (ug/kg)	2	0	0						16 U	21 U	19	16 U	16 U
10	Ethylbenzene (ug/kg)	2	0	0						10 U	10 U	10	10 U	10 U
10	gamma-Chlordane (ug/kg)	2	0	0						0.96 U	0.97 U	0.97	0.96 U	0.96 U
10	MCPA (ug/kg)	2	0	0						16 U	21 U	19	16 U	16 U
10	MCPP (ug/kg)	2	0	0						16 U	21 U	19	16 U	16 U
10	Methyl isobutyl ketone (ug/kg)	2	0	0						100 U	100 U	100	100 U	100 U
10	Methyl N-butyl ketone (ug/kg)	2	0	0						100 U	100 U	100	100 U	100 U
10	Methylene chloride (ug/kg)	2	0	0						10 U	10 U	10	10 U	10 U
10	Methylethyl ketone (ug/kg)	2	0	0						200 U	200 U	200	200 U	200 U
10	Silvex (ug/kg)	2	0	0						16 U	21 U	19	16 U	16 U
10	Styrene (ug/kg)	2	0	0						10 U	10 U	10	10 U	10 U
10	trans-1,2-Dichloroethene (ug/kg)	2	0	0						10 U	10 U	10	10 U	10 U
10	trans-1,3-Dichloropropene (ug/kg)	2	0	0						10 U	10 U	10	10 U	10 U
10	Trichloroethene (ug/kg)	2	0	0						10 U	10 U	10	10 U	10 U
10	Trichlorofluoromethane (ug/kg)	2	0	0						20 U	20 U	20	20 U	20 U
10	Trichlorotrifluoroethane (ug/kg)	2	0	0						20 U	20 U	20	20 U	20 U
10	Vinyl acetate (ug/kg)	2	0	0						100 U	100 U	100	100 U	100 U

Table 4-6. Historical Subsurface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detects	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
10	Vinyl chloride (ug/kg)	2	0	0						20 U	20 U	20	20 U	20 U
10	Vinylidene chloride (ug/kg)	2	0	0						10 U	10 U	10	10 U	10 U
10	Xylene (ug/kg)	2	0	0						10 U	10 U	10	10 U	10 U
11	Clay (%)	7	7	100	4.1	11.4	6.8	5.5	7.8	4.1	11.4	6.8	5.5	7.8
11	Fines (%)	7	7	100	35.9	90.6	67.5	59.3	85.9	35.9	90.6	67.5	59.3	85.9
11	Mean grain size (mm)	7	7	100	0.03	0.21	0.08	0.05	0.1	0.03	0.21	0.08	0.05	0.1
11	Median grain size (mm)	7	7	100	0.02	0.15	0.06	0.04	0.06	0.02	0.15	0.06	0.04	0.06
11	Silt (%)	7	7	100	31.8	80.4	60.6	52.7	79.2	31.8	80.4	60.6	52.7	79.2
11	Total volatile solids (%)	7	7	100	3.1	8.6	5.3	4.7	6.9	3.1	8.6	5.3	4.7	6.9
11	Aroclor 1260 (ug/kg)	6	6	100	9	43	24	15	42	9	43	24	15	42
11	Benzo(a)pyrene (ug/kg)	6	6	100	0.5 G	170 G	53.75	29	56	0.5 G	170 G	53.75	29	56
11	Benzo(b)fluoranthene (ug/kg)	6	6	100	22 G	88 G	46	37 G	63 J	22 G	88 G	46	37 G	63 J
11	Benzo(b+k)fluoranthene (ug/kg)	6	6	100	40 A	196 A	82	51 A	85 A	40 A	196 A	82	51 A	85 A
11	Benzo(g,h,i)perylene (ug/kg)	6	6	100	0.7 G	87 G	35	21 G	53	0.7 G	87 G	35	21 G	53
11	Benzo(k)fluoranthene (ug/kg)	6	6	100	10 J	108 G	36	21 G	35 G	10 J	108 G	36	21 G	35 G
11	Cadmium (mg/kg)	6	6	100	0.19	0.38	0.27	0.23	0.33	0.19	0.38	0.27	0.23	0.33
11	Chromium (mg/kg)	6	6	100	19.7	34.5	27.1	28.7	30.4	19.7	34.5	27.1	28.7	30.4
11	Copper (mg/kg)	6	6	100	31.5	35.9	33.65	33	35.9	31.5	35.9	33.65	33	35.9
11	Dibenzofuran (ug/kg)	6	6	100	3 J	8 G	6	5 G	8 G	3 J	8 G	6	5 G	8 G
11	Fluoranthene (ug/kg)	6	6	100	0.7 G	217 G	108	110 G	130 J	0.7 G	217 G	108	110 G	130 J
11	High Molecular Weight PAH (ug/kg)	6	6	100	2.8 A	1314 A	538	427 A	660 A	2.8 A	1314 A	538	427 A	660 A
11	Lead (mg/kg)	6	6	100	17.7	38.7	26.5	25.7	28.5	17.7	38.7	26.5	25.7	28.5
11	Mercury (mg/kg)	6	6	100	0.07	0.19 E	0.12	0.09	0.18 E	0.07	0.19 E	0.12	0.09	0.18 E
11	Nickel (mg/kg)	6	6	100	18.5	22.8	20.7	19.8	22.6	18.5	22.8	21	19.8	22.6
11	Polychlorinated biphenyls (ug/kg)	6	6	100	9 A	86 A	34	15 A	43 A	9 A	86 A	34	15 A	43 A
11	Polycyclic Aromatic Hydrocarbons (ug/kg)	6	6	100	2.8 A	1659 A	691	535 A	753 A	2.8 A	1659 A	691	535 A	753 A
11	Pyrene (ug/kg)	6	6	100	0.9 G	237 G	112.2	100 J	150 J	0.9 G	237 G	112.15	100 J	150 J
11	Silver (mg/kg)	6	6	100	0.22	0.41	0.3	0.29	0.38	0.22	0.41	0.3	0.29	0.38
11	Total organic carbon (%)	6	6	100	1.64	2.42	2.0	1.83	2.33	1.64	2.42	2.0	1.83	2.33
11	Zinc (mg/kg)	6	6	100	78	181	123	108	161	78	181	123	108	161
11	4,4'-DDD (ug/kg)	4	4	100	0.7	4	1.9	1	2	0.7	4	1.9	1	2
11	4,4'-DDE (ug/kg)	4	4	100	1	4	2.3	2	2	1	4	2.3	2	2
11	Acid Volatile Sulfides (mg/kg)	4	4	100	13 G	46 G	28	17	37	13 G	46 G	28	17	37
11	Total of 3 isomers: pp-DDT,-DDD,-DDE (ug/kg)	4	4	100	3.3 A	8 A	5.3	4 A	5.7 A	3.3 A	8 A	5.25	4 A	5.7 A
11	Total solids (%)	4	4	100	55.8	61.9	59	59.7	60.5	55.8	61.9	59	59.7	60.5
11	Sand (%)	3	3	100	9.4	40.6	21	9.4	14.1	9.4	40.6	21	9.4	14.1
11	Antimony (mg/kg)	2	2	100	0.23	0.25	0.24	0.23	0.23	0.23	0.25	0.24	0.23	0.23
11	Benzoic acid (ug/kg)	2	2	100	40 J	60 J	50	40 J	40 J	40 J	60 J	50	40 J	40 J
11	Beryllium (mg/kg)	2	2	100	0.38	0.44	0.41	0.38	0.38	0.38	0.44	0.41	0.38	0.38
11	Butyltin ion (ug/kg)	2	2	100	2	4	3	2	2	2	4	3	2	2
11	Dibutyltin ion (ug/kg)	2	2	100	2	4	3	2	2	2	4	3	2	2
11	Selenium (mg/kg)	2	2	100	2.1	4.5	3.3	2.1	2.1	2.1	4.5	3.3	2.1	2.1
11	Thallium (mg/kg)	2	2	100	0.08	0.1	0.09	0.08	0.08	0.08	0.1	0.09	0.08	0.08
11	Tributyltin ion (ug/kg)	2	2	100	4	13	8.5	4	4	4	13	8.5	4	4
11	Bis(2-ethylhexyl) phthalate (ug/kg)	2	2	100	100 J	200 J	150	100 J	100 J	100 J	200 J	150	100 J	100 J
11	Butylbenzyl phthalate (ug/kg)	2	2	100	8 J	9 J	8.5	8 J	8 J	8 J	9 J	8.5	8 J	8 J

Table 4-6. Historical Subsurface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detects	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
11	Carbazole (ug/kg)	2	2	100	5 J	7 J	6	5 J	5 J	5 J	7 J	6	5 J	5 J
11	Dibutyl phthalate (ug/kg)	2	2	100	5 J	7 J	6	5 J	5 J	5 J	7 J	6	5 J	5 J
11	Diesel fuels (mg/kg)	2	2	100	130	300	215	130	130	130	300	215	130	130
11	Diethyl phthalate (ug/kg)	2	2	100	5 J	5 J	5	5 J	5 J	5 J	5 J	5	5 J	5 J
11	Phenol (ug/kg)	2	2	100	7 J	8 J	7.5	7 J	7 J	7 J	8 J	7.5	7 J	7 J
11	Residual Range Organics (mg/kg)	2	2	100	430	730	580	430	430	430	730	580	430	430
11	2-Methylnaphthalene (ug/kg)	6	5	83	2 J	42 G	20	7 J	25 G	2 J	42 G	17.5	7 J	25 G
11	Acenaphthylene (ug/kg)	6	5	83	6 G	66 G	19	7 J	10 J	5 UG	66 G	17	7 J	10 J
11	Anthracene (ug/kg)	6	5	83	5 J	42 G	19	15 G	19 G	5 UG	42 G	17	15 G	19 G
11	Arsenic (mg/kg)	6	5	83	0.5 E	4.4	2.8	2	3.6	0.5 U	4.4	2.4	2	3.6
11	Benz(a)anthracene (ug/kg)	6	5	83	28 G	157 G	65	37	52	5 UG	157 G	55	37	52
11	Chrysene (ug/kg)	6	5	83	42 G	137 G	70	45	74	5 UG	137 G	60	45	74
11	Dibenz(a,h)anthracene (ug/kg)	6	5	83	5 G	17 G	8	5 J	8 J	5 UG	17 G	8	5 J	8 J
11	Fluorene (ug/kg)	6	5	83	8 J	14 G	11	10 G	13 G	5 UG	14 G	10	10 G	13 G
11	Indeno(1,2,3-cd)pyrene (ug/kg)	6	5	83	18 G	96 G	43	20 J	52	5 UG	96 G	37	20 J	52
11	Low Molecular Weight PAH (ug/kg)	6	5	83	93 A	345 A	183	108 A	184 A	5 UA	345 A	153	108 A	184 A
11	Naphthalene (ug/kg)	6	5	83	6 J	55 G	25	10 J	32 G	5 UG	55 G	22	10 J	32 G
11	Phenanthrene (ug/kg)	6	5	83	58 J	124 G	80	63 J	82 G	5 UG	124 G	68	63 J	82 G
11	Acenaphthene (ug/kg)	6	4	67	9 J	21 G	12	9 G	10 G	5 UG	21 G	12	9 G	15 U
11	4,4'-DDT (ug/kg)	4	2	50	0.3	4	2.2	0.3	0.3	0.3	4	2.075	2 U	2 U
11	Dimethyl phthalate (ug/kg)	2	1	50	2 J	2 J	2	2 J	2 J	2 J	15 U	8.5	2 J	2 J
11	Aroclor 1254 (ug/kg)	6	2	33	14	44	29	14	14	10 U	44	16	10 U	14
11	Gravel (%)	3	1	33	0.1	0.1	0.1	0.1	0.1	0.1	0.1 U	0.1	0.1	0.1 U
11	alpha-Endosulfan (ug/kg)	4	1	25	0.5 J	0.5 J	0.5	0.5 J	0.5 J	0.5 J	2 UG	1.625	2 U	2 U
11	Dieldrin (ug/kg)	4	1	25	0.4	0.4	0.4	0.4	0.4	0.4	2 U	1.6	2 U	2 U
11	Aroclor 1016 (ug/kg)	6	0	0						10 U	12 U	10	10 U	10 UG
11	Aroclor 1221 (ug/kg)	6	0	0						10 U	37 U	16	10 U	20 U
11	Aroclor 1232 (ug/kg)	6	0	0						10 U	24 U	13	10 U	11 U
11	Aroclor 1242 (ug/kg)	6	0	0						10 U	12 U	10	10 U	10 U
11	Aroclor 1248 (ug/kg)	6	0	0						10 U	20 U	12	10 U	10 UG
11	Aldrin (ug/kg)	4	0	0						2 U	2 U	2	2 U	2 UG
11	alpha-Hexachlorocyclohexane (ug/kg)	4	0	0						2 U	2 U	2	2 U	2 UG
11	beta-Endosulfan (ug/kg)	4	0	0						2 U	2 U	2	2 U	2 UG
11	beta-Hexachlorocyclohexane (ug/kg)	4	0	0						2 U	2 U	2	2 U	2 UG
11	Chlordane (cis & trans) (ug/kg)	4	0	0						10 U	10 U	10	10 U	10 U
11	delta-Hexachlorocyclohexane (ug/kg)	4	0	0						2 U	2 UG	2	2 U	2 U
11	Endosulfan sulfate (ug/kg)	4	0	0						2 U	2 UG	2	2 U	2 U
11	Endrin (ug/kg)	4	0	0						2 U	2 UG	2	2 U	2 U
11	Endrin aldehyde (ug/kg)	4	0	0						2 U	2 UG	2	2 U	2 U
11	gamma-Hexachlorocyclohexane (ug/kg)	4	0	0						2 U	2 UG	2	2 U	2 U
11	Heptachlor (ug/kg)	4	0	0						2 U	2 UG	2	2 U	2 U
11	Heptachlor epoxide (ug/kg)	4	0	0						2 U	2 UG	2	2 U	2 U
11	Methoxychlor (ug/kg)	4	0	0						4 U	4 UG	4	4 U	4 U
11	Toxaphene (ug/kg)	4	0	0						30 U	50 UG	45	50 U	50 U
11	2,4-Dinitrotoluene (ug/kg)	2	0	0						75 U	75 U	75	75 U	75 U
11	2,6-Dinitrotoluene (ug/kg)	2	0	0						30 U	30 U	30	30 U	30 U

Table 4-6. Historical Subsurface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detects	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
11	2-Chloronaphthalene (ug/kg)	2	0	0						15 U	15 U	15	15 U	15 U
11	2-Nitroaniline (ug/kg)	2	0	0						30 U	30 U	30	30 U	30 U
11	3,3'-Dichlorobenzidine (ug/kg)	2	0	0						200 U	200 U	200	200 U	200 U
11	3-Nitroaniline (ug/kg)	2	0	0						300 U	300 U	300	300 U	300 U
11	4-Bromophenyl phenyl ether (ug/kg)	2	0	0						15 U	15 U	15	15 U	15 U
11	4-Chloroaniline (ug/kg)	2	0	0						75 U	75 U	75	75 U	75 U
11	4-Chlorophenyl phenyl ether (ug/kg)	2	0	0						15 U	15 U	15	15 U	15 U
11	4-Nitroaniline (ug/kg)	2	0	0						150 U	150 U	150	150 U	150 U
11	Benzyl alcohol (ug/kg)	2	0	0						75 U	75 U	75	75 U	75 U
11	Bis(2-chloroethoxy) methane (ug/kg)	2	0	0						30 U	30 U	30	30 U	30 U
11	Bis(2-chloroethyl) ether (ug/kg)	2	0	0						15 U	15 U	15	15 U	15 U
11	Bis(2-chloroisopropyl) ether (ug/kg)	2	0	0						15 U	15 U	15	15 U	15 U
11	Hexachlorobutadiene (ug/kg)	2	0	0						15 U	15 U	15	15 U	15 U
11	Hexachlorocyclopentadiene (ug/kg)	2	0	0						300 U	300 U	300	300 U	300 U
11	Hexachloroethane (ug/kg)	2	0	0						60 U	60 U	60	60 U	60 U
11	Isophorone (ug/kg)	2	0	0						15 U	15 U	15	15 U	15 U
11	Nitrobenzene (ug/kg)	2	0	0						15 U	15 U	15	15 U	15 U
11	N-Nitrosodiphenylamine (ug/kg)	2	0	0						15 U	15 U	15	15 U	15 U
11	N-Nitrosodipropylamine (ug/kg)	2	0	0						15 U	15 U	15	15 U	15 U
11	Tetrabutyltin (ug/kg)	2	0	0						3 U	3 U	3	3 U	3 U
11	1,2,4-Trichlorobenzene (ug/kg)	2	0	0						15 U	15 U	15	15 U	15 U
11	1,2-Dichlorobenzene (ug/kg)	2	0	0						15 U	15 U	15	15 U	15 U
11	1,3-Dichlorobenzene (ug/kg)	2	0	0						15 U	15 U	15	15 U	15 U
11	1,4-Dichlorobenzene (ug/kg)	2	0	0						15 U	15 U	15	15 U	15 U
11	2,4,5-Trichlorophenol (ug/kg)	2	0	0						75 U	75 U	75	75 U	75 U
11	2,4,6-Trichlorophenol (ug/kg)	2	0	0						75 U	75 U	75	75 U	75 U
11	2,4-Dichlorophenol (ug/kg)	2	0	0						150 U	150 U	150	150 U	150 U
11	2,4-Dimethylphenol (ug/kg)	2	0	0						300 U	300 U	300	300 U	300 U
11	2,4-Dinitrophenol (ug/kg)	2	0	0						450 U	450 U	450	450 U	450 U
11	2-Chlorophenol (ug/kg)	2	0	0						75 U	75 U	75	75 U	75 U
11	2-Methylphenol (ug/kg)	2	0	0						300 U	300 U	300	300 U	300 U
11	2-Nitrophenol (ug/kg)	2	0	0						75 U	75 U	75	75 U	75 U
11	3- and 4-Methylphenol Coelution (ug/kg)	2	0	0						300 U	300 U	300	300 U	300 U
11	4,6-Dinitro-2-methylphenol (ug/kg)	2	0	0						300 U	300 U	300	300 U	300 U
11	4-Chloro-3-methylphenol (ug/kg)	2	0	0						75 U	75 U	75	75 U	75 U
11	4-Nitrophenol (ug/kg)	2	0	0						150 U	150 U	150	150 U	150 U
11	Di-n-octyl phthalate (ug/kg)	2	0	0						300 U	300 U	300	300 U	300 U
11	Gasoline (mg/kg)	2	0	0						67 U	69 U	68	67 U	67 U
11	Hexachlorobenzene (ug/kg)	2	0	0						15 U	15 U	15	15 U	15 U
11	Pentachlorophenol (ug/kg)	2	0	0						450 U	450 U	450	450 U	450 U
12	Fines (%)	23	23	100	0.1	71.2	22.2	0.7	52.28	0.1	71.2	22.2	0.7	52.28
12	Mean grain size (mm)	23	23	100	0.04	4.45	0.77	0.35	1.71	0.04	4.45	0.77	0.35	1.71
12	Median grain size (mm)	23	23	100	0.02	1.12	0.36	0.25	0.63	0.02	1.12	0.36	0.25	0.63
12	Silt (%)	23	23	100	0.1	59.1	19.4	0.7	46.9	0.1	59.1	19.4	0.7	46.9
12	Total volatile solids (%)	23	23	100	0.8	8.99	3.5	1.4	7.41	0.8	8.99	3.52	1.4	7.41
12	Benz(a)anthracene (ug/kg)	20	20	100	0.7 G	6400	349	25	135 G	0.7 G	6400	349	25	135 G

Table 4-6. Historical Subsurface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detects	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
12	Cadmium (mg/kg)	20	20	100	0.04	2.12	0.283	0.19	0.36 J	0.04	2.12	0.28	0.19	0.36 J
12	Chrysene (ug/kg)	20	20	100	0.7 G	8100	439	34	149 G	0.7 G	8100	439	34	149 G
12	Fluoranthene (ug/kg)	20	20	100	2 G	16000	885	87	310 G	2 G	16000	885	87	310 G
12	High Molecular Weight PAH (ug/kg)	20	20	100	6 A	74460 A	4112	291 A	1647 A	6 A	74460 A	4112	291 A	1647 A
12	Lead (mg/kg)	20	20	100	2.2	489	63	26	367	2.2	489	63	26	367
12	Low Molecular Weight PAH (ug/kg)	20	20	100	1.4 A	9654 A	620	97.4 A	671 A	1.4 A	9654 A	620	97.4 A	671 A
12	Mercury (mg/kg)	20	20	100	0.01 E	0.87 E	0.15	0.08 E	0.35	0.01 E	0.87 E	0.15	0.08 E	0.35
12	Nickel (mg/kg)	20	20	100	10.4	31	18	17.1	28	10.4	31	18	17.1	28
12	Phenanthrene (ug/kg)	20	20	100	0.9 G	6800	400	45 G	226 G	0.9 G	6800	400	45 G	226 G
12	Polycyclic Aromatic Hydrocarbons (ug/kg)	20	20	100	7.4 A	84114 A	4732	381.6 A	2318 A	7.4 A	84114 A	4732	381.6 A	2318 A
12	Pyrene (ug/kg)	20	20	100	1 G	19000	1038	68	450 G	1 G	19000	1038	68	450 G
12	Silver (mg/kg)	20	20	100	0.03	1.1	0.28	0.18 G	0.59 J	0.03	1.1	0.28	0.18 G	0.59 J
12	Total organic carbon (%)	20	20	100	0.07	3.1	1.41	1.4	2.74	0.07	3.1	1.41	1.4	2.74
12	Zinc (mg/kg)	20	20	100	29.4	230	104.98	102	190	29.4	230	105	102	190
12	Total solids (%)	17	17	100	53.2	92.8	72	66.6	89.7	53.2	92.8	72	66.6	89.7
12	Chromium (mg/kg)	16	16	100	13.9	47.8 G	24	19.6	35.4	13.9	47.8 G	24	19.6	35.4
12	Sand (%)	14	14	100	28.8	99.2	66	60.4	95	28.8	99.2	66	60.4	95
12	Gravel (%)	9	9	100	0.1	45.4	8.3	0.6	11	0.1	45.4	8.3	0.6	11
12	Bis(2-ethylhexyl) phthalate (ug/kg)	7	7	100	20 J	220	139	98 B	210 B	20 J	220	139	98 B	210 B
12	Total sulfides (mg/kg)	2	2	100	2 G	58 G	30	2 G	2 G	2 G	58 G	30	2 G	2 G
12	4-Methylphenol (ug/kg)	2	2	100	44	52	48	44	44	44	52	48	44	44
12	1,2,3,4,6,7,8-Heptachlorodibenzofuran (ng/kg)	1	1	100	19	19	19	19	19	19	19	19	19	19
12	1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin (ng/kg	1	1	100	160	160	160	160	160	160	160	160	160	160
12	1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin (ng/kg)	1	1	100	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
12	1,2,3,6,7,8-Hexachlorodibenzofuran (ng/kg)	1	1	100	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
12	1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin (ng/kg)	1	1	100	17	17	17	17	17	17	17	17	17	17
12	1,2,3,7,8,9-Hexachlorodibenzofuran (ng/kg)	1	1	100	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
12	1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin (ng/kg)	1	1	100	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8
12	2,3,4,7,8-Pentachlorodibenzofuran (ng/kg)	1	1	100	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59
12	2,3,7,8-Tetrachlorodibenzofuran (ng/kg)	1	1	100	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
12	4-Chloroaniline (ug/kg)	1	1	100	4 J	4 J	4	4 J	4 J	4 J	4 J	4	4 J	4 J
12	Beryllium (mg/kg)	1	1	100	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46
12	Bromine (ug/kg)	1	1	100	13	13	13	13	13	13	13	13	13	13
12	Chlorine (ug/kg)	1	1	100	286	286	286	286	286	286	286	286	286	286
12	Dibutyltin ion (ug/kg)	1	1	100	0.5 J	0.5 J	0.5	0.5 J	0.5 J	0.5 J	0.5 J	0.5	0.5 J	0.5 J
12	Heptachlorodibenzofuran (ng/kg)	1	1	100	64	64	64	64	64	64	64	64	64	64
12	Heptachlorodibenzo-p-dioxin (ng/kg)	1	1	100	310	310	310	310	310	310	310	310	310	310
12	Hexachlorodibenzofuran (ng/kg)	1	1	100	47	47	47	47	47	47	47	47	47	47
12	Hexachlorodibenzo-p-dioxin (ng/kg)	1	1	100	110	110	110	110	110	110	110	110	110	110
12	Octachlorodibenzofuran (ng/kg)	1	1	100	69	69	69	69	69	69	69	69	69	69
12	Octachlorodibenzo-p-dioxin (ng/kg)	1	1	100	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200
12	Pentachlorodibenzofuran (ng/kg)	1	1	100	20	20	20	20	20	20	20	20	20	20
12	Pentachlorodibenzo-p-dioxin (ng/kg)	1	1	100	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
12	Tetrachlorodibenzofuran (ng/kg)	1	1	100	15	15	15	15	15	15	15	15	15	15
12	Tetrachlorodibenzo-p-dioxin (ng/kg)	1	1	100	3	3	3	3	3	3	3	3	3	3
12	Thallium (mg/kg)	1	1	100	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09

Table 4-6. Historical Subsurface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detects	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
12	Carbazole (ug/kg)	1	1	100	0.6 J	0.6 J	0.6	0.6 J	0.6 J	0.6 J	0.6 J	0.6	0.6 J	0.6 J
12	Diesel fuels (mg/kg)	1	1	100	40 J	40 J	40	40 J	40 J	40 J	40 J	40	40 J	40 J
12	Residual Range Organics (mg/kg)	1	1	100	100 J	100 J	100	100 J	100 J	100 J	100 J	100	100 J	100 J
12	Benzo(a)pyrene (ug/kg)	20	19	95	0.6 G	7300	419	25	168 G	0.6 G	7300	399	25	168 G
12	Naphthalene (ug/kg)	20	19	95	0.4 G	212 G	37	11 G	190	0.4 G	212 G	36	20 U	190
12	2-Methylnaphthalene (ug/kg)	18	17	94	0.6 G	25	10	5.3	24 G	0.6 G	25	10	5.3	24 G
12	Benzo(g,h,i)perylene (ug/kg)	20	18	90	0.7 G	4400	284	21 G	270	0.7 G	4400	257	21 G	270
12	Copper (mg/kg)	20	18	90	11	70.1	28	30.4	42	11	70.1	27	26.6 UG	42
12	Acenaphthylene (ug/kg)	20	17	85	2 J	240	24	6 G	32 G	2 J	240	22	6 G	32 G
12	Benzo(b)fluoranthene (ug/kg)	20	17	85	2 J	2900	198	28	91 G	2 J	2900	169	25 G	91 G
12	Benzo(b+k)fluoranthene (ug/kg)	20	17	85	2 A	8000 A	519	50 A	183 A	2 A	8000 A	442	44 A	183 A
12	Fluorene (ug/kg)	20	17	85	0.9 J	190	23	6.5	50 G	0.9 J	190	21	6.5	50 G
12	Acid Volatile Sulfides (mg/kg)	13	11	85	0.6	42	16	2.9	42	0.6	42	13	2.9	42
12	Anthracene (ug/kg)	20	16	80	4.5	2200	156	13 G	56 G	4.5	2200	127	13 G	56 G
12	Benzo(k)fluoranthene (ug/kg)	20	16	80	9 G	5100	342	18 G	92 G	2.2 U	5100	275	16	92 G
12	Indeno(1,2,3-cd)pyrene (ug/kg)	20	16	80	1 J	4600	334	22 G	360	1 J	4600	268	16 G	360
12	3- and 4-Methylphenol Coelution (ug/kg)	5	4	80	44	360	174	130	160	44	360	199	130	300 U
12	Total of 3 isomers: pp-DDT,-DDD,-DDE (ug/kg)	19	14	74	0.3 A	23 A	5.4	2.9 A	15.4 A	0.3 A	23 A	5.4	2 UA	20 UA
12	Acenaphthene (ug/kg)	20	14	70	4 G	93 G	21	10 G	59 G	2.2 U	93 G	17	10 G	59 G
12	Dibenz(a,h)anthracene (ug/kg)	20	13	65	2 G	660	59	5 G	53	2 G	660	41	5 G	53
12	Dibenzofuran (ug/kg)	20	12	60	0.7 G	27	8.6	5 G	16	0.7 G	27	9	5 UG	20 U
12	4,4'-DDE (ug/kg)	19	11	58	0.5	5.4	2.7	2	5.4	0.5	20 U	3.4	2 U	5.4
12	Arsenic (mg/kg)	20	11	55	0.5	19.7	4.2	2.3	5	0.5 U	19.7	2.5	0.5 U	5
12	Aroclor 1260 (ug/kg)	20	10	50	6	7100	807	16	710	6	7100	410	13 U	710
12	Polychlorinated biphenyls (ug/kg)	20	10	50	10 A	7100 A	829	45 A	710 A	10 A	7100 A	424	26 UA	710 A
12	Clay (%)	23	11	48	2.2	12.1	5.8	4.36	10.9	0.1 U	12.1	2.8	0.1 U	7.5
12	4,4'-DDD (ug/kg)	19	9	47	0.3	19	3.1	0.8	3	0.3	20 U	3.6	2	19
12	Aroclor 1254 (ug/kg)	20	8	40	4	90	27	11	46	4	90	18	10 U	46
12	Tributyltin ion (ug/l)	3	1	33	0.05 G	0.05 G	0.05	0.05 G	0.05 G	0.04 U	0.05 G	0.04	0.04 U	0.04 U
12	4,4'-DDT (ug/kg)	19	6	32	0.2	10	2.9	1	3.4	0.2	20 U	3.3	2	10
12	Antimony (mg/kg)	7	2	29	0.14	1.1 J	0.62	0.14	0.14	0.14	4.8 U	2.2	0.26 UG	4.5 U
12	Benzoic acid (ug/kg)	7	2	29	11	52	32	11	11	10 U	590 U	125	11	100 U
12	Butylbenzyl phthalate (ug/kg)	7	2	29	2 J	28	15	2 J	2 J	2 J	28	13	10 U	20 U
12	Dibutyl phthalate (ug/kg)	7	2	29	12 B	13 B	13	12 B	12 B	10 U	30 U	16	12 B	20 U
12	Phenol (ug/kg)	7	2	29	7 J	20	14	7 J	7 J	7 J	20	14	10 U	20 U
12	Dieldrin (ug/kg)	19	4	21	2	13	6	3.4	3.8	2 U	65 UB	6	2 U	13
12	Endrin (ug/kg)	19	3	16	0.5 J	3.9	1.7	0.5 J	0.8 J	0.5 J	20 U	3	2 U	3.9
12	1,4-Dichlorobenzene (ug/kg)	7	1	14	5.8 J	5.8 J	5.8	5.8 J	5.8 J	1 U	15 U	8	5.8 J	12 U
12	Diethyl phthalate (ug/kg)	7	1	14	6 J	6 J	6	6 J	6 J	6 J	20 U	13	10 U	20 U
12	gamma-Hexachlorocyclohexane (ug/kg)	19	2	11	0.2 J	0.88 J	0.54	0.2 J	0.2 J	0.2 J	2 U	2	2 U	2 U
12	Methoxychlor (ug/kg)	19	2	11	1 J	2	2	1 J	1 J	1 J	40 U	8	4 U	16 U
12	Chlordane (cis & trans) (ug/kg)	17	1	6	47	47	47	47	47	10 U	47	13	10 U	16 U
12	Aldrin (ug/kg)	19	1	5	1 J	1 J	1	1 J	1 J	1 J	2 U	2	2 U	2 U
12	alpha-Endosulfan (ug/kg)	19	1	5	1 J	1 J	1	1 J	1 J	1 J	20 U	3	2 U	2 U
12	beta-Endosulfan (ug/kg)	19	1	5	2 J	2 J	2	2 J	2 J	2 U	20 U	3	2 U	3.2 U
12	beta-Hexachlorocyclohexane (ug/kg)	19	1	5	1 J	1 J	1	1 J	1 J	1 J	2 U	2	2 U	2 U

Table 4-6. Historical Subsurface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detects	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
12	Endosulfan sulfate (ug/kg)	19	1	5	0.5 J	0.5 J	0.5	0.5 J	0.5 J	0.5 J	20 U	3	2 U	4 U
12	Endrin aldehyde (ug/kg)	19	1	5	5.6	5.6	5.6	5.6	5.6	2 U	190 UB	13	2 U	15 UB
12	Aroclor 1016 (ug/kg)	20	0	0						10 U	25 U	12	10 U	16 U
12	Aroclor 1221 (ug/kg)	20	0	0						10 U	32 U	15	10 U	29 U
12	Aroclor 1232 (ug/kg)	20	0	0						10 U	25 U	12	10 U	16 U
12	Aroclor 1242 (ug/kg)	20	0	0						10 U	16 U	11	10 U	15 U
12	Aroclor 1248 (ug/kg)	20	0	0						10 U	50 U	13	10 U	16 U
12	alpha-Hexachlorocyclohexane (ug/kg)	19	0	0						1.3 U	2 U	1.9	2 U	2 U
12	delta-Hexachlorocyclohexane (ug/kg)	19	0	0						1.3 U	2 U	1.9	2 U	2 U
12	Heptachlor (ug/kg)	19	0	0						1.3 U	2 U	1.9	2 U	2 U
12	Heptachlor epoxide (ug/kg)	19	0	0						1.3 U	2 U	1.9	2 U	2 U
12	Toxaphene (ug/kg)	19	0	0						30 U	300 UB	97	30 U	300 U
12	Benzyl alcohol (ug/kg)	7	0	0						6 U	74 U	18	10 U	12 U
12	Hexachlorobutadiene (ug/kg)	7	0	0						10 U	20 U	14	11 U	20 U
12	N-Nitrosodiphenylamine (ug/kg)	7	0	0						10 U	15 U	12	11 U	12 U
12	1,2-Dichlorobenzene (ug/kg)	7	0	0						1 U	15 U	9	10 U	12 U
12	1,3-Dichlorobenzene (ug/kg)	7	0	0						1 U	15 U	9	10 U	12 U
12	2,4-Dimethylphenol (ug/kg)	7	0	0						6 U	300 U	51	10 U	12 U
12	2-Methylphenol (ug/kg)	7	0	0						6 U	300 U	51	10 U	12 U
12	Dimethyl phthalate (ug/kg)	7	0	0						10 U	20 U	14	11 U	20 U
12	Di-n-octyl phthalate (ug/kg)	7	0	0						10 U	300 U	55	11 U	20 U
12	Hexachlorobenzene (ug/kg)	7	0	0						10 U	20 U	14	11 U	20 U
12	Pentachlorophenol (ug/kg)	7	0	0						10 U	450 U	88	11 U	61 U
12	Endrin ketone (ug/kg)	6	0	0						2 U	20 U	6	2.9 U	3.2 U
12	Hexachloroethane (ug/kg)	5	0	0						10 U	59 U	20	10 U	12 U
12	1,2,4-Trichlorobenzene (ug/kg)	5	0	0						10 U	15 U	12	10 U	12 U
12	Ammonia (mg/kg)	2	0	0						65 UJ	100 UJ	83	65 UJ	65 UJ
12	Butyltin ion (ug/l)	2	0	0						0.04 U	0.04 U	0.04	0.04 U	0.04 U
12	Dibutyltin ion (ug/l)	2	0	0						0.04 U	0.04 U	0.04	0.04 U	0.04 U
12	Tetrabutyltin (ug/l)	2	0	0						0.04 U	0.04 U	0.04	0.04 U	0.04 U
12	alpha-Chlordane (ug/kg)	2	0	0						2 U	20 U	11	2 U	2 U
12	gamma-Chlordane (ug/kg)	2	0	0						3 UB	20 U	12	3 UB	3 UB
12	1,2,3,4,7,8,9-Heptachlorodibenzofuran (ng/kg)	1	0	0						2.2 U	2.2 U	2.2	2.2 U	2.2 U
12	1,2,3,4,7,8-Hexachlorodibenzofuran (ng/kg)	1	0	0						4.5 U	4.5 U	4.5	4.5 U	4.5 U
12	1,2,3,7,8-Pentachlorodibenzofuran (ng/kg)	1	0	0						0.97 U	0.97 U	0.97	0.97 U	0.97 U
12	1,2,3,7,8-Pentachlorodibenzo-p-dioxin (ng/kg)	1	0	0						1.5 U	1.5 U	1.5	1.5 U	1.5 U
12	2,3,4,6,7,8-Hexachlorodibenzofuran (ng/kg)	1	0	0						0.49 U	0.49 U	0.49	0.49 U	0.49 U
12	2,3,7,8-Tetrachlorodibenzo-p-dioxin (ng/kg)	1	0	0						1.3 U	1.3 U	1.3	1.3 U	1.3 U
12	2,4-Dinitrotoluene (ug/kg)	1	0	0						74 U	74 U	74	74 U	74 U
12	2,6-Dinitrotoluene (ug/kg)	1	0	0						30 U	30 U	30	30 U	30 U
12	2-Chloronaphthalene (ug/kg)	1	0	0						15 U	15 U	15	15 U	15 U
12	2-Nitroaniline (ug/kg)	1	0	0						30 U	30 U	30	30 U	30 U
12	3,3'-Dichlorobenzidine (ug/kg)	1	0	0						200 U	200 U	200	200 U	200 U
12	3-Nitroaniline (ug/kg)	1	0	0						300 U	300 U	300	300 U	300 U
12	4-Bromophenyl phenyl ether (ug/kg)	1	0	0						15 U	15 U	15	15 U	15 U
12	4-Chlorophenyl phenyl ether (ug/kg)	1	0	0						15 U	15 U	15	15 U	15 U

Table 4-6. Historical Subsurface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detects	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
12	4-Nitroaniline (ug/kg)	1	0	0						150 U	150 U	150	150 U	150 U
12	Bis(2-chloroethoxy) methane (ug/kg)	1	0	0						30 U	30 U	30	30 U	30 U
12	Bis(2-chloroethyl) ether (ug/kg)	1	0	0						15 U	15 U	15	15 U	15 U
12	Bis(2-chloroisopropyl) ether (ug/kg)	1	0	0						15 U	15 U	15	15 U	15 U
12	Butyltin ion (ug/kg)	1	0	0						1 U	1 U	1	1 U	1 U
12	Hexachlorocyclopentadiene (ug/kg)	1	0	0						300 U	300 U	300	300 U	300 U
12	Isophorone (ug/kg)	1	0	0						15 U	15 U	15	15 U	15 U
12	Nitrobenzene (ug/kg)	1	0	0						15 U	15 U	15	15 U	15 U
12	N-Nitrosodipropylamine (ug/kg)	1	0	0						15 U	15 U	15	15 U	15 U
12	Selenium (mg/kg)	1	0	0						2 U	2 U	2	2 U	2 U
12	Tetrabutyltin (ug/kg)	1	0	0						3 U	3 U	3	3 U	3 U
12	Tributyltin ion (ug/kg)	1	0	0						1 U	1 U	1	1 U	1 U
12	2,4,5-Trichlorophenol (ug/kg)	1	0	0						74 U	74 U	74	74 U	74 U
12	2,4,6-Trichlorophenol (ug/kg)	1	0	0						74 U	74 U	74	74 U	74 U
12	2,4-Dichlorophenol (ug/kg)	1	0	0						150 U	150 U	150	150 U	150 U
12	2,4-Dinitrophenol (ug/kg)	1	0	0						450 U	450 U	450	450 U	450 U
12	2-Chlorophenol (ug/kg)	1	0	0						74 U	74 U	74	74 U	74 U
12	2-Nitrophenol (ug/kg)	1	0	0						74 U	74 U	74	74 U	74 U
12	4,6-Dinitro-2-methylphenol (ug/kg)	1	0	0						300 U	300 U	300	300 U	300 U
12	4-Chloro-3-methylphenol (ug/kg)	1	0	0						74 U	74 U	74	74 U	74 U
12	4-Nitrophenol (ug/kg)	1	0	0						150 U	150 U	150	150 U	150 U
12	Gasoline (mg/kg)	1	0	0						72 U	72 U	72	72 U	72 U
16	Total solids (%)	76	76	100	57.9	90.6	72.9	71.4	86.2	57.9	90.6	72.9	71.4	86.2
16	Copper (mg/kg)	74	74	100	10.5	1340	67	28.2 J	95.8 J	10.5	1340	67	28.2 J	95.8 J
16	Lead (mg/kg)	74	74	100	2	409	30	8.98	129	2	409	30	8.98	129
16	Nickel (mg/kg)	74	74	100	9.36	112	22	19.8	29.6	9.36	112	22	19.8	29.6
16	Zinc (mg/kg)	74	74	100	21.9	960	93	59.5	196 J	21.9	960	93	59.5	196 J
16	Total organic carbon (%)	69	69	100	0.06	7.35	0.75	0.52	1.6	0.06	7.35	0.75	0.52	1.6
16	Chromium (mg/kg)	40	40	100	7.07	26.8	15.5	15.1	24.4	7.07	26.8	15.5	15.1	24.4
16	Tributyltin ion (ug/l)	5	5	100	0.23	27	6.33	0.34	3.4	0.23	27	6.33	0.34	3.4
16	Arsenic (mg/kg)	74	60	81	1.1	24.4	3.5	2.6	7.5	0.2 UJ	24.4	3.2	2.51 U	5.8
16	Tributyltin ion (ug/kg)	36	27	75	0.2 J	2000	204	5	440	0.2 J	2000	153	1 U	440
16	Total Petroleum Hydrocarbons (mg/kg)	67	48	72	9 J	640	168	100 J	640	9 J	640	142	100 U	312
16	Silver (mg/kg)	74	49	66	0.05 J	0.7	0.20	0.14	0.6	0.004 U	0.7	0.19	0.2 U	0.5
16	Dibutyltin ion (ug/kg)	36	23	64	0.3 J	320	31	4	68	0.3 J	320	20	1 U	68
16	Cadmium (mg/kg)	74	46	62	0.03	1.7	0.26	0.14	0.9	0.03	1.7	0.27	0.23	0.6
16	Dibutyltin ion (ug/l)	5	3	60	0.07 J	1.1	0.46	0.07 J	0.2	0.05 U	1.1	0.29	0.05 U	0.2
16	Mercury (mg/kg)	74	43	58	0.01	1.43	0.13	0.04	0.32	0.01	1.43	0.14	0.1 U	0.23
16	Polycyclic Aromatic Hydrocarbons (ug/kg)	71	40	56	60 A	816600 A	44969	886 A	35962 A	50 UA	816600 A	25430	300 UA	25820 A
16	Total of 3 isomers: pp-DDT,-DDD,-DDE (ug/kg)	67	37	55	0.2 A	6500 A	233	4 A	754.7 A	0.2 A	6500 A	131	6.7 UA	209 A
16	High Molecular Weight PAH (ug/kg)	71	39	55	60 A	726000 A	40781	828 A	31740 A	50 UA	726000 A	22501	300 UA	19840 A
16	Butyltin ion (ug/kg)	35	19	54	0.3 J	37	6.0	1 J	20	0.3 J	37	3.7	1 UJ	15
16	Pyrene (ug/kg)	71	38	54	57	110000	6431	140	4700	50 U	110000	3546	200 J	4100
16	4,4'-DDD (ug/kg)	67	34	51	0.3 J	3700	116	3	59	0.3 J	3700	60	3.3 U	17
16	4,4'-DDE (ug/kg)	67	32	48	0.2 J	2800	96	2	88	0.2 J	2800	47	2.3 U	8
16	Fluoranthene (ug/kg)	71	33	46	55	120000	8120	150	5700	50 U	120000	3899	300 U	5100

Table 4-6. Historical Subsurface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detects	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
16	Polychlorinated biphenyls (ug/kg)	67	31	46	4 A	2900 A	261	54 A	237 A	4 A	2900 A	131	20 UA	190 A
16	Bis(2-ethylhexyl) phthalate (ug/kg)	71	30	42	100 J	3600	539	200 J	1100	100 U	3600	361	300 U	740
16	Aroclor 1260 (ug/kg)	67	27	40	4 J	1000	115	19	156	4 J	1000	52	10 U	151
16	Butyltin ion (ug/l)	5	2	40	0.05 J	0.2	0.13	0.05 J	0.05 J	0.05 U	0.2	0.08	0.05 U	0.05 J
16	Antimony (mg/kg)	72	28	39	0.03	8.6 J	0.8	0.17	0.81	0.03	8.6 J	1.4	0.34 J	2.59 UJ
16	Methylene chloride (ug/kg)	26	10	38	2 J	59	14	2 J	55	2 J	59	12	10 U	14 U
16	Low Molecular Weight PAH (ug/kg)	71	27	38	58 A	90600 A	7714	200 A	5980 A	50 UA	90600 A	3063	300 UA	4222 A
16	Benzo(a)pyrene (ug/kg)	71	26	37	70 J	89000	7363	110	3500	50 U	89000	2830	300 U	1600
16	Benzo(b+k)fluoranthene (ug/kg)	71	26	37	72 A	122000 A	10246	200 A	5500 A	50 UA	122000 A	3886	300 UA	3000 A
16	Chrysene (ug/kg)	71	26	37	73	71000	6021	110	3400	50 U	71000	2339	300 U	2200
16	Indeno(1,2,3-cd)pyrene (ug/kg)	71	26	37	52	72000	5933	100	2900	50 U	72000	2306	300 U	1000
16	Phenanthrene (ug/kg)	71	26	37	58	53000	4719	200 J	3800	50 U	53000	1862	300 U	2700
16	Aroclor 1254 (ug/kg)	67	24	36	5 J	1900	202	33	136	5 J	1900	80	10 U	120
16	Benz(a)anthracene (ug/kg)	71	25	35	66	79000	6906	110	3400	50 U	79000	2570	300 U	2300
16	Benzo(b)fluoranthene (ug/kg)	71	25	35	72	63000	5547	100	3200	50 U	63000	2091	300 U	1700
16	Benzo(g,h,i)perylene (ug/kg)	71	24	34	60 J	51000	4545	100 J	2100	50 U	51000	1672	200	540
16	Tetrabutyltin (ug/kg)	36	12	33	0.4 J	28	5.4	1	15	0.4 J	28	3.8	3 U	8
16	Benzo(k)fluoranthene (ug/kg)	71	21	30	63	59000	6053	100 J	2300	50 U	59000	1938	300 U	1300
16	Acetone (ug/kg)	26	6	23	12 J	39 J	21	20 J	21 J	12 J	71 U	46	50 U	57 U
16	Tetrabutyltin (ug/l)	5	1	20	0.2	0.2	0.2	0.2	0.2	0.05 U	0.2	0.08	0.05 U	0.05 UJ
16	Methylethyl ketone (ug/kg)	26	5	19	2 J	5 J	3.6	3 J	4 J	2 J	30 U	19	20 U	28 U
16	Endrin aldehyde (ug/kg)	33	6	18	0.6 J	6	2.2	0.9 J	4	0.6 J	6	2.2	2 U	4
16	4,4'-DDT (ug/kg)	67	12	18	0.3 J	730	136	7	730	0.3 J	730	38	6.7 U	62
16	Anthracene (ug/kg)	71	12	17	50 J	14000	2560	90 J	14000	50 U	14000	597	300 U	460
16	Acenaphthene (ug/kg)	71	11	15	60 J	17000	3322	82	17000	50 U	17000	677	300 U	540
16	2-Methylnaphthalene (ug/kg)	71	9	13	67	940	355	69	940	50 U	940	215	300 U	300 U
16	Dibenz(a,h)anthracene (ug/kg)	71	9	13	30 J	12000	2815	56	12000	30 J	12000	524	300 U	300 U
16	Fluorene (ug/kg)	71	9	13	80 J	4800	1354	430	4800	50 U	4800	335	300 U	430
16	Dibenzofuran (ug/kg)	71	7	10	100 J	1700	649	180	1700	50 U	1700	236	300 U	300 U
16	Naphthalene (ug/kg)	71	7	10	60 J	1800	621	82	1800	50 U	1800	233	300 U	300 U
16	alpha-Hexachlorocyclohexane (ug/kg)	33	2	6	0.9 J	1 J	0.95	0.9 J	0.9 J	0.9 J	4 U	2.0	2 U	2 U
16	1,3,5-Trimethylbenzene (ug/kg)	26	1	4	5 J	5 J	5	5 J	5 J	5 J	30 U	21	20 U	28 U
16	n-Butylbenzene (ug/kg)	26	1	4	5 J	5 J	5	5 J	5 J	5 J	30 U	21	20 U	28 U
16	p-Cymene (ug/kg)	26	1	4	6 J	6 J	6	6 J	6 J	6 J	30 U	21	20 U	28 U
16	Pseudocumene (ug/kg)	26	1	4	14 J	14 J	14	14 J	14 J	14 J	30 U	22	20 U	28 U
16	Sec-butylbenzene (ug/kg)	26	1	4	3 J	3 J	3	3 J	3 J	3 J	30 U	21	20 U	28 U
16	Dieldrin (ug/kg)	33	1	3	0.5 J	0.5 J	0.5	0.5 J	0.5 J	0.5 J	4 U	2.0	2 U	2 U
16	Endosulfan sulfate (ug/kg)	33	1	3	0.2 J	0.2 J	0.2	0.2 J	0.2 J	0.2 J	4 U	2.0	2 U	2 U
16	gamma-Chlordane (ug/kg)	33	1	3	0.2 J	0.2 J	0.2	0.2 J	0.2 J	0.2 J	4 U	2.0	2 U	2 U
16	Lube Oil (mg/kg)	67	2	3	140	200	170	140	140	25 U	200	64	25 U	100 U
16	Dibutyl phthalate (ug/kg)	71	2	3	130	130	130	130	130	100 U	500 U	216	300 U	300 U
16	Aroclor 1242 (ug/kg)	67	1	1	43	43	43	43	43	10 U	100 U	13	10 U	10 U
16	Diesel fuels (mg/kg)	67	1	1	540	540	540	540	540	10 U	540	25	10 UJ	25 U
16	Non-petroleum hydrocarbons (mg/kg)	67	1	1	8 J	8 J	8	8 J	8 J	8 J	100 U	73	50 U	100 U
16	Pentachlorophenol (ug/kg)	69	1	1	200 J	200 J	200	200 J	200 J	200 J	15000 U	1590	2000 U	2000 U
16	Acenaphthylene (ug/kg)	71	0	0						50 U	500 U	193	300 U	300 U

Table 4-6. Historical Subsurface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detects	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
16	Benzoic acid (ug/kg)	71	0	0						250 U	12500 U	1507	2000 U	2000 U
16	Benzyl alcohol (ug/kg)	71	0	0						25 U	2500 U	238	300 U	300 U
16	Hexachlorobutadiene (ug/kg)	71	0	0						20 U	500 U	129	160 U	300 U
16	Hexachloroethane (ug/kg)	71	0	0						50 U	2000 U	235	300 U	300 U
16	N-Nitrosodiphenylamine (ug/kg)	71	0	0						20 U	500 U	179	300 U	300 U
16	1,2,4-Trichlorobenzene (ug/kg)	71	0	0						20 U	500 U	129	160 U	300 U
16	2,4-Dimethylphenol (ug/kg)	71	0	0						20 U	10000 U	447	300 U	300 U
16	2-Methylphenol (ug/kg)	71	0	0						20 U	5000 U	306	300 U	300 U
16	3- and 4-Methylphenol Coelution (ug/kg)	71	0	0						100 U	10000 U	483	300 U	300 U
16	Butylbenzyl phthalate (ug/kg)	71	0	0						100 U	500 U	218	300 U	300 U
16	Diethyl phthalate (ug/kg)	71	0	0						100 U	500 U	215	300 U	300 U
16	Dimethyl phthalate (ug/kg)	71	0	0						100 U	500 U	215	300 U	300 U
16	Di-n-octyl phthalate (ug/kg)	71	0	0						100 U	500 U	218	300 U	300 U
16	Hexachlorobenzene (ug/kg)	71	0	0						20 U	500 U	179	300 U	300 U
16	Phenol (ug/kg)	71	0	0						100 U	2500 U	272	300 U	300 U
16	Aroclor 1016 (ug/kg)	67	0	0						10 U	100 U	13	10 U	10 U
16	Aroclor 1221 (ug/kg)	67	0	0						20 U	200 U	25	20 U	20 U
16	Aroclor 1232 (ug/kg)	67	0	0						10 U	100 U	13	10 U	10 U
16	Aroclor 1248 (ug/kg)	67	0	0						10 U	100 U	13	10 U	10 U
16	Heavy oil (mg/kg)	67	0	0						25 UJ	100 U	62	25 U	100 U
16	Jet fuel A (mg/kg)	67	0	0						10 U	25 U	17	10 UJ	25 U
16	Kerosene (mg/kg)	67	0	0						10 U	25 U	17	10 U	25 U
16	Mineral spirits (mg/kg)	67	0	0						10 U	25 U	17	10 U	25 U
16	1,2-Dichlorobenzene (ug/kg)	63	0	0						7.9 U	300 U	120	152.5 U	300 U
16	1,3-Dichlorobenzene (ug/kg)	63	0	0						7.9 U	300 U	120	152.5 U	300 U
16	1,4-Dichlorobenzene (ug/kg)	63	0	0						7.9 U	300 U	120	152.5 U	300 U
16	Benzene (ug/kg)	52	0	0						4 U	7.4 U	5.3	5 U	6.6 U
16	Ethylbenzene (ug/kg)	52	0	0						4 U	7.4 U	5.3	5 U	6.6 U
16	m,p-Xylene (ug/kg)	52	0	0						4 U	7.4 U	5.3	5 U	6.6 U
16	o-Xylene (ug/kg)	52	0	0						4 U	7.4 U	5.3	5 U	6.6 U
16	Toluene (ug/kg)	52	0	0						4 U	7.4 U	5.3	5 U	6.6 U
16	Trichloroethene (ug/kg)	52	0	0						4 U	7.4 U	5.3	5 U	6.6 U
16	2,4-Dinitrotoluene (ug/kg)	37	0	0						300 U	300 U	300	300 U	300 U
16	2,6-Dinitrotoluene (ug/kg)	37	0	0						300 U	300 U	300	300 U	300 U
16	2-Chloronaphthalene (ug/kg)	37	0	0						300 U	300 U	300	300 U	300 U
16	2-Nitroaniline (ug/kg)	37	0	0						2000 U	2000 U	2000	2000 U	2000 U
16	3,3'-Dichlorobenzidine (ug/kg)	37	0	0						2000 U	2000 U	2000	2000 U	2000 U
16	3-Nitroaniline (ug/kg)	37	0	0						2000 U	2000 U	2000	2000 U	2000 U
16	4-Bromophenyl phenyl ether (ug/kg)	37	0	0						300 U	300 U	300	300 U	300 U
16	4-Chloroaniline (ug/kg)	37	0	0						300 U	300 U	300	300 U	300 U
16	4-Chlorophenyl phenyl ether (ug/kg)	37	0	0						300 U	300 U	300	300 U	300 U
16	4-Nitroaniline (ug/kg)	37	0	0						2000 U	2000 U	2000	2000 U	2000 U
16	Aniline (ug/kg)	37	0	0						1000 U	1000 U	1000	1000 U	1000 U
16	Bis(2-chloroethoxy) methane (ug/kg)	37	0	0						300 U	300 U	300	300 U	300 U
16	Bis(2-chloroethyl) ether (ug/kg)	37	0	0						300 U	300 U	300	300 U	300 U
16	Bis(2-chloroisopropyl) ether (ug/kg)	37	0	0						300 U	300 U	300	300 U	300 U

Table 4-6. Historical Subsurface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detects	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
16	Hexachlorocyclopentadiene (ug/kg)	37	0	0						300 U	300 U	300	300 U	300 U
16	Isophorone (ug/kg)	37	0	0						300 U	300 U	300	300 U	300 U
16	Nitrobenzene (ug/kg)	37	0	0						300 U	300 U	300	300 U	300 U
16	N-Nitrosodimethylamine (ug/kg)	37	0	0						2000 U	2000 U	2000	2000 U	2000 U
16	N-Nitrosodipropylamine (ug/kg)	37	0	0						300 U	300 U	300	300 U	300 U
16	2,4,5-Trichlorophenol (ug/kg)	37	0	0						300 U	300 U	300	300 U	300 U
16	2,4,6-Trichlorophenol (ug/kg)	37	0	0						300 U	300 U	300	300 U	300 U
16	2,4-Dichlorophenol (ug/kg)	37	0	0						300 U	300 U	300	300 U	300 U
16	2,4-Dinitrophenol (ug/kg)	37	0	0						2000 U	2000 U	2000	2000 U	2000 U
16	2-Chlorophenol (ug/kg)	37	0	0						300 U	300 U	300	300 U	300 U
16	2-Nitrophenol (ug/kg)	37	0	0						300 U	300 U	300	300 U	300 U
16	4,6-Dinitro-2-methylphenol (ug/kg)	37	0	0						2000 U	2000 U	2000	2000 U	2000 U
16	4-Chloro-3-methylphenol (ug/kg)	37	0	0						300 U	300 U	300	300 U	300 U
16	4-Nitrophenol (ug/kg)	37	0	0						2000 U	2000 U	2000	2000 U	2000 U
16	JP-4 jet fuel (mg/kg)	34	0	0						10 U	10 UJ	10	10 UJ	10 UJ
16	Naphtha distillate (mg/kg)	34	0	0						10 U	10 UJ	10	10 UJ	10 UJ
16	Aldrin (ug/kg)	33	0	0						2 U	4 U	2.1	2 U	2 U
16	alpha-Chlordane (ug/kg)	33	0	0						2 U	4 U	2.1	2 U	2 U
16	alpha-Endosulfan (ug/kg)	33	0	0						2 U	4 U	2.1	2 U	2 U
16	beta-Endosulfan (ug/kg)	33	0	0						2 U	11 U	2.3	2 U	2 U
16	beta-Hexachlorocyclohexane (ug/kg)	33	0	0						2 U	4 U	2.1	2 U	2 U
16	delta-Hexachlorocyclohexane (ug/kg)	33	0	0						2 U	4 U	2.1	2 U	2 U
16	Endrin (ug/kg)	33	0	0						2 U	4 U	2.1	2 U	2 U
16	Endrin ketone (ug/kg)	33	0	0						2 U	4 U	2.1	2 U	2 U
16	gamma-Hexachlorocyclohexane (ug/kg)	33	0	0						2 U	4 U	2.1	2 U	2 U
16	Heptachlor (ug/kg)	33	0	0						2 U	4 U	2.1	2 U	2 U
16	Heptachlor epoxide (ug/kg)	33	0	0						2 U	4 U	2.1	2 U	2 U
16	Methoxychlor (ug/kg)	33	0	0						4 U	8 U	4.1	4 U	4 U
16	Toxaphene (ug/kg)	33	0	0						30 U	200 U	42	30 U	97 U
16	1,1,1,2-Tetrachloroethane (ug/kg)	26	0	0						5 U	7.4 U	5.5	5 U	7 U
16	1,1,1-Trichloroethane (ug/kg)	26	0	0						5 U	7.4 U	5.5	5 U	7 U
16	1,1,2,2-Tetrachloroethane (ug/kg)	26	0	0						5 U	7.4 U	5.5	5 U	7 U
16	1,1,2-Trichloroethane (ug/kg)	26	0	0						5 U	7.4 U	5.5	5 U	7 U
16	1,1-Dichloroethane (ug/kg)	26	0	0						5 U	7.4 U	5.5	5 U	7 U
16	1,1-Dichloropropene (ug/kg)	26	0	0						5 U	7.4 U	5.5	5 U	7 U
16	1,2,3-Trichlorobenzene (ug/kg)	26	0	0						20 U	30 U	22	20 U	28 U
16	1,2,3-Trichloropropane (ug/kg)	26	0	0						5 U	7.4 U	5.5	5 U	7 U
16	1,2-Dibromo-3-chloropropane (ug/kg)	26	0	0						20 U	30 U	22	20 U	28 U
16	1,2-Dichloroethane (ug/kg)	26	0	0						5 U	7.4 U	5.5	5 U	7 U
16	1,2-Dichloropropane (ug/kg)	26	0	0						5 U	7.4 U	5.5	5 U	7 U
16	1,3-Dichloropropane (ug/kg)	26	0	0						5 U	7.4 U	5.5	5 U	7 U
16	2,2-Dichloropropane (ug/kg)	26	0	0						5 U	7.4 U	5.5	5 U	7 U
16	2-Chlorotoluene (ug/kg)	26	0	0						20 U	30 U	22	20 U	28 U
16	4-Chlorotoluene (ug/kg)	26	0	0						20 U	30 U	22	20 U	28 U
16	Bromobenzene (ug/kg)	26	0	0						5 U	7.4 U	5.5	5 U	7 U
16	Bromochloromethane (ug/kg)	26	0	0						5 U	7.4 U	5.5	5 U	7 U

Table 4-6. Historical Subsurface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detects	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
16	Bromodichloromethane (ug/kg)	26	0	0						5 U	7.4 U	5.5	5 U	7 U
16	Bromoform (ug/kg)	26	0	0						5 U	7.4 U	5.5	5 U	7 U
16	Bromomethane (ug/kg)	26	0	0						5 U	7.4 U	5.5	5 U	7 U
16	Carbon disulfide (ug/kg)	26	0	0						5 U	7.4 U	5.5	5 U	7 U
16	Carbon tetrachloride (ug/kg)	26	0	0						5 U	7.4 U	5.5	5 U	7 U
16	Chlorobenzene (ug/kg)	26	0	0						5 U	7.4 U	5.5	5 U	7 U
16	Chlorodibromomethane (ug/kg)	26	0	0						5 U	7.4 U	5.5	5 U	7 U
16	Chloroethane (ug/kg)	26	0	0						5 U	7.4 U	5.5	5 U	7 U
16	Chloroform (ug/kg)	26	0	0						5 U	7.4 U	5.5	5 U	7 U
16	Chloromethane (ug/kg)	26	0	0						5 U	7.4 U	5.5	5 U	7 U
16	cis-1,2-Dichloroethene (ug/kg)	26	0	0						5 U	7.4 U	5.5	5 U	7 U
16	cis-1,3-Dichloropropene (ug/kg)	26	0	0						5 U	7.4 U	5.5	5 U	7 U
16	Dichlorodifluoromethane (ug/kg)	26	0	0						5 U	7.4 U	5.5	5 U	7 U
16	Ethylene dibromide (ug/kg)	26	0	0						20 U	30 U	22	20 U	28 U
16	Isopropylbenzene (ug/kg)	26	0	0						20 U	30 U	22	20 U	28 U
16	Methyl isobutyl ketone (ug/kg)	26	0	0						20 U	30 U	22	20 U	28 U
16	Methyl N-butyl ketone (ug/kg)	26	0	0						20 U	30 U	22	20 U	28 U
16	Methylene bromide (ug/kg)	26	0	0						5 U	7.4 U	5.5	5 U	7 U
16	n-Propylbenzene (ug/kg)	26	0	0						20 U	30 U	22	20 U	28 U
16	Styrene (ug/kg)	26	0	0						5 U	7.4 U	5.5	5 U	7 U
16	tert-Butylbenzene (ug/kg)	26	0	0						20 U	30 U	22	20 U	28 U
16	Tetrachloroethene (ug/kg)	26	0	0						5 U	7.4 U	5.5	5 U	7 U
16	trans-1,2-Dichloroethene (ug/kg)	26	0	0						5 U	7.4 U	5.5	5 U	7 U
16	trans-1,3-Dichloropropene (ug/kg)	26	0	0						5 U	7.4 U	5.5	5 U	7 U
16	Trichlorofluoromethane (ug/kg)	26	0	0						5 U	7.4 U	5.5	5 U	7 U
16	Vinyl chloride (ug/kg)	26	0	0						5 U	7.4 U	5.5	5 U	7 U
16	Vinylidene chloride (ug/kg)	26	0	0						5 U	7.4 U	5.5	5 U	7 U
16	Gasoline (mg/kg)	17	0	0						10 UJ	10 UJ	10	10 UJ	10 UJ
16	Natural gasoline (mg/kg)	17	0	0						10 U	10 UJ	10	10 U	10 U
24	Fines (%)	1	1	100	21	21	21	21	21	21	21	21	21	21
24	Gravel (%)	1	1	100	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
24	Sand (%)	1	1	100	78.9	78.9	78.9	78.9	78.9	78.9	78.9	78.9	78.9	78.9
24	Total solids (%)	1	1	100	62.7	62.7	62.7	62.7	62.7	62.7	62.7	62.7	62.7	62.7
24	Acenaphthene (ug/kg)	1	0	0						13.4 U	13.4 U	13.4	13.4 U	13.4 U
24	Acenaphthylene (ug/kg)	1	0	0						13.4 U	13.4 U	13.4	13.4 U	13.4 U
24	Anthracene (ug/kg)	1	0	0						13.4 U	13.4 U	13.4	13.4 U	13.4 U
24	Benz(a)anthracene (ug/kg)	1	0	0						13.4 U	13.4 U	13.4	13.4 U	13.4 U
24	Benzo(a)pyrene (ug/kg)	1	0	0						13.4 U	13.4 U	13.4	13.4 U	13.4 U
24	Benzo(b)fluoranthene (ug/kg)	1	0	0						13.4 U	13.4 U	13.4	13.4 U	13.4 U
24	Benzo(b+k)fluoranthene (ug/kg)	1	0	0						13.4 UA	13.4 UA	13.4	13.4 UA	13.4 UA
24	Benzo(g,h,i)perylene (ug/kg)	1	0	0						13.4 U	13.4 U	13.4	13.4 U	13.4 U
24	Benzo(k)fluoranthene (ug/kg)	1	0	0						13.4 U	13.4 U	13.4	13.4 U	13.4 U
24	Chrysene (ug/kg)	1	0	0						13.4 U	13.4 U	13.4	13.4 U	13.4 U
24	Dibenz(a,h)anthracene (ug/kg)	1	0	0						13.4 U	13.4 U	13.4	13.4 U	13.4 U
24	Fluoranthene (ug/kg)	1	0	0						13.4 U	13.4 U	13.4	13.4 U	13.4 U
24	Fluorene (ug/kg)	1	0	0						13.4 U	13.4 U	13.4	13.4 U	13.4 U

Table 4-6. Historical Subsurface Sediment and Porewater Chemical Data Summary by River Mile.

River Mile	Analyte	N	N Detected	% Detects	Detected Concentrations					Detected and Nondetected Concentrations				
					Minimum	Maximum	Mean	Median	95th	Minimum	Maximum	Mean	Median	95th
24	High Molecular Weight PAH (ug/kg)	1	0	0						13.4 UA	13.4 UA	13.4	13.4 UA	13.4 UA
24	Indeno(1,2,3-cd)pyrene (ug/kg)	1	0	0						13.4 U	13.4 U	13.4	13.4 U	13.4 U
24	Low Molecular Weight PAH (ug/kg)	1	0	0						13.4 UA	13.4 UA	13.4	13.4 UA	13.4 UA
24	Naphthalene (ug/kg)	1	0	0						13.4 U	13.4 U	13.4	13.4 U	13.4 U
24	Phenanthrene (ug/kg)	1	0	0						13.4 U	13.4 U	13.4	13.4 U	13.4 U
24	Polycyclic Aromatic Hydrocarbons (ug/kg)	1	0	0						13.4 UA	13.4 UA	13.4	13.4 UA	13.4 UA
24	Pyrene (ug/kg)	1	0	0						13.4 U	13.4 U	13.4	13.4 U	13.4 U
24	Pentachlorophenol (ug/kg)	1	0	0						67 U	67 U	67	67 U	67 U

Notes:
A - Detected quantities of analytes added together as defined in WAC 173-204-320 for LPAH and HPAH, as in DMMO 2000 for DDT, and for all Aroclors or congeners for PCB.
B - Possible method blank contamination.
E - Estimate, usually applied because the value exceeded the instrument calibration range.
G - Estimate is greater than value shown.
H - Holding time exceeded.
J - Estimate, usually applied because the value is less than the method reporting limit but greater than the method detection limit, or for QA/QC concerns.
L - Value is less than the maximum shown.
N - Presumptive evidence of presence of material.
U - Not detected at detection limit shown.
X - Recovery less than 10%.
Subsurface sediment is defined as any sediment sample that was collected 30 cm or more below sediment/water interface.

Table 4-7. Water Quality Monitoring Locations in the Lower Willamette River.

Organization	Primary Station ID	River Mile	Location	Available Data (1990 - 2000)						Data Usability Category
				Conventional Parameters	Major Metals	Trace Metals	Pesticides/ PCBs	Volatiles/ Semivolatiles	Dioxins	
DEQ	402000*	7	Willamette R. at SP&S Railroad Bridge	x	x					2
	402478*	~8.4	Swan Island Channel Midpoint	x	x					2
	402288*	13.2	Willamette R. at Hawthorne Bridge	x	x					2
USGS	14211720	12.8	Willamette R. at Portland	x	x	x	x			2
DEQ	SW99-01	7	McCormick & Baxter					x		1
	SW99-02	7	McCormick & Baxter					x		1
	SW99-03	8	McCormick & Baxter					x		1
	SW99-04	8	McCormick & Baxter					x		1
	SW99-05	8	McCormick & Baxter					x		1
Woodward-Clyde	WR-1	8	Rhône-Poulenc St Helens Road Facility	x	x	x	x	x	x	1
	WR-2	7	Rhône-Poulenc St Helens Road Facility	x	x	x	x	x	x	1
	WR-3	7	Rhône-Poulenc St Helens Road Facility	x	x	x	x	x	x	1
	WR-4	7	Rhône-Poulenc St Helens Road Facility	x	x	x	x	x	x	1
EPA, Region 10	SED-1	7	McCormick & Baxter		x			x		1
	SED-2	7	McCormick & Baxter		x			x		1
	SED-3	7	McCormick & Baxter		x			x		1
	SED-4	7	McCormick & Baxter		x			x		1
	SED-5	7	McCormick & Baxter		x			x		1
	SED-6	7	McCormick & Baxter		x			x		1
	SED-7	7	McCormick & Baxter		x			x		1
	SED-8	7	McCormick & Baxter		x			x		1
	SED-9	7	McCormick & Baxter		x			x		1
DEQ/OSU	SPMD-1	7	McCormick & Baxter		x			x		1
	SPMD-2	7	McCormick & Baxter		x			x		1
	SPMD-3	7	McCormick & Baxter		x			x		1

Table 4-7. Water Quality Monitoring Locations in the Lower Willamette River.

Organization	Primary Station ID	River Mile	Location	Available Data (1990 - 2000)						Data Usability Category
				Conventional Parameters	Major Metals	Trace Metals	Pesticides/ PCBs	Volatiles/ Semivolatiles	Dioxins	
DEQ/OSU	SPMD-4	7	McCormick & Baxter		x			x		1
	SPMD-5	7	McCormick & Baxter		x			x		1
	SPMD-6	7	McCormick & Baxter		x			x		1
	SPMD-7	7	McCormick & Baxter		x			x		1
	SPMD-8	7	McCormick & Baxter		x			x		1
	SPMD-9	7	McCormick & Baxter		x			x		1
	SPMD-10	7	McCormick & Baxter		x			x		1
	SPMD-11	7	McCormick & Baxter		x			x		1
	SPMD-12	7	McCormick & Baxter		x			x		1
	SPMD-14	7	McCormick & Baxter		x			x		1
	SPMD-15	7	McCormick & Baxter		x			x		1
	SPMD-16	7	McCormick & Baxter		x			x		1
	SPMD-17	7	McCormick & Baxter		x			x		1
	SPMD-18	7	McCormick & Baxter		x			x		1
	SPMD-19	7	McCormick & Baxter		x			x		1
	SPMD-20	7	McCormick & Baxter		x			x		1

Notes:
*STORET number

Table 4-8a. Dissolved Metals and Selected Conventional Water Quality Data Summary, 1990-2001.

Parameter[1]	Station[2]	Data Summary			
		Number of Measurements	Minimum	Maximum	Mean
Temperature (°C)	402000	77	3.0	24.5	14.2
	402288	155	3.0	24.5	13.4
	402478	65	5.0	24.0	13.5
	14211720	100	4.8	24.2	12.6
Dissolved Oxygen (mg/L)	402000	77	6.4	14.2	10.6
	402288	155	7.5	15.2	10.8
	402478	66	7.5	14.2	11.1
	14211720	97	6.96	14.97	11.2
pH	402000	75	6.8	8.3	7.4
	402288	152	6.9	8.3	7.4
	402478	64	7.1	8.9	7.6
	14211720	100	6.79	7.92	7.3
Hardness (mg/L)	402000	101	16	41	26
	402288	194	17	33	24
	402478	83	13	34	27
	14211720	51	17	35	27
Turbidity (NTU)	402000	21	3.0	50.0	12.06
	402288	46	3.0	58.0	10.37
	402478	23	3.0	37.0	9.70
	14211720	85	0.9	99.0	11.82
Total Suspended Solids[3] (mg/L)	402000	80	2	110	11
	402288	78	1	770	28
	402478	78	1	120	9
	14211720	---	---	---	---
Aluminum (µg/L)	402000	47	19.0	400.0	127.3
	402288	106	0.2	600.0	129.2
	402478	44	24.0	700.0	133.0
	14211720	67	2.6	170	40.3
Antimony (µg/L)	14211720	43	<1.0	<1.0	<1.0
Arsenic (µg/L)	14211720	62	<1.0	<1.0	<1.0
Beryllium (µg/L)	402000	2	<10.0	<10.0	<10.0
	402288	2	<10.0	<10.0	<10.0
	402478	2	<10.0	<10.0	<10.0
	14211720	52	<0.5	<1.0	<1.0
Cadmium (µg/L)	402000	2	<10.0	<10.0	<10.0
	402288	2	<10.0	<10.0	<10.0
	402478	2	<10.0	<10.0	<10.0
	14211720	52	<1.0	<1.0	<1.0
Chromium (µg/L)	402000	2	<30.0	<30.0	<30.0
	402288	2	<30.0	<30.0	<30.0
	402478	2	<30.0	<30.0	<30.0
	14211720	52	<1.0	<5.0	<1.0

Table 4-8a. Dissolved Metals and Selected Conventional Water Quality Data Summary, 1990-2001.

Parameter[1]	Station[2]	Data Summary			
		Number of Measurements	Minimum	Maximum	Mean
Copper (µg/L)	402000	2	<20.0	<20.0	<20.0
	402288	2	<20.0	<20.0	<20.0
	402478	2	<20.0	<20.0	<20.0
	14211720	52	<1.0	<10	1.7
Iron (µg/L)	402000	47	<40	506	121
	402288	106	0.3	520	119
	402478	44	<40	570	144
	14211720	86	16.2	290	66
Lead (µg/L)	14211720	51	<1.0	1.0	1.0
Manganese (µg/L)	402000	47	6.9	50	19
	402288	106	0.02	100	17
	402478	44	3.3	149	29
	14211720	77	1	35	9
Mercury (µg/L)	14211720	12	<0.10	0.6 E	0.14
Nickel (µg/L)	402000	2	<40.0	<40.0	<40.0
	402288	2	<40.0	<40.0	<40.0
	402478	2	<40.0	<40.0	<40.0
	14211720	67	<1.0	<10.0	1.2
Selenium (µg/L)	402000	1	<5.0	<5.0	<5.0
	402288	1	<5.0	<5.0	<5.0
	402478	1	<5.0	<5.0	<5.0
	14211720	77	<1.0	1.1	1.0
Silver (µg/L)	402000	2	<10.0	<10.0	<10.0
	402288	2	<10.0	<10.0	<10.0
	402478	2	<10.0	<10.0	<10.0
	14211720	67	<1.0	<1.0	<1.0
Zinc (µg/L)	402000	2	<20.0	<20.0	<20.0
	402288	2	<20.0	<20.0	<20.0
	402478	2	<20.0	<20.0	<20.0
	14211720	52	1.0	12.0	3.0

Notes:

[1]Parameters most relevant to sediments and indicative of general water quality in the LWR are included here. See Section 4.3.2.
[2]Routine monitoring stations sampled by DEQ and USGS. Station location information is provided in Table 4-7.

[3]If TSS results from February 1996 (flood period) are omitted, maximum TSS values at the three stations range from 20-42 mg/L and mean TSS is reduced to 6 - 9 mg/L.

Table 4-8b. Metal Concentrations in Unfiltered Water Samples from Lower Willamette River Monitoring Stations[1].

Metal (ug/L)	DEQ 402000	DEQ 402288	DEQ 402478[2]	USGS 14211720
Barium	<30.0	<30.0	<30.0	--
Beryllium	<10.0	<10.0	<10.0	--
Cadmium	<10.0	<10.0	<10.0	<1.0
Chromium	<30.0	<30.0	<30.0	1.1
Cobalt	<60.0	<60.0	<60.0	--
Copper	<20.0	<20.0	<20.0	2.0
Lead	--	--	--	<1.0
Molybdenum	<50.0	<50.0	<50.0	--
Nickel	<40.0	<40.0	<40.0	1.0
Selenium	<5.0	<5.0	<5.0	--
Silver	<10.0	<10.0	<10.0	--
Vanadium	<30.0	<30.0	<30.0	--
Zinc	90.0	<20.0	40.0	<10.0

Notes:

Station numbers are shown on Map 4-39.

[1]DEQ samples for total recoverable metals were collected 2/21/96. USGS samples for total metals were collected 10/29/94. (Methods are not comparable)

[2]Mean of duplicate results.

Table 4-8c. Organic Chemicals in Water Samples from USGS Station 14211720, 1993-1998. (Concentrations are dissolved, unless otherwise noted.)

Chemical (ug/L)	Number of Measurements	Number of Detected Values	Minimum	Maximum
1-Naphthol	7	0	< 0.007	< 0.05
2,4,5-T	7	0	< 0.007	< 0.05
2,4-D	7	0	< 0.035	0 0.05
2,4-DB	7	0	< 0.035	< 0.05
2,6-Diethylaniline	69	0	< 0.003	< 0.003
3-Hydroxycarbofuran	7	0	< 0.014	< 0.05
Acetochlor	63	0	< 0.002	< 0.002
Acifluorfen	7	0	< 0.035	< 0.05
Alachlor	69	3	< 0.002	< 0.003 E
Aldicarb Sulfone	7	0	< 0.016	< 0.05
Aldicarb Sulfoxide	7	0	< 0.021	< 0.05
Aldicarb	7	0	< 0.016	< 0.05
Aldrin, Total	9	0	< 0.001	< 0.001
Alpha Bhc	69	0	< 0.002	< 0.002
Atrazine	69	65	< 0.001	0.328
Benfluralin	69	1	0.0012 E	< 0.002
Bentazon	7	0	< 0.014	< 0.05
Bromacil	7	0	< 0.035	< 0.05
Bromoxynil	7	0	< 0.035	< 0.05
Butylate	69	0	< 0.002	< 0.003
Carbaryl	76	15	0.0025 E	< 0.05
Carbofuran	76	9	< 0.003	0.181 E
Chloramben	7	0	< 0.011	< 0.05
Chlordane, Total	9	0	< 0.1	< 0.1
Chlorothalonil	7	0	< 0.035	< 0.05
Chlorpyrifos	69	27	0.003 E	0.014
Clopyralid	7	0	< 0.05	< 0.05
Cyanazine	69	0	< 0.004	< 0.004
Dacthal, Mono-Acid	7	0	< 0.017	< 0.05
DCPA	69	3	0.001 E	0.004
Deethyl Atrazine	69	55	0.001 E	0.026 E
Diazinon	69	28	< 0.002	0.009
Dicamba	7	0	< 0.035	0.12
Dichlobenil	7	0	< 0.02	< 0.05
Dichlorprop	7	0	< 0.0332	< 0.05
Dieldrin, Dissolved	69	0	< 0.001	< 0.001
Dieldrin, Total	9	1	< 0.001	0.002
Dinoseb	7	0	< 0.035	< 0.05
Disulfoton	69	0	< 0.017	< 0.017
Diuron	7	3	< 0.02	0.24
DNOC	7	0	< 0.035	< 0.05
Endosulfan I, Total	9	0	< 0.001	< 0.001
Endrin, Unfiltered	9	0	< 0.001	< 0.001
EPTC	69	15	0.001	0.026
Esfenvalerate	7	0	< 0.019	< 0.05
Ethalfluralin	69	0	< 0.004	< 0.004

Table 4-8c. Organic Chemicals in Water Samples from USGS Station 14211720, 1993-1998. (Concentrations are dissolved, unless otherwise noted.)

Chemical (ug/L)	Number of Measurements	Number of Detected Values	Minimum	Maximum
Ethoprop	69	12	0.002 E	0.029
Fenuron	7	0	< 0.013	< 0.05
Fluometuron	7	0	< 0.035	< 0.05
Fonofos	69	9	0.0015 E	0.01
Heptachlor Epoxide, Total	9	0	< 0.001	< 0.001
Heptachlor, Total	9	0	< 0.001	< 0.001
Lindane, Dissolved	69	0	< 0.004	< 0.004
Lindane, Total	9	1	< 0.001	0.007
Linuron	76	0	< 0.002	< 0.05
Malathion	69	0	< 0.005	< 0.005
MCPA	7	0	< 0.035	< 0.05
MCPA	7	0	< 0.035	< 0.05
Methiocarb	7	0	< 0.026	< 0.05
Methomyl	7	0	< 0.017	< 0.05
Methoxychlor, Total	9	0	< 0.01	< 0.01
Methyl Azinphos	69	0	< 0.001	< 0.001
Methyl Parathion	69	0	< 0.006	< 0.006
Metolachlor	69	64	< 0.002	0.122
Metribuzin, (Sencor)	69	28	< 0.004	0.075
Mirex, Total	9	0	< 0.01	< 0.01
Molinate	69	0	< 0.004	< 0.004
Napropamide	69	19	< 0.003	0.068
Neburon	7	0	< 0.015	< 0.05
Norflurazon	7	0	< 0.024	< 0.05
Oryzalin	7	0	< 0.019	< 0.05
Oxamyl	7	0	< 0.018	< 0.05
P,P' DDE	69	3	0.00046 E	< 0.006
P,P'-DDD	9	0	< 0.001	< 0.001
P,P'-DDE, Total	9	1	< 0.001	0.001
P,P'-DDT	9	2	< 0.001	0.001
Parathion	69	0	< 0.004	< 0.004
PCB, Total	9	0	< 0.1	< 0.1
PCNS	9	0	< 0.1	< 0.1
Pebulate	69	0	< 0.004	< 0.004
Pendimethalin	69	0	< 0.004	< 0.004
Permethrin, Cis	69	0	< 0.005	< 0.005
Perthane, Total	9	0	< 0.1	< 0.1
Phorate	69	0	< 0.002	< 0.002
Picloram	7	0	< 0.05	< 0.05
Prometon	69	5	0.003 E	< 0.018
Pronamide	69	32	0.0023 E	0.082
Propachlor	69	2	0.004 E	0.007 E
Propanil	69	0	< 0.004	< 0.004
Propargite	69	1	< 0.013	0.014
Propham	7	0	< 0.035	< 0.05
Propoxur	7	0	< 0.035	< 0.05

Table 4-8c. Organic Chemicals in Water Samples from USGS Station 14211720, 1993-1998. (Concentrations are dissolved, unless otherwise noted.)

Chemical (ug/L)	Number of Measurements	Number of Detected Values	Minimum	Maximum
Silvex	7	0	< 0.021	< 0.05
Simazine	69	62	0.0036 E	0.157
Tebuthiuron	69	15	0.0029 E	0.015 E
Terbacil	69	35	0.0034 E	< 0.1
Terbufos	69	0	< 0.013	< 0.013
Thiobencarb	69	0	< 0.002	< 0.002
Toxaphene, Total	9	0	< 1	< 1
Triallate	69	9	< 0.001	0.047
Triclopyr	7	0	< 0.05	< 0.05
Trifluralin	69	5	< 0.002	0.009

Notes:
E = Estimated value

Table 4-8d. Water Quality Data Results from Rhone-Polenc St. Helens Road Facility.

Parameter	Data Summary					
	Unit	Number of Measurements	Minimum	Maximum	Mean	Number Detected
Arsenic	mg/L	10	0.005 U	0.0092	0.0056	2
Cadmium	mg/L	10	0.0005 U	0.0027	0.00094	1
Chromium	mg/L	10	0.001	0.016	0.0041	4
Lead	mg/L	10	0.005 U	0.21	0.049	2
Mercury	mg/L	10	0.0002 U	0.0014	0.00036	2
Zinc	mg/L	10	0.02 U	0.57	0.14	2
1,2,3,4,6,7,8-Heptachlorodibenzofuran	pg/L	5	1.2 U	120	47	2
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	pg/L	5	5.3 U	540	220	2
1,2,3,4,7,8,9-Heptachlorodibenzofuran	pg/L	5	0.35 U	12 U	5.4	0
1,2,3,4,7,8-Hexachlorodibenzofuran	pg/L	5	0.84 U	16 U	7.5	0
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	pg/L	5	1.3 U	4.9 U	2.8	0
1,2,3,6,7,8-Hexachlorodibenzofuran	pg/L	5	0.63 U	11 U	4.9	0
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	pg/L	5	1.2 U	20 U	8.6	0
1,2,3,7,8,9-Hexachlorodibenzofuran	pg/L	5	0.56 U	2 U	1	0
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	pg/L	5	1.3 U	15 U	6.7	0
1,2,3,7,8-Pentachlorodibenzofuran	pg/L	5	1.3 U	4.9 U	3.4	0
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	pg/L	5	1.2 U	2.7 U	1.9	0
2,3,4,6,7,8-Hexachlorodibenzofuran	pg/L	5	0.46 U	7.3 U	3.5	0
2,3,4,7,8-Pentachlorodibenzofuran	pg/L	5	1.2 U	5.6 U	3.1	0
2,3,7,8-Tetrachlorodibenzofuran	pg/L	5	0.76 U	6.4	4.2	2
2,3,7,8-Tetrachlorodibenzo-p-dioxin	pg/L	5	0.84 U	4.4 U	2.1	0
Heptachlorodibenzofuran	pg/L	5	1.2 U	340	140	1
Heptachlorodibenzo-p-dioxin	pg/L	5	5.3 U	1100	420	2
Hexachlorodibenzofuran	pg/L	5	0.84 U	87	36	2
Hexachlorodibenzo-p-dioxin	pg/L	5	1.3 U	79	31	2
Octachlorodibenzofuran	pg/L	5	3.6 U	340	140	2
Octachlorodibenzo-p-dioxin	pg/L	5	48 U	6200	2400	3
Pentachlorodibenzofuran	pg/L	5	1.3 U	25 U	11	0
Pentachlorodibenzo-p-dioxin	pg/L	5	1.3 U	8.4 U	4	0
Tetrachlorodibenzofuran	pg/L	5	1.3 U	90	35	3
Tetrachlorodibenzo-p-dioxin	pg/L	5	2 UJ	31 J	10	2
pH		4	7.81	8.15	8.01	4
1,1,1-Trichloroethane	µg/L	5	0.5 U	0.5 U	0.5	0
1,1,2,2-Tetrachloroethane	µg/L	5	1 U	1 U	1	0
1,1,2-Trichloro-1,2,2-trifluoroethane	µg/L	5	5 U	5 U	5	0
1,1,2-Trichloroethane	µg/L	5	1 U	1 U	1	0
1,1-Dichloroethane	µg/L	5	0.5 U	0.5 U	0.5	0
1,2,4,5-Tetrachlorobenzene	µg/L	5	10 U	10 U	10	0
1,2,4-Trichlorobenzene	µg/L	5	10 U	10 U	10	0
1,2-Dichlorobenzene	µg/L	5	1 U	1 U	1	0
1,2-Dichloroethane	µg/L	5	1 U	1 U	1	0
1,2-Dichloroethene	µg/L	5	0.5 U	0.5 U	0.5	0
1,2-Dichloropropane	µg/L	5	1 U	1 U	1	0
1,2-Diphenylhydrazine	µg/L	5	50 U	50 U	50	0
1,3-Dichlorobenzene	µg/L	5	1 U	1 U	1	0
1,4-Dichlorobenzene	µg/L	5	1 U	1 U	1	0

Table 4-8d. Water Quality Data Results from Rhone-Polenc St. Helens Road Facility.

Parameter	Data Summary					
	Unit	Number of Measurements	Minimum	Maximum	Mean	Number Detected
1-Chloronaphthalene	µg/L	5	10 U	10 U	10	0
1-Naphthylamine	µg/L	5	10 U	10 U	10	0
2,2'-Oxybis(1-chloropropane)	µg/L	5	10 U	10 U	10	0
2,3,4,6-Tetrachlorophenol	µg/L	5	50 U	50 U	50	0
2,4,5-T	µg/L	5	0.05 U	0.05 U	0.05	0
2,4,5-Trichlorophenol	µg/L	5	10 U	10 U	10	0
2,4,6-Trichlorophenol	µg/L	5	1 U	1 U	1	0
2,4-D	µg/L	5	0.25 U	1.2	0.59	2
2,4-DB	µg/L	5	0.1 U	1 U	0.82	0
2,4-Dichloro-6-methylphenol	µg/L	5	5 U	5 U	5	0
2,4-Dichlorophenol	µg/L	5	0.5 U	0.5 U	0.5	0
2,4-Dimethylphenol	µg/L	5	0.5 U	0.5 U	0.5	0
2,4-Dinitrophenol	µg/L	5	1 U	1 U	1	0
2,4-Dinitrotoluene	µg/L	5	10 U	10 U	10	0
2,6-Dichlorophenol	µg/L	5	3 U	3 U	3	0
2,6-Dinitrotoluene	µg/L	5	10 U	10 U	10	0
2-Chloroethyl vinyl ether	µg/L	5	5 U	5 U	5	0
2-Chloronaphthalene	µg/L	5	10 U	10 U	10	0
2-Chlorophenol	µg/L	5	0.5 U	0.5 U	0.5	0
2-Methylnaphthalene	µg/L	5	10 U	10 U	10	0
2-Naphthylamine	µg/L	5	10 U	10 U	10	0
2-Nitroaniline	µg/L	5	50 U	50 U	50	0
2-Nitrophenol	µg/L	5	0.5 U	0.5 U	0.5	0
2-Picoline	µg/L	5	10 U	10 U	10	0
3,3'-Dichlorobenzidine	µg/L	5	20 U	20 U	20	0
3-Methylcholanthrene	µg/L	5	10 U	10 U	10	0
3-Nitroaniline	µg/L	5	50 U	50 U	50	0
4,4'-DDD	µg/L	5	0.1 U	0.1 U	0.1	0
4,4'-DDE	µg/L	5	0.1 U	0.1 U	0.1	0
4,4'-DDT	µg/L	5	0.1 U	0.2 U	0.12	0
4,6-Dinitro-2-methylphenol	µg/L	10	1 U	50 U	26	0
4-Aminobiphenyl	µg/L	5	10 U	10 U	10	0
4-Bromophenyl phenyl ether	µg/L	5	10 U	10 U	10	0
4-Chloro-3-methylphenol	µg/L	5	0.5 U	0.5 U	0.5	0
4-Chloroaniline	µg/L	5	10 U	10 U	10	0
4-Chloro-o-cresol	µg/L	5	2 U	2 U	2	0
4-Chlorophenol	µg/L	5	8 U	8 U	8	0
4-Chlorophenyl phenyl ether	µg/L	5	10 U	10 U	10	0
4-Nitroaniline	µg/L	5	50 U	50 U	50	0
4-Nitrophenol	µg/L	5	1 U	1 U	1	0
7,12-Dimethylbenz(a)anthracene	µg/L	5	10 U	10 U	10	0
Acenaphthene	µg/L	5	10 U	10 U	10	0
Acenaphthylene	µg/L	5	10 U	10 U	10	0
Acetophenone	µg/L	5	10 U	10 U	10	0
Aldrin	µg/L	5	0.05 U	0.05 U	0.05	0
alpha,alpha-Dimethylphenethylamine	µg/L	5	10 U	10 U	10	0

Table 4-8d. Water Quality Data Results from Rhone-Polenc St. Helens Road Facility.

Parameter	Data Summary					
	Unit	Number of Measurements	Minimum	Maximum	Mean	Number Detected
alpha-Endosulfan	µg/L	5	0.05 U	0.05 U	0.05	0
alpha-Hexachlorocyclohexane	µg/L	5	0.05 U	0.05 U	0.05	0
Aniline	µg/L	5	10 U	10 U	10	0
Anthracene	µg/L	5	10 U	10 U	10	0
Azinphosmethyl	µg/L	5	1 U	1 U	1	0
Benz(a)anthracene	µg/L	5	10 U	10 U	10	0
Benzene	µg/L	5	0.5 U	0.5 U	0.5	0
Benzidine	µg/L	5	50 U	50 U	50	0
Benzo(a)pyrene	µg/L	5	10 U	10 U	10	0
Benzo(b)fluoranthene	µg/L	5	10 U	10 U	10	0
Benzo(b+k)fluoranthene	µg/L	5	10 U	10 U	10	0
Benzo(g,h,i)perylene	µg/L	5	10 U	10 U	10	0
Benzo(k)fluoranthene	µg/L	5	10 U	10 U	10	0
Benzoic acid	µg/L	5	50 U	50 U	50	0
Benzyl alcohol	µg/L	5	10 U	10 U	10	0
beta-Endosulfan	µg/L	5	0.1 U	0.1 U	0.1	0
beta-Hexachlorocyclohexane	µg/L	5	0.05 U	0.05 U	0.05	0
Bis(2-chloroethoxy)methane	µg/L	5	10 U	10 U	10	0
Bis(2-chloroethyl)ether	µg/L	5	10 U	10 U	10	0
Bis(2-ethylhexyl) phthalate	µg/L	5	10 U	10 U	10	0
Bromodichloromethane	µg/L	5	1 U	1 U	1	0
Bromoform	µg/L	5	5 U	5 U	5	0
Bromomethane	µg/L	5	5 U	5 U	5	0
Bromoxynil	µg/L	5	0.25 U	1.2 U	0.44	0
Butylbenzyl phthalate	µg/L	5	10 U	10 U	10	0
Carbon tetrachloride	µg/L	5	0.5 U	0.5 U	0.5	0
Chlordane (alpha & gamma)	µg/L	5	0.5 U	0.71	0.57	2
Chlorobenzene	µg/L	10	0.5 U	2	1.3	1
Chlorodibromomethane	µg/L	5	1 U	1 U	1	0
Chloroethane	µg/L	5	5 U	5 U	5	0
Chloroform	µg/L	5	0.5 U	0.5 U	0.5	0
Chloromethane	µg/L	5	5 U	5 U	5	0
Chlorpyrifos	µg/L	5	1 U	1 U	1	0
Chrysene	µg/L	5	10 U	10 U	10	0
cis-1,3-Dichloropropene	µg/L	5	2 U	2 U	2	0
Coumaphos	µg/L	5	1 U	1 U	1	0
Cresol	µg/L	5	1 U	1 U	1	0
Dalapon	µg/L	5	5 U	5 U	5	0
delta-Hexachlorocyclohexane	µg/L	5	0.05 U	0.05 U	0.05	0
Demeton	µg/L	5	1 U	1 U	1	0
Diazinon	µg/L	5	1 U	1 U	1	0
Dibenz(a,h)anthracene	µg/L	5	10 U	10 U	10	0
Dibenzofuran	µg/L	5	10 U	10 U	10	0
Dibutyl phthalate	µg/L	5	10 U	10 U	10	0
Dicamba	µg/L	5	0.1 U	0.1 U	0.1	0
Dichlorodifluoromethane	µg/L	5	10 U	10 U	10	0

Table 4-8d. Water Quality Data Results from Rhone-Polenc St. Helens Road Facility.

Parameter	Data Summary					
	Unit	Number of Measurements	Minimum	Maximum	Mean	Number Detected
Dichloroprop	µg/L	5	0.25 U	0.25 U	0.25	0
Dichlorvos	µg/L	5	2 U	2 U	2	0
Dieldrin	µg/L	5	0.1 U	0.1 U	0.1	0
Diethyl phthalate	µg/L	5	10 U	10 U	10	0
Dimethyl phthalate	µg/L	5	10 U	10 U	10	0
Di-n-octyl phthalate	µg/L	5	10 U	10 U	10	0
Dinoseb	µg/L	5	0.25 U	0.25 U	0.25	0
Diphenylamine	µg/L	5	10 U	10 U	10	0
Disulfoton	µg/L	5	1 U	1 U	1	0
Endosulfan sulfate	µg/L	5	0.1 U	0.1 U	0.1	0
Endrin	µg/L	5	0.1 U	0.1 U	0.1	0
Endrin aldehyde	µg/L	5	5 U	5 U	5	0
Endrin ketone	µg/L	5	0.1 U	0.1 U	0.1	0
Ethoprop	µg/L	5	1 U	1 U	1	0
Ethyl methanesulfonate	µg/L	5	10 U	10 U	10	0
Ethylbenzene	µg/L	5	0.5 U	0.5 U	0.5	0
Ethylene dibromide	µg/L	5	2 U	2 U	2	0
Fensulfothion	µg/L	5	1 U	1 U	1	0
Fenthion	µg/L	5	1 U	1 U	1	0
Fluoranthene	µg/L	5	10 U	10 U	10	0
Fluorene	µg/L	5	10 U	10 U	10	0
gamma-Hexachlorocyclohexane	µg/L	5	0.035 U	0.05	0.047	1
Heptachlor	µg/L	5	0.05 U	0.05 U	0.05	0
Heptachlor epoxide	µg/L	5	0.05 U	0.05 U	0.05	0
Hexachlorobutadiene	µg/L	5	10 U	10 U	10	0
Hexachlorocyclopentadiene	µg/L	5	10 U	10 U	10	0
Hexachloroethane	µg/L	5	10 U	10 U	10	0
Indeno(1,2,3-cd)pyrene	µg/L	5	10 U	10 U	10	0
Isophorone	µg/L	5	10 U	10 U	10	0
Malathion	µg/L	5	1 U	9.8	2.8	1
MCPA	µg/L	5	50 U	50 U	50	0
MCPP	µg/L	5	50 U	50 U	50	0
Merphos	µg/L	5	1 U	1 U	1	0
Methoxychlor	µg/L	5	0.5 U	0.5 U	0.5	0
Methyl methanesulfonate	µg/L	5	10 U	10 U	10	0
Methyl parathion	µg/L	5	1 U	1 U	1	0
Methylene chloride	µg/L	5	5 U	5 U	5	0
Mevinphos	µg/L	5	1 U	1 U	1	0
Naled	µg/L	5	2 U	2 U	2	0
Naphthalene	µg/L	5	10 U	10 U	10	0
Nitrobenzene	µg/L	5	10 U	10 U	10	0
N-Nitrosodibutylamine	µg/L	5	10 U	10 U	10	0
N-Nitrosodimethylamine	µg/L	5	10 U	10 U	10	0
N-Nitrosodiphenylamine	µg/L	5	10 U	10 U	10	0
N-Nitrosodipropylamine	µg/L	5	10 U	10 U	10	0
N-Nitrosopiperidine	µg/L	5	10 U	10 U	10	0

Table 4-8d. Water Quality Data Results from Rhone-Polenc St. Helens Road Facility.

Parameter	Data Summary					
	Unit	Number of Measurements	Minimum	Maximum	Mean	Number Detected
p-Dimethylaminoazobenzene	µg/L	5	10 U	10 U	10	0
Pentachlorobenzene	µg/L	5	10 U	10 U	10	0
Pentachloronitrobenzene	µg/L	5	50 U	50 U	50	0
Pentachlorophenol	µg/L	5	1 U	1 U	1	0
Perthane	µg/L	5	1 U	1 U	1	0
Phenacetin	µg/L	5	10 U	10 U	10	0
Phenanthrene	µg/L	5	10 U	10 U	10	0
Phenol	µg/L	5	0.5 U	0.5 U	0.5	0
Phorate	µg/L	5	1 U	1 U	1	0
Pronamide	µg/L	5	10 U	10 U	10	0
Prothiophos	µg/L	5	1 U	1 U	1	0
Pyrene	µg/L	5	10 U	10 U	10	0
Ronnel	µg/L	5	1 U	1 U	1	0
Silvex	µg/L	5	0.05 U	0.11	0.07	2
Sulprofos	µg/L	5	1 U	1 U	1	0
Tetrachloroethene	µg/L	5	0.5 U	0.5 U	0.5	0
Tetrachlorvinphos	µg/L	5	1 U	1 U	1	0
Tetraethyl pyrophosphate	µg/L	5	2.5 U	2.5 U	2.5	0
Toluene	µg/L	5	0.5 U	0.77	0.6	2
Toxaphene	µg/L	5	1 U	1 U	1	0
trans-1,3-Dichloropropene	µg/L	5	1 U	1 U	1	0
Trichloroethene	µg/L	5	0.5 U	0.5 U	0.5	0
Trichlorofluoromethane	µg/L	5	10 U	10 U	10	0
Trichloronate	µg/L	5	1 U	1 U	1	0
Vinyl chloride	µg/L	5	1 U	5 U	1.8	0
Vinylidene chloride	µg/L	5	0.5 U	0.5 U	0.5	0
Xylene	µg/L	5	1 U	1 U	1	0

Notes:

U - Undetected at concentration shown

J - Estimated value

Table 4-8e. Water Quality Data results from McCormick & Baxter (1992) (RI Phase 3).

Parameter	Data Summary				
	Number of Measurements	Minimum (ug/L)	Maximum (ug/L)	Mean (ug/L)	Number Detected
Acenaphthene	6	0.1 U	1.2	0.67	1
Acenaphthylene	6	0.1 U	0.1 U	0.1	0
Anthracene	6	0.1 U	0.1 U	0.1	0
Benz(a)anthracene	6	0.1 U	0.1 U	0.1	0
Benzo(a)pyrene	6	0.1 U	0.1 U	0.1	0
Benzo(b)fluoranthene	6	0.1 U	0.1 U	0.1	0
Benzo(b+k)fluoranthene	6	0.1 U	0.1 U	0.1	0
Benzo(g,h,i)perylene	6	0.1 U	0.1 U	0.1	0
Benzo(k)fluoranthene	6	0.1 U	0.1 U	0.1	0
Chrysene	6	0.1 U	0.1 U	0.1	0
Dibenz(a,h)anthracene	6	0.1 U	0.1 U	0.1	0
Fluoranthene	6	0.1 U	0.4	0.27	1
Fluorene	6	0.1 U	0.7	0.43	1
High Molecular Weight PAH	6	0.1 U	0.6	0.38	1
Indeno(1,2,3-cd)pyrene	6	0.1 U	0.1 U	0.1	0
Low Molecular Weight PAH	6	0.3 U	2.4	1.8	1
Naphthalene	6	0.1 U	1.1	0.38	1
Pentachlorophenol	6	0.5 U	1 U	0.92	0
Phenanthrene	6	0.1 U	0.5	0.4	1
Polycyclic Aromatic Hydrocarbons	6	0.3 U	3	2.2	1
Pyrene	6	0.1 U	0.2	0.13	1

Notes:

U - Undetected at concentration shown

Table 4-8f. Grab Sample Water Quality Data results from McCormick & Baxter September 2002 Sampling Report.

Parameter	Data Summary (Unfiltered)					Data Summary (Filtered)				
	Number of Measurements	Minimum (ug/L)	Maximum (ug/L)	Mean (ug/L)	Number Detected	Number of Measurements	Minimum (ug/L)	Maximum (ug/L)	Mean (ug/L)	Number Detected
Arsenic	20	0.001 U	0.005 U	0.004	0	7	0.001 U	0.001	0.001	1
Chromium	20	0.001 U	0.040	0.013	15	7	0.001 U	0.001 U	0.001	0
Copper	20	0.002	1.7	0.941	20	7	0.001	0.003	0.002	7
Zinc	20	0.005 U	0.022	0.006	0	7	0.005 U	0.005 U	0.005	0
Acenaphthene	17	0.013	9.8	0.596	2	7	0.024 U	0.027 U	0.025	0
Acenaphthylene	17	0.018 U	0.042	0.022	1	7	0.024 U	0.027 U	0.025	0
Anthracene	17	0.018 U	3.8	0.243	1	7	0.024 U	0.027 U	0.025	0
Benz(a)anthracene	17	0.004	1.5	0.114	3	7	0.024 U	0.027 U	0.025	0
Benzo(a)pyrene	17	0.024 U	0.44	0.055	1	7	0.024 U	0.027 U	0.025	0
Benzo(b)fluoranthene	17	0.018 U	0.77	0.065	1	7	0.024 U	0.027 U	0.025	0
Benzo(k)fluoranthene	17	0.018 U	0.39	0.043	1	7	0.024 U	0.027 U	0.025	0
Benzo(g,h,i)perylene	17	0.018 U	0.087	0.025	1	7	0.024 U	0.027 U	0.025	0
Chrysene	17	0.004	1.2	0.096	3	7	0.024 U	0.027 U	0.025	0
Dibenz(a,h)anthracene	17	0.036 U	0.093	0.045	1	7	0.047 U	0.054 U	0.049	0
Fluoranthene	17	0.004	11.9	0.718	10	7	0.024 U	0.060	0.029	1
Fluorene	7	0.024 U	0.025 U	0.024	0	7	0.024 U	0.027 U	0.025	0
High Molecular Weight PAH	17	0.004	21.81	1.314	10	7	0.047 U	0.102	0.056	1
Indeno(1,2,3-cd)pyrene	17	0.024 U	0.13	0.037	1	7	0.024 U	0.027 U	0.025	0
Low Molecular Weight PAH	17	0.009 U	39.6	2.352	4	7	0.024 U	0.027 U	0.025	0
Naphthalene	17	0.018 U	3.3	0.214	1	7	0.024 U	0.027 U	0.025	0
Pentachlorophenol	17	0.018 U	0.253 U	0.120	5	7	0.236 U	0.270 U	0.025	0
Phenanthrene	17	0.009	22.7	1.354	4	7	0.024 U	0.027 U	0.025	0
Polycyclic Aromatic Hydrocarbons	17	0.004	61.45	3.651	10	7	0.047 U	0.102	0.056	1
Pyrene	17	0.011	5.3	0.331	4	7	0.024 U	0.0423	0.027	1

Notes:

U - Undetected at concentration shown

Table 4-8g. SPMD/DGT Water Quality Data Results from McCormick & Baxter September 2002 Sampling Report.

Parameter	Data Summary				
	Number of Measurements	Minimum (ug/L)	Maximum (ug/L)	Mean (ug/L)	Number Detected
Arsenic	20	0.002 U	0.002 U	0.002	0
Chromium	20	0.002 U	0.54	0.261	9
Copper	20	0.005 U	0.03	0.007	3
Zinc	20	0.002 U	0.002 U	0.002	0
Acenaphthene	19	0.0055	0.0671	0.028	19
Acenaphthylene	19	0.0021 U	0.0021 U	0.002	0
Anthracene	19	0.0025	0.0351	0.011	19
Benz(a)anthracene	0				0
Benzo(a)pyrene	19	0.00033 U	0.00033 U	0.000	0
Benzo(b)fluoranthene	19	0.00015 U	0.00015 U	0.000	0
Benzo(k)fluoranthene	19	0.00015 U	0.00015 U	0.000	0
Benzo(g,h,i)perylene	19	0.0149 U	0.0149 U	0.015	0
Chrysene	0				0
Dibenz(a,h)anthracene	19	0.007 U	0.007 U	0.007	0
Fluoranthene	19	0.0237	0.445	0.116	19
Fluorene	19	0.0952	0.6750	0.300	19
High Molecular Weight PAH	19	0.0446	0.499	0.192	19
Indeno(1,2,3-cd)pyrene	19	0.0152 U	0.0152 U	0.015	0
Low Molecular Weight PAH	19	0.1206	0.9322	0.389	19
Naphthalene	19	0.0014 U	0.0014 U	0.001	0
Pentachlorophenol	20				0
Phenanthrene	19	0.0124	0.1550	0.050	19
Polycyclic Aromatic Hydrocarbons	19	0.1652	1.3742	0.581	19
Pyrene	19	0.0209	0.154	0.075	19

Notes:

U - Undetected at concentration shown

SPMD - Semipermeable membrane device

DGT - Diffusive gel thinfilm

Table 4-9. QA/QC Summary of Existing Willamette River Bioassay Data.

Citation	Location	Project Type	Tests Completed	Samples	Surface vs. Subsurface[1]	Data Usability Category
Maul, Foster & Alongi (1996)	Moody Ave. Waterfront	Remedial Investigation	10-Day Amphipod-*Hyalella azteca* Midge Mortality and Growth-*Chironomus t.*	4 + 1 ref 1 1	surface	First 5 samples tested are Category 1. Last 2 samples (WRS25-1&WRS26-1) are Category 2 for both tests due to hold time exceedances.
Ecology and Environment (2001)	McCormick & Baxter RD Ph. I and II	Remedial Design	10-Day Amphipod-*Hyalella azteca* Midge Mortality and Growth-*Chironomus t.*	39 + 4 ref 17 + 1 ref	Ph. I surface, Ph. II subsurface	Category 1. No raw data sheets available for independent review. All data found usable by E&E.
Harding ESE (2001)	Cargill Elevator Terminal	Dredging	10-Day Amphipod-*Hyalella azteca* Midge Mortality and Growth-*Chironomus t.*	3	subsurface	Category 1. No reference sample(s).
Hart Crowser (2000)	Ross Island	Site Investigation	10-Day Amphipod-*Hyalella azteca* Midge Mortality and Growth-*Chironomus t.*	11 + 3 ref	surface	Category 1.
Corps, Portland District (1999)	Willamette River	Dredging	10-Day Amphipod-*Hyalella azteca* Midge Mortality and Growth-*Chironomus t.* 28-Day Bioaccumulation-*Lumbriculus*	4 + 1 ref	subsurface	Category 1. Amphipod and Midge tests. Category 2. Organism behavorial information and mortality data not recorded for 28-Day bioaccumulation test.
Landau Associates (2000b)	Ross Island	Remedial Investigation	10-Day Amphipod-*Hyalella azteca* Midge Mortality and Growth-*Chironomus t.*	1 + 4 ref	surface	Category 1.
Exponent (1999)	TOSCO Terminal	Dredging	10-Day Amphipod-*Hyalella azteca* Midge Mortality and Growth-*Chironomus t.*	2 + 1 ref	subsurface	Category 1.
Hart Crowser (1999a)	Terminal 4, Slip 3 Ph. I and II	Remedial Investigation	10-Day Amphipod-*Hyalella azteca* Midge Mortality and Growth-*Chironomus t.*	6 + 2 ref 10 + 2 ref	surface	Category 1.
Hart Crowser (1999d)	Terminal 4, Berth 416	Dredging	10-Day Amphipod-*Hyalella azteca* Midge Mortality and Growth-*Chironomus t.*	1 + 1 ref	subsurface	Category 1.
Hart Crowser (1999c)	Terminal 2, Berths 203-206	Dredging	10-Day Amphipod-*Hyalella azteca* Midge Mortality and Growth-*Chironomus t.*	2 + 1 ref	subsurface	Category 1.
SEA (1998)	Portland Shipyard	Site Investigation	10-Day Amphipod-*Hyalella azteca* Midge Mortality and Growth-*Chironomus t.* Microtox-saline extract	36 + 3 ref	surface	Category 1, except 25 samples with Microtox holding time exceedances of reconstituted bacteria. These are Category 2.
Dames & Moore (1998)	Portland Shipyard	Site Investigation	10-Day - *Hyalella azteca*	2	surface	Category 1. No reference sample(s).
Dames & Moore (1998 - data collected 12/97)	Portland Shipyard	Site Investigation	10-Day - *Hyalella azteca*	5	surface	Category 1. No reference sample(s).

Table 4-9. QA/QC Summary of Existing Willamette River Bioassay Data.

Citation	Location	Project Type	Tests Completed	Samples	Surface vs. Subsurface[1]	Data Usability Category
Port of Portland (1994b)	Terminal 2, Berth 203	Dredging	10-Day Amphipod-*Hyalella azteca* 48-Hour *Daphnia magna* Mortality	1	subsurface	Category 1. No reference sample(s) for solid phase test.
PTI (1992)	McCormick & Baxter Ph. I and II	Remedial Investigation	10-Day Amphipod-*Hyalella azteca* Microtox-porewater	46 + 4 ref 6 + 1 ref	surface	Category 2. Generally no supporting documentation, one data validation memorandum available for Phase I data only.
Port of Portland - 1991 (as reported in Dames & Moore, 1998)	Portland Shipyard - Dry Dock 4	Dredging	10-Day Amphipod-*Hyalella azteca* 48-Hour *Daphnia magna* Mortality *96-Hour Daphnia magna* Mortality Rainbow Trout Mortality and Bioaccumulation	1	subsurface	Category 2. Generally, no supporting documentation. No reference sediment for solid phase tests.
DEQ (1994)	Willamette River	Willamette River Toxics Study	10-Day Amphipod-*Hyalella azteca* Midge Mortality and Growth-*Chironomus r.* 48-Hour *Daphnia magna* Mortality Microtox-porewater	6 in 88&89, 14 Microtox	surface	Category 2. Generally, no supporting documentation and no methods references.
Corps, Portland District (1990)	Lower Willamette River	Dredging	Midge Mortality and Growth-Chironomus r. 48-Hour Mortality *Daphnia magna* Elutriate Mortality *Daphnia magna*	4	subsurface	Category 2. No reference sample(s). No QA/QC back-up so data could not be validated.

Notes:

[1] Surface samples were generally collected using a surface grab and represented the top 6 inches of sediment. Subsurface samples were collected with a coring device and represented samples collected below the top 6 inches.

Table 4-10. Bioassay Data Sets from Environmental Investigations in the Lower Willamette River.

Citation	Title	Test Start Date
Maul, Foster & Alongi (1996)	Zidell Waterfront RI	Nov-00, Dec-00, Jan-01
Ecology and Environment (2001)	McCormick & Baxter Creosoting Company, Sediment Remedial Design	Oct-01
Harding ESE (2001)	Results of Sediment Sampling and Analysis, Cargill Elevator Terminal	Aug-01
Hart Crowser (2000)	Site Investigation Report, Port of Portland Confined Dredged Material Disposal, Ross Island Facility	Dec-99
Corps, Portland District (1999)	Willamette River Sediment Sampling Evaluation, Portland District	Nov-99
Landau Associates (2000c)	Phase I Remedial Investigation, Ross Island Sand & Gravel Co.	Nov-99
Exponent (1999)	January 1999 Sediment Sampling Results for TOSCO Terminal	Jan-99
Hart Crowser (1999a)	Remedial Investigation Report, Terminal 4, Slip 3 Sediments, Port of Portland (Phase I and Phase II data)	Oct-98, Dec-98
Hart Crowser (1999d)	Sediment Characterization Study, Marine Terminal 4, Berth 416, Port of Portland	Oct-98
Hart Crowser (1999c)	Sediment Characterization Study Marine Terminal 2, Berths 203-206, Port of Portland	Oct-98
SEA (1998)	Portland Shipyard Sediment Investigation	Apr-98
Dames & Moore (1998)	Portland Shipyard Environmental Audit	Dec-97, Jan-98
Port of Portland (1994b)	Dredging Study Marine Terminal 2, Berth 203	May-94
PTI (1992)	McCormick & Baxter Creosoting Company Remedial Investigation (Phase I and Phase II data)	Sep-90, Jan-92
Port of Portland - 1991 (as reported in Dames & Moore, 1998)	Port of Portland Dry Dock 4	Dec-91
DEQ (1994)	Willamette River Toxics Study (1988-1991)	Aug-88, Jan-88
Corps, Portland District (1990)	Lower Willamette River sediment samples	Mar-88

Table 4-11. Tissue Data Summary.

Chemical	*d*	Min	units	DQ	Max	units	DQ
Wet weight							
Signal crayfish (*Pacifastacus leniusculus*)							
Low Molecular Weight PAH	4	130	ppb	L	160	ppb	L
Naphthalene	4	26	ppb		57	ppb	
Zinc	6	14	ppm		15	ppm	M
Acenaphthene	1	21	ppb		21	ppb	
Arsenic	6	0.14	ppm	E	0.24	ppm	E
Chromium	6	0.48	ppm		1.6	ppm	
Copper	6	9.4	ppm		13	ppm	
Mercury	1	0.069	ppm		0.069	ppm	
4,4'-DDE	1	4.6	ppb		4.6	ppb	
Largescale sucker (*Catostomus macrocheilus*)							
Acenaphthene	7	10	ppb	E	57	ppb	
Chromium	17	0.072	ppm	E	0.55	ppm	
Copper	15	0.053	ppm		0.5	ppm	
Mercury	18	0.07	ppm		0.37	ppm	
Fluorene	3	16	ppb	E	46	ppb	
High Molecular Weight PAH	1	180	ppb	LM	180	ppb	LM
Low Molecular Weight PAH	7	110	ppb	L	220	ppb	L
Pyrene	1	17	ppb	E	17	ppb	E
Naphthalene	7	21	ppb		78	ppb	M
Zinc	18	3.6	ppm		7.4	ppm	E
Sturgeon (*Acipenser* spp.)							
Mercury	1	0.18	ppm		0.18	ppm	
Smallmouth bass (*Micropterus dolomieu*)							
Mercury	12	0.11	ppm		0.54	ppm	
2,2',5,5'-Tetrachlorobiphenyl	7	2.6	ppb		17	ppb	
2,2',4,5'-Tetrachlorobiphenyl	5	3.4	ppb		8.9	ppb	
2,3,4,4'-Tetrachlorobiphenyl	4	2.65	ppb		5.5	ppb	
2,2',4,5,5'-Pentachlorobiphenyl	12	2	ppb		50	ppb	
2,2',4,4',5-Pentachlorobiphenyl	9	1.7	ppb		27	ppb	
2,3,4,4',5,6-Hexachlorobiphenyl	4	3.2	ppb		5.7	ppb	
2,2',3,3',4,4'-Hexachlorobiphenyl	7	3.1	ppb		16	ppb	
alpha-Chlordane	4	0.5	ppb		3.8	ppb	
4,4'-DDE	16	15	ppb		450	ppb	
4,4'-DDD	11	2.2	ppb		32	ppb	
4,4'-DDT	15	2.46	ppb		79	ppb	
Dieldrin	7	1.34	ppb		3.6	ppb	
gamma-Hexachlorocyclohexane	3	0.19	ppb		2	ppb	
beta-Hexachlorocyclohexane	2	0.04	ppb		2	ppb	
gamma-Chlordane	3	0.25	ppb		2	ppb	
alpha-Hexachlorocyclohexane	1	2	ppb		2	ppb	
delta-Hexachlorocyclohexane	1	2	ppb		2	ppb	
Heptachlor	1	2	ppb		2	ppb	
Aldrin	1	2	ppb		2	ppb	
Heptachlor epoxide	1	2	ppb		2	ppb	

Table 4-11. Tissue Data Summary.

Chemical	*d*	Min	units	DQ	Max	units	DQ
Black crappie (*Pomoxis nigromaculatus*)							
Mercury	7	0.013	ppm		0.52	ppm	
2,2',5,5'-Tetrachlorobiphenyl	9	2.3	ppb		3.7	ppb	
2,2',4,5'-Tetrachlorobiphenyl	4	2.37	ppb		3.6	ppb	
2,2',4,5,5'-Pentachlorobiphenyl	12	3.2	ppb		9.7	ppb	
2,2',4,4',5-Pentachlorobiphenyl	12	2.4	ppb		6.7	ppb	
2,3,4,4',5,6-Hexachlorobiphenyl	1	2.4	ppb		2.4	ppb	
2,2',3,3',4,4'-Hexachlorobiphenyl	1	2.7	ppb		2.7	ppb	
alpha-Chlordane	5	0.47	ppb		0.88	ppb	
4,4'-DDE	14	14	ppb		130	ppb	
4,4'-DDD	12	3	ppb		11	ppb	
4,4'-DDT	14	1.8	ppb		15	ppb	
Dieldrin	7	0.95	ppb		2.7	ppb	
gamma-Hexachlorocyclohexane	5	0.09	ppb		0.18	ppb	
gamma-Chlordane	5	0.24	ppb		0.37	ppb	
Common carp (*Cyprinus carpio*)							
Mercury	19	0.054	ppm		0.49	ppm	
2,2',5,5'-Tetrachlorobiphenyl	6	2	ppb		13	ppb	
2,2',4,5'-Tetrachlorobiphenyl	5	3.1	ppb		10	ppb	
2,2',4,5,5'-Pentachlorobiphenyl	6	4.6	ppb		59.2	ppb	
2,2',4,4',5-Pentachlorobiphenyl	4	5.1	ppb		11	ppb	
2,2',3,3',4,4'-Hexachlorobiphenyl	5	2.6	ppb		7.3	ppb	
2,3,4,4'-Tetrachlorobiphenyl	1	2.1	ppb		2.1	ppb	
alpha-Chlordane	2	2.5	ppb		8.2	ppb	
4,4'-DDE	6	25	ppb		85	ppb	
4,4'-DDD	6	7.2	ppb		37	ppb	
4,4'-DDT	6	3.3	ppb		16	ppb	
Dieldrin	3	3.2	ppb		4.6	ppb	
gamma-Chlordane	1	4.2	ppb		4.2	ppb	
Chinook salmon, spring (*Oncorhynchus tshawytscha*)							
Mercury	2	0.08	ppm		0.12	ppm	
gamma-Chlordane	2	0.19	ppb		0.23	ppb	
alpha-Chlordane	2	0.65	ppb		0.68	ppb	
4,4'-DDE	2	6	ppb		7.45	ppb	
Dieldrin	2	0.52	ppb		0.73	ppb	
4,4'-DDD	2	1.97	ppb		2.03	ppb	
4,4'-DDT	1	1.56	ppb		1.56	ppb	
2,2',5,5'-Tetrachlorobiphenyl	1	2.5	ppb		2.5	ppb	
beta-Hexachlorocyclohexane	1	0.05	ppb		0.05	ppb	
Heptachlor epoxide	1	0.14	ppb		0.14	ppb	
Sucker (*Catostomus* spp.)							
Mercury	3	0.05	ppm		0.35	ppm	
Peamouth (*Mylocheilus caurinus*)							
Mercury	2	0.05	ppm		0.17	ppm	
Chiselmouth (*Acrocheilus alutaceus*)							
Mercury	2	0.04	ppm		0.13	ppm	

Table 4-11. Tissue Data Summary.

Chemical	*d*	Min	units	DQ	Max	units	DQ
Northern pikeminnow (*Ptychocheilus oregonensis*)							
Mercury	2	0.8	ppm		0.8	ppm	
Largemouth bass (*Micropterus salmoides*)							
Mercury	5	0.16	ppm		0.91	ppm	
White crappie (*Pomoxis annularis*)							
Mercury	1	0.23	ppm		0.23	ppm	
Dry weight							
Common carp (*Cyprinus carpio*)							
Tetrachlorodibenzo-p-dioxin	1	7	ppt		7	ppt	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	1	3.4	ppt		3.4	ppt	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	1	25	ppt		25	ppt	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	1	1.3	ppt		1.3	ppt	
Hexachlorodibenzo-p-dioxin	1	30	ppt		30	ppt	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	1	33	ppt		33	ppt	
Heptachlorodibenzo-p-dioxin	1	34	ppt		34	ppt	
Octachlorodibenzo-p-dioxin	1	31	ppt		31	ppt	
Tetrachlorodibenzofuran	1	19	ppt		19	ppt	
1,2,3,7,8-Pentachlorodibenzofuran	1	1.8	ppt		1.8	ppt	
2,3,4,7,8-Pentachlorodibenzofuran	1	7	ppt		7	ppt	
Pentachlorodibenzofuran	1	8.7	ppt		8.7	ppt	
2,3,4,6,7,8-Hexachlorodibenzofuran	1	1.2	ppt		1.2	ppt	
1,2,3,4,7,8-Hexachlorodibenzofuran	1	2.6	ppt		2.6	ppt	
1,2,3,6,7,8-Hexachlorodibenzofuran	1	1.3	ppt		1.3	ppt	
Hexachlorodibenzofuran	1	7.9	ppt		7.9	ppt	
1,2,3,4,6,7,8-Heptachlorodibenzofuran	1	2.8	ppt		2.8	ppt	
Heptachlorodibenzofuran	1	2.8	ppt		2.8	ppt	
2,3,7,8-Tetrachlorodibenzo-p-dioxin	7	0.26	ppt		7	ppt	
2,3,7,8-Tetrachlorodibenzofuran	7	0.28	ppt		17	ppt	
Cadmium	2	0.02	ppm		0.02	ppm	
Copper	10	0.13	ppm		0.78	ppm	
Mercury	10	0.11	ppm		0.46	ppm	J
Zinc	10	4.85	ppm	J	14.56	ppm	
Chromium	1	0.04	ppm		0.04	ppm	
Lead	1	0.03	ppm		0.03	ppm	
alpha-Hexachlorocyclohexane	3	4	ppb		4	ppb	
delta-Hexachlorocyclohexane	4	2	ppb		5	ppb	
gamma-Hexachlorocyclohexane	1	2	ppb		2	ppb	
4,4'-DDD	12	4	ppb		144	ppb	
4,4'-DDE	13	12	ppb		268	ppb	
4,4'-DDT	9	5	ppb		216	ppb	
Heptachlor	6	2	ppb		68	ppb	
Heptachlor epoxide	2	4	ppb		6	ppb	
Dieldrin	3	10	ppb		352	ppb	

Table 4-11. Tissue Data Summary.

Chemical	*d*	Min	units	DQ	Max	units	DQ
alpha-Endosulfan	2	2	ppb		148	ppb	
Endosulfan sulfate	2	19	ppb		26	ppb	
Endrin aldehyde	2	25	ppb		88	ppb	
Methoxychlor	1	832	ppb		832	ppb	
Aroclor 1254	3	160	ppb		360	ppb	
Aroclor 1260	4	25	ppb		1403	ppb	
Aroclor 1232	1	6.7	ppb		6.7	ppb	
3,3',4,4'-Tetrachlorobiphenyl	1	37	ppb		37	ppb	
2,3,3',4,4'-Pentachlorobiphenyl	1	6	ppb		6	ppb	
3,3',4,4',5-Pentachlorobiphenyl	1	21	ppb		21	ppb	
Acenaphthene	1	500	ppb		500	ppb	
Naphthalene	1	500	ppb		500	ppb	
Northern pikeminnow (*Ptychocheilus oregonensis*)							
2,3,7,8-Tetrachlorodibenzo-p-dioxin	6	0.8	ppt		1.89	ppt	
2,3,7,8-Tetrachlorodibenzofuran	6	1.13	ppt		30.31	ppt	
Arsenic	1	0.3	ppm		0.3	ppm	
Copper	2	0.24	ppm		0.57	ppm	
Mercury	2	0.21	ppm		0.34	ppm	
Lead	1	0.03	ppm		0.03	ppm	
Selenium	1	0.25	ppm		0.25	ppm	
Zinc	2	4.98	ppm		16.35	ppm	
Aroclor 1254	1	200	ppb		200	ppb	
Aroclor 1260	3	96	ppb		209	ppb	
alpha-Chlordane	1	10	ppb		10	ppb	
4,4'-DDD	1	20	ppb		20	ppb	
4,4'-DDE	2	52	ppb		130	ppb	
4,4'-DDT	1	10	ppb		10	ppb	
cis-Nonachlor	1	10	ppb		10	ppb	
trans-Nonachlor	1	10	ppb		10	ppb	
Pentachloroanisole	1	10	ppb		10	ppb	
3,3',4,4'-Tetrachlorobiphenyl	2	7	ppb		11	ppb	
3,3',4,4',5-Pentachlorobiphenyl	1	6	ppb		6	ppb	
alpha-Hexachlorocyclohexane	1	4	ppb		4	ppb	
Peamouth (*Mylocheilus caurinus*)							
Arsenic	2	0.06	ppm		0.07	ppm	
Cadmium	2	0.01	ppm		0.01	ppm	
Copper	2	0.5	ppm		0.59	ppm	
Mercury	2	0.04	ppm		0.05	ppm	
Lead	2	0.05	ppm		0.08	ppm	
Selenium	2	0.11	ppm		0.13	ppm	
Zinc	2	17.48	ppm		17.55	ppm	
Aroclor 1254	2	10	ppb		100	ppb	

Table 4-11. Tissue Data Summary.

Chemical	*d*	Min	units	DQ	Max	units	DQ
Aroclor 1260	1	100	ppb		100	ppb	
alpha-Chlordane	2	10	ppb		10	ppb	
4,4'-DDD	2	10	ppb		10	ppb	
4,4'-DDE	2	30	ppb		30	ppb	
4,4'-DDT	1	10	ppb		10	ppb	
trans-Nonachlor	2	10	ppb		10	ppb	
Pentachloroanisole	2	10	ppb		10	ppb	
Dieldrin	1	10	ppb		10	ppb	
Bass (*Micropterus* spp.)							
Copper	1	0.23	ppm		0.23	ppm	
Mercury	1	0.1	ppm		0.1	ppm	
Zinc	1	5.8	ppm		5.8	ppm	
Sucker (*Catostomus* spp.)							
Copper	1	0.27	ppm		0.27	ppm	
Mercury	1	0.05	ppm		0.05	ppm	
Zinc	1	5.64	ppm		5.64	ppm	
Heptachloro-1,1'-biphenyl	1	84.3	ppb		84.3	ppb	
Octachloro-1,1'-biphenyl	1	12.6	ppb		12.6	ppb	
alpha-Hexachlorocyclohexane	1	7.17	ppb		7.17	ppb	
gamma-Hexachlorocyclohexane	1	18.6	ppb		18.6	ppb	
4,4'-DDE	1	37.1	ppb		37.1	ppb	
Pentachloroanisole	1	5.24	ppb		5.24	ppb	
Biphenyl	1	7.33	ppb		7.33	ppb	
Signal crayfish (*Pacifastacus leniusculus*)							
Heptachlorodibenzo-p-dioxin	1	34.42	ppt		34.42	ppt	
Heptachlorodibenzofuran	1	6.44	ppt		6.44	ppt	
1,2,3,4,7,8,9-Heptachlorodibenzofuran	1	1.76	ppt		1.76	ppt	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	1	10.05	ppt		10.05	ppt	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	1	1.42	ppt		1.42	ppt	
1,2,3,4,7,8-Hexachlorodibenzofuran	1	18.85	ppt	*	18.85	ppt	*
1,2,3,6,7,8-Hexachlorodibenzofuran	1	10.15	ppt		10.15	ppt	
1,2,3,7,8,9-Hexachlorodibenzofuran	1	0.23	ppt		0.23	ppt	
2,3,4,6,7,8-Hexachlorodibenzofuran	1	0.87	ppt		0.87	ppt	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	1	3.75	ppt		3.75	ppt	
1,2,3,7,8-Pentachlorodibenzofuran	1	54.32	ppt		54.32	ppt	
2,3,4,7,8-Pentachlorodibenzofuran	1	19.02	ppt		19.02	ppt	
2,3,7,8-Tetrachlorodibenzo-p-dioxin	1	2.61	ppt		2.61	ppt	
2,3,7,8-Tetrachlorodibenzofuran	1	48.14	ppt		48.14	ppt	
Largemouth bass (*Micropterus salmoides*)							
Heptachlorodibenzo-p-dioxin	1	0.43	ppt		0.43	ppt	
Heptachlorodibenzofuran	1	0.24	ppt		0.24	ppt	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	1	0.82	ppt		0.82	ppt	
2,3,4,7,8-Pentachlorodibenzofuran	1	0.34	ppt		0.34	ppt	
2,3,7,8-Tetrachlorodibenzo-p-dioxin	1	0.74	ppt		0.74	ppt	
2,3,7,8-Tetrachlorodibenzofuran	1	1.09	ppt		1.09	ppt	

Table 4-11. Tissue Data Summary.

Chemical	*d*	Min	units	DQ	Max	units	DQ
Largescale sucker (*Catostomus macrocheilus*)							
Heptachlorodibenzo-p-dioxin	1	16.57	ppt		16.57	ppt	
Heptachlorodibenzofuran	1	2.66	ppt		2.66	ppt	
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	1	1.1	ppt		1.1	ppt	
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	1	4.06	ppt		4.06	ppt	
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	1	0.61	ppt		0.61	ppt	
1,2,3,4,7,8-Hexachlorodibenzofuran	1	3.02	ppt	*	3.02	ppt	*
2,3,4,6,7,8-Hexachlorodibenzofuran	1	1.16	ppt		1.16	ppt	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	1	3.31	ppt		3.31	ppt	
1,2,3,7,8-Pentachlorodibenzofuran	1	0.91	ppt		0.91	ppt	
2,3,4,7,8-Pentachlorodibenzofuran	1	2.27	ppt		2.27	ppt	
2,3,7,8-Tetrachlorodibenzo-p-dioxin	1	2.25	ppt		2.25	ppt	
2,3,7,8-Tetrachlorodibenzofuran	1	3.35	ppt		3.35	ppt	
Prickly sculpin (*Cottus asper*)							
Polychlorinated biphenyls	4	190	ppb		630	ppb	

Notes:

d Total number of detections

Data Qualifier (DQ) Codes

* Coelution of 1,2,3,4,7,8-HxCDF with 1,2,3,4,6,7-HxCDF on the GC column

E Estimate, value exceeds highest calibration standard

EM Combination qualifier code

L Value is less than the maximum shown

LM Combination qualifier code

M Value is a mean

Tissue data were compiled from the following sources:

DEQ (1994). Willamette River Toxics Study (1988-1991).

DEQ (2000b). DEQ Water Quality Program--Mercury Data from Gene Foster per Avocet.

EPA (1992). EPA National Study of Chemical Residues in Fish.

Hart Crowser, Inc. (1988). Remedial Action Plan, Station "L" Site, Willamette River Sediments.

The Oregonian (2000). River of Risk Series.

PTI (1992). McCormick & Baxter Creosoting Company Remedial Investigation Report

Bonn (1998). Dioxins and Furans in Bed Sediments and Fish Tissue of the Willamette Basin, Oregon.

Table 4-12. 28-Day Bioaccumulation Testing (*Lumbriculus variegates*) (USACE 1999).

Sample I.D.	Micrograms per kilogram (ug/kg)			
	4,4′-DDD	4,4′-DDE	4,4′-DDT	Total DDT
Control				
Rep-1	<2.1	9.9	<5.2	9.9
Rep-2	<2.1	11	<5.1	11
Rep-3	<1.9	11	<4.7	11
Rep-4	<2.0	10	<5.0	10
Rep-5	<2.3	30	15	45
CR-VC-01R				
Rep-1	<2.3	72	<5.7	72
Rep-2	<1.7	78	<4.2	78
Rep-3	<2.1	87	<5.2	87
Rep-4	<2.3	75	<5.8	75
Rep-5	<1.8	74	<4.5	74
WR-VC-02				
Rep-1	7.1	30	<5.8	37.1
Rep-2	9.1	47	<3.8	56.1
Rep-3	9.3	47	<5.4	56.3
Rep-4	7.2	37	<5.9	44.2
Rep-5	11	44	<5.0	55
WR-VC-03				
Rep-1	4.2	36	<4.1	40.2
Rep-2	4.6	38	<5.0	42.6
Rep-3	3.8	42	<5.1	45.8
Rep-4	2.8	31	<4.2	33.8
Rep-5	4.6	37	<4.5	41.6
WR-VC-04				
Rep-1	2.8	26	<4.1	28.8
Rep-2	3.2	28	<5.3	31.2
Rep-3	4.2	33	<7.9	37.2
Rep-4	<12.0	40	<29.0	40
Rep-5	*	*	*	*
WR-VC-05				
Rep-1	<17.0	32	<42.0	32
Rep-2	*	*	*	*
Rep-3	<4.9	31	<12.0	31
Rep-4	11	30	<26.0	41
Rep-5	*	*	*	*

Notes:

* Tissue samples not sent for chemical analysis.

< Chemical not detected at the reported limit.

Total DDT = Sum of detected DDD, DDE, and DDT concentrations.

Table 4-13. Number of Post-1990 Category 1 Sediment Samples in Portland Harbor by River Mile.

Surface Sediment	River Mile 0 - 1	1 - 2	2 - 3	3 - 4	4 - 5	5 - 6	6 - 7	7 - 8	8 - 9	9 - 10	10 - 11	Total
Aroclors	2	4	17	6	16	14	31	31	91	17	24	253
Butyltins	2	3	3	9	11	27	34	48	77	12	19	245
Conventionals	2	4	17	17	82	34	86	124	159	22	27	574
Dioxins_Furans	--	--	--	--	--	--	14	8	--	--	--	22
Herbicides	--	--	--	--	--	--	8	3	18	--	--	29
Metals	2	4	17	20	67	43	93	108	109	18	22	503
PAHs	2	4	17	17	82	29	89	112	110	18	27	507
Pesticides	2	3	3	6	21	8	33	40	44	14	18	192
Petroleum	--	--	1	--	44	6	9	4	18	--	3	85
SVOCs	2	3	17	17	71	26	51	83	106	16	24	416
Phenols	--	2	14	15	70	24	67	98	102	14	20	426
Phthalates	--	1	14	15	70	24	47	77	108	17	23	396
VOCs	--	--	--	--	41	--	23	31	26	6	13	140

Subsurface Sediment	River Mile 0 - 1	1 - 2	2 - 3	3 - 4	4 - 5	5 - 6	6 - 7	7 - 8	8 - 9	9 - 10	10 - 11	Total
Aroclors	10	7	4	1	12	11	5	30	55	16	11	162
Butyltins	3	7	2	1	6	11	9	33	26	12	7	117
Conventionals	11	8	5	3	33	11	91	101	144	17	12	436
Dioxins_Furans	--	--	1	--	--	--	10	3	1	--	--	15
Herbicides	--	--	2	--	--	--	--	--	7	2	--	11
Metals	10	7	2	3	26	12	80	56	71	12	11	290
PAHs	10	7	5	3	33	12	100	73	64	18	12	337
Pesticides	10	7	4	1	12	8	43	34	16	18	9	162
Petroleum	--	--	1	--	16	3	9	26	--	--	2	57
SVOCs	10	6	5	3	33	12	53	63	62	17	8	272
Phenols	1	7	4	3	32	11	33	63	59	16	7	236
Phthalates	1	6	4	3	32	11	4	45	60	12	2	180
VOCs	--	--	--	--	21	--	27	27	2	2	--	79

Notes: River mile 0 is the confluence with the Columbia River.

Table 6-1. Portland Harbor RI/FS Deliverable Descriptions

Phase	Deliverable	Purpose
Project Scoping	Process to Identify COPCs TM	Describes the process and timing for identifying COPCs based on Round 1 and Round 2A data. Result of the screening will be identification of COPCs that will be the focus of future sampling rounds and risk analysis and will be limited to those chemicals that are identified as COPCs by screening methods or based on preliminary risk estimates. Descriptions of COPC screening methods used in the ERA and HHRA will be included. This technical memorandum will identify the steps in the RI process at which COPC identification will occur (e.g., the Ecological Preliminary Risk Evaluation and Round 2 Site Characterization and Summary Report). The technical memorandum will also identify potential interim steps where additional risk evaluation may be needed to support data gaps analysis or risk communication needs.
	Process for Derivation of PRGs TM	Explains the approach to be used for developing PRGs. Development of initial PRGs is expected to occur after Round 2, which will be used in identifying data gaps for Round 3. These initial PRGs will be revised based on results of Round 3 and used to develop refined PRGs for use in the FS. In addition to addressing the requirements of the SOW, the possible approaches include deriving site-specific BSAFs, using an aquatic food web model, using the benthic predictive model, and/or evaluating potential reduction in risk under various exposure scenarios.
	Ecological and Human Health Groundwater Pathways Assessment/ Groundwater Sampling Approach TM	Specifies a framework for identifying data uses and data needs for evaluating the effects of COIs in groundwater discharging to the Transition Zone and surface water. Identifies which sites to conduct additional evaluation of the groundwater pathway to the river, summarizes exposure scenarios to COIs discharging to the Transition Zone and surface water, identifies how existing data and field data collected as part of the RI/FS will be used, establishes a process for identifying locations where additional data to assess groundwater discharge are needed, and identifies data needs from those locations.
	Approach to Determining Background for the Portland Harbor Superfund Site / Process for Delineating the Extent of Contamination Upstream and Downstream of the ISA	Describes the definition and approach for determining background levels for the Site. This information will be used, following the risk characterization in the risk assessment, as a risk management tool, consistent with EPA guidelines (EPA 2002c). Describes the general approach to determine the data and analyses needed upstream and downstream of the ISA for EPA to determine Site boundaries.
	Conceptual Site Model Update	Presents existing upland site information for potential sources and source-related data as well as data on potential past and/or current pathways to sediment, surface water, and Transition Zone water, from groundwater, storm and wastewater discharges, erosion, and over-water activities. The update will focus on providing detailed data on the groundwater transport pathway to facilitate scoping of Round 2B subsurface sediment sampling. The CSM will be more completely updated in the Comprehensive Round 2 Site Characterization Summary and Data Gaps Analysis Report.
	Round 2 Quality Assurance Project Plan	Describes laboratory and QA/QC procedures applicable to Round 2 sediment and surface water sampling

Table 6-1. Portland Harbor RI/FS Deliverable Descriptions

Phase	Deliverable	Purpose
Project Scoping	Cultural Resource Survey	Reviews agency records, historical documents, and other published and unpublished materials to define locations of known or reported cultural resources and locations where cultural resources are likely to be present. The survey area extends from the mouth of the Willamette River to Willamette Falls. Will include information gathered by certain Tribes on traditional and present cultural use of the study area.
Hydrodynamic Modeling	Hydrodynamic Modeling TM	Presents and analyzes existing data about physical processes that could influence hydrodynamic and sedimentation in the Lower Willamette River. Identifies those processes that should be included in a model description of the study area. Proposes the model to be used to simulate hydrodynamic and sedimentation processes in the Lower Willamette River. Proposes the extent of the area to be modeled and the approach to model calibration and application.
	Step 1 Hydrodynamic Modeling Results	Presents the development of the model grid to the Lower Willamette River and Multnomah Channel. Presents the preparation of model input and calibration data. Presents and analyzes the model calibration to observations (hydrodynamic and sediment). Presents a sensitivity analysis of study area processes. Recommends whether the 2-D model is adequate for application to evaluate remedial alternatives or whether a 3-D model should be developed from the 2-D model grid. Identifies types and locations of additional data that could benefit the modeling processes.
	Step 2 Hydrodynamic Modeling Results	Assuming that the 2-D model adequately represents hydrodynamic and sedimentation processes in the study area, the report presents the development of hydrodynamic and sediment conditions to be used to evaluate remedial alternatives. Presents and analyzes the results of the simulation of remedial alternatives. (If a 3-D model is needed, or if significant additional data are needed to validate either the 2-D or 3-D model, the report also presents the re-calibration of the model.)
Ecological Risk Assessment	TRV Selection TM	Explains the identification process of chemicals of interest and the selection process of TRVs based on Round 1 data to be used in the ERA. The methods and guidelines used to prioritize the available literature for TRV selection, detailed discussion of the selection process for each TRV, and the results of the TRV selection process for each receptor (i.e., benthic invertebrate tissue-based approach, fish, bird, and mammals) will also be included. For wildlife and dietary update to fish, TRVs will be based on conservative assumptions using a food-web model. For whole-body fish tissue and invertebrate tissue, tissue-based TRVs will be developed for direct comparison to Round 1 tissue data. The technical memorandum will present the recommended TRVs for wildlife, fish, and invertebrate tissue. Amphibian and plant TRVs will be developed following collection of Round 2 surface water and sediment data.
	Preliminary Risk Evaluation Approach TM	Explains the approach for Preliminary Risk Evaluation (PRE). Includes outline of PRE and description of how risks to aquatic feeding wildlife and fish and invertebrates will be assessed in the PRE. Describes how the various receptor groups (i.e., fish, birds, mammals) will be assessed with respect to potential exposure and how data from each medium will be aggregated to estimate exposure point concentrations (EPCs). (Note: TRVs for wildlife, fish, and invertebrate tissue will be approved by EPA before this TM is approved.)

Table 6-1. Portland Harbor RI/FS Deliverable Descriptions

Phase	Deliverable	Purpose
Ecological Risk Assessment	Benthic Assessment Interpretive Approach TM	Describes the development and application of a predictive relationship model between chemical concentrations in the sediment and bioassay responses. Several different explorative approaches to evaluate the relationship will be described including, but not limited to, determining the reliability of published sediment quality guidelines to predict toxicity in Portland Harbor sediments, and developing site-specific relationships between chemical contaminants detected in sediment and toxicity (e.g. logistic regression model). Other models may be identified. The appropriate model or approach may vary for different COPCs, receptors, or uses. This technical memorandum will also propose the collection of bioassay samples at reference locations for later use in risk characterization and risk management.
	Comprehensive ERA Approach TM	Characterizes how the various receptor groups (i.e., benthic invertebrates, fish, birds, mammals, and plants) will be assessed with respect to potential exposure and how data from each medium will be aggregated to estimate EPCs. Linkage between assessment endpoints and measures, including prioritization of lines-of-evidence for risk management decisions, will be presented. This memorandum will also describe the analysis framework for assessing each assessment endpoint in the risk characterization. Spatial data analysis methods that account for habitat preferences for each species to be evaluated in the baseline ERA will also be presented. Chemical-specific evaluation methods will be discussed.
	Food Web Model TM	Provides details on the use of BSAFs and/or a food web model for the RI/FS. The TM will include the objectives for selection of either the BSAFs and/or a food web model, including the need to assess steady-state versus time-varying conditions at the site as well as spatially varying conditions. The TM will describe the model selection process, including the use of historical data and data collected in Round 1 (e.g., co-located sediment and tissue samples) to perform initial runs of the candidate food web models. The following components of the model will be described: model setup, model calibration, model validation, sensitivity analysis, and uncertainty analysis. The sensitivity and uncertainty analyses will identify parameters that have the greatest impact on the results. The results of this initial modeling effort, as well as the results of the sensitivity and uncertainty analyses, will be used to select the preferred food web model that will be further evaluated after collection of Round 2 data and to identify data gaps in the food web model. The level of effort needed to apply the model should be discussed for both the modeling itself as well as for collecting additional site-specific data (other than Round 2 data, which will be incorporated into the food web model report), if needed. The TM should also give examples of other sites where the selected food web model has been calibrated and validated in an environment similar to the Portland Harbor site.

Table 6-1. Portland Harbor RI/FS Deliverable Descriptions

Phase	Deliverable	Purpose
Ecological Risk Assessment	Ecological Preliminary Risk Evaluation (PRE)	Includes a risk characterization based on historical, pre-AOC, and Round 1 data for benthic invertebrates using the tissue-residue approach, fish, and wildlife. Results will be used, in part, to help identify COPCs related to contaminant concentrations in fish and invertebrate tissue. This applies primarily to risks to aquatic-feeding wildlife that consume fish or invertebrates from the river, and risks to invertebrates and fish containing the compounds. This COPC identification is narrowly focused because sediment data from Round 2 are needed to identify a comprehensive list of COPCs. The PRE will not rely on the benthic assessment technical memorandum, which addresses the analysis framework for the sediment toxicity data to be collected during Round 2. The preliminary risk estimates and the associated uncertainty will help to identify ERA data and information gaps that may be filled during subsequent investigations/evaluations prior to the baseline ERA.
	Round 2 Benthic Assessment Report	Uses the results of Round 2 sediment bioassays to implement the analyses described in the Benthic Assessment Interpretive Approach TM. Objectives are to 1) develop and apply a predictive relationship model between chemical concentrations in the sediment and bioassay responses, and 2) confirm toxicity in high priority areas.
	Food Web Modeling Report	Uses Round 2 data to supplement Round 1 data to perform additional runs of food web model identified in the food web model TM. If the available data were insufficient for selecting a food web model in the TM, a model will be selected after incorporation of the Round 2 data. If none of the steady-state models evaluated can be used to achieve the objectives outlined in the food web model TM, the need for the collection of additional data and/or the evaluation of non-steady-state (i.e., time-varying) models that incorporate the results of hydrodynamic and fate and transport modeling will be discussed with EPA and its partners. Additional data needs for model calibration and validation (which will be separate from those data used to develop the model) will also be discussed. An approach and schedule for collecting additional data and food web model reports, if necessary, will be included.
Human Health Risk Assessment	Fish Tissue Exposure Point Concentrations Interim Deliverable	Provides exposure point concentrations (EPCs) for fish and crayfish tissue for human health evaluation. Information will be provided in a format agreed to by EPA and the LWG. EPCs will be calculated as described in Appendix C.
	Round 1 Data Gaps Analysis Interim Deliverable	Analyzes Round 1 data to determine if data gaps for fish tissue or beach sediment exist for the HHRA.
	COPC Selection Interim Deliverable	Describes COPC selection methods for beach sediment, in-water sediment and surface water (see Section 2.3 of Appendix C). This interim deliverable will include a description of these procedures and the resulting COPC lists for these media. A list of detected chemicals in fish tissues will be included. Any other media that may be included in the HHRA will be screened for COPCs according to methods determined through future discussions with EPA and its partners. For purposes of the RI/FS and associated baseline risk assessment, COPC identification will be developed for the Comprehensive Round 2 Site Characterization Summary Report. However, additional COPC selection may be needed to support interim risk communication needs outside of the RI/FS, such as the ODH public health assessment that is scheduled to be completed before the RI/FS.
	EPC Calculation Approach TM	Describes the process for calculating EPCs for in-water sediment, surface water, and seep water (see Section 3.4 of Appendix C).

Table 6-1. Portland Harbor RI/FS Deliverable Descriptions

Phase	Deliverable	Purpose
Human Health Risk Assessment	Summary of Exposure Factors Interim Deliverable	Provides a summary of all exposure factors developed for use in the HHRA by receptor and exposure pathway. Exposure factors are discussed qualitatively in several parts of Appendix C and specifically in Section 3.5.1 (Receptor Specific Assumptions) and are presented in Tables 5 through 14 of Appendix C for beach sediment and surface water. Exposure factors for media and pathways not included in the Work Plan (i.e., in-water sediment, seep water) also will be included in the interim deliverable and will be developed through discussions with EPA.
	Toxicity Values Interim Deliverable	Presents a summary of selected toxicity values for chemicals detected in Round 1 beach sediment and biota evaluated for human health. Toxicity values for additional COPCs identified from subsequent sampling rounds will be added; any values updated prior to future risk evaluations will be revised, as needed, through discussion with EPA. The hierarchy of sources for toxicity values for the HHRA is defined in Section 4.1 of Appendix C.
	HHRA Uncertainty Analysis Outline	Discusses the areas of uncertainty inherent in the risk assessment process (such as estimates of exposure and toxicity).
Site Characterization	Validated Analytical Results	Provides validated analytical data in electronic format showing locations, media, and results. As specified in the AOC, and upon request, analytical data will be made available to EPA within 60 days of each sampling activity.
	Field Sampling Reports	Summarizes field sampling activities, including sampling locations (maps), requested sample analyses, sample collection methods, and any deviations from the FSP.
	Site Characterization Summary Reports	Provides validated sample analysis results in tabular format. Provides chemical concentration maps showing the distribution of sample analysis results for selected COIs. Data validation reports and a summary of data validation results also will be included in each site characterization summary report. EPCs for human health will be submitted as interim deliverables with site characterization summary reports.
	Bioassay Data Report	Documents all activities associated with the collection, handling, and analysis of Round 2 bioassay samples. Includes a brief review of the study design and methods, data tables summarizing the testing, deviations from the protocols appended to the approved QAPP, copies of chain-of-custody forms, data validation reports, and tables of all raw data.

Table 6-1. Portland Harbor RI/FS Deliverable Descriptions

Phase	Deliverable	Purpose
Site Characterization	Comprehensive Round 2 Site Characterization Summary and Data Gaps Analysis Report	Summarizes pre-AOC, Round 1, and Round 2 investigation results; presents preliminary evaluation of risks to human health (as described in Appendix C of Work Plan) and ecological receptors (as described in Appendix B of Work Plan and associated technical memoranda) based on site-specific data for purposes of identifying COPCs 'risk drivers' and data gaps to be addressed in Round 3 sampling; provides a comprehensive update of the CSM; provides initial PRGs; presents a screening of pre-AOC, Round 1, and Round 2 data relative to PRGs; and identifies any data gaps to be addressed in Round 3. Also provides the most current results of the food web model, its application to development of initial PRGs, and food web modeling data gaps. This summary reviews the investigative activities and displays Site information and data documenting the location and characteristics of surface and subsurface features and contamination at the Site, including sample locations, chemical concentration distributions, and the results of any biological testing. This evaluation will include, to the extent practicable, COPC concentration distributions relative to known sources, and the extent of contaminant migration through the in-water portion of the Site. The data compilation and summary will provide EPA with a preliminary reference for evaluating the risk assessments, the development and screening of remedial alternatives, and the further identification of ARARs.
	Draft RI Report and Baseline Risk Assessment Reports	Includes 1) a characterization of the distribution of chemicals and sources that affect the river; 2) an assessment of ecological risk including risks to benthos, fish, wildlife, and other receptors of concern; 3) an assessment of human health risks from contact with sediment and water, and fish and shellfish ingestion; 4) a preliminary delineation of SMAs and sediment volumes that pose unacceptable risks; 5) a preliminary delineation of principal threat areas, and 6) a preliminary understanding of the potential for natural attenuation as a remedial alternative.
	Final RI Report and Baseline Risk Assessment Reports	See draft RI Report above.
Feasibility Study	2003 Sediment Stake Results Report	Describes data collected in 2003 from shoreline stakes that measure changes in sediment elevation changes throughout the ISA. These data will be compared to available bathymetry changes in deeper waters near these stations.
	Step 1 Natural Attenuation Evaluation and Step 2 Field Sampling Plan and Data Evaluation Methods TM	Describes the selection of sampling locations and types based on Step 1 of the Natural Attenuation Evaluation process described in Appendix A. Also describes the field sampling plan for Step 2 of the process as well as the data evaluation procedures that will be employed once Step 2 data are received. EPA may request that the field sampling plan be separated from the data evaluation procedures, resulting in two separate submittals (Round 2 FSP Addendum and Natural Attenuation Data Evaluation Methods TM).
	Step 2 Natural Attenuation Evaluation Report	Presents results from the data collected per the Step 1 Evaluation and Step 2 Field Sampling Plan and Data Evaluation Methods memorandum above. In addition, it will present data evaluations, including any necessary modeling efforts to identify potential areas for further investigation of natural attenuation as a remedial technology.

Table 6-1. Portland Harbor RI/FS Deliverable Descriptions

Phase	Deliverable	Purpose
Feasibility Study	Step 3 Natural Attenuation TM and Field Sampling Plan	Presents proposed methods for determination of candidate areas for natural attenuation as a remedial technology. Includes methods for selection of sampling locations and types as well as data evaluation procedures (including any modeling) that will be employed once Step 3 data are received.
	Step 3 Natural Attenuation Field Sampling Report	Presents results from the data collected per the Step 3 Natural Attenuation TM and Field Sampling Plan (above). Additionally presents data evaluations, including any necessary modeling efforts to identify candidate areas for natural attenuation as a remedial technology to be considered in the FS Report.
	Facility Siting Inventory Report	Presents an inventory of possible disposal sites and screens those sites based on several criteria (see Appendix A) to obtain a refined list of potential disposal sites for contaminated sediments.
	Facility Siting Re-Screen Report	Presents an additional screening of potential disposal sites identified from the Inventory Report (above) based on Portland Harbor-specific information that will be available later in the RI/FS process (e.g., areas and volumes of sediments that are potentially contaminated). The report will present a refined list of disposal sites for further evaluation (see Appendix A).
	Facility Siting Final Ranking Report	Uses the list of disposal sites from the Facility Siting Re-Screen Report (above), and criteria and methods described in Appendix A, to obtain a final ranking of potential disposal sites for Portland Harbor contaminated sediments.
	Recontamination Potential Modeling Approach TM	Presents the types of sampling and data evaluation procedures that will be used to determine the level and extent of recontamination potential that may exist at the site. Includes the general types of sampling, the target locations of such sampling, and the data evaluation procedures (including any modeling) that will be used to determine the potential for recontamination after remediation of sediments takes place.
	Literature Survey of Treatability Studies	This memorandum (described in detail in Appendix A)will contain a review of literature to determine: 1) which treatment technologies are effective and cost competitive (potentially suitable) as compared to other remedial technologies, and 2) for those potentially suitable technologies, whether treatability studies would be needed to determine the appropriateness of the technologies for this specific site. The survey will contain a conclusion section that will describe whether further treatability studies are needed, and if so, the general extent of those studies.
	Refined Preliminary RAOs TM	Includes updated RAOs and PRGs to be used in the FS. As required by the SOW, general types of PRGs (e.g., national or regional numeric sediment guidelines) will be considered when refining PRGs. However, refined PRGs will be primarily based on the results of the risk assessment and other work (e.g., food web modeling) conducted during the RI. As with the preliminary RAOs, the refined RAOs will specify the chemicals and media of interest, exposure pathways and receptors, and an acceptable chemical level or range of levels (i.e., a PRG). PRGs will be location-specific within the project study area where risks estimates vary across the study area due to differences in exposure levels/routes or other site-specific risk parameters.
	Alternatives Development and Screening Report	Per Section 9.2 of the SOW, this task summarizes results of the identification, assembly, refinement, and screening of remedial alternatives. It will contain the results of Sections 5.3 through 5.7 of Appendix A, which describes these studies in detail.

Table 6-1. Portland Harbor RI/FS Deliverable Descriptions

Phase	Deliverable	Purpose
Feasibility Study	Draft FS Report	As described in Appendix A, the LWG will complete the detailed analysis of remedial alternatives including recommending remedial alternatives that meet the refined RAOs and include any appropriate restoration components. A justification for the selection of this recommendation will also be included. This recommendation, along with all the supporting analysis and information developed in Sections 3, 4 and 5 of Appendix A, will be submitted in a Draft Feasibility Study Report to EPA.
	Final FS Report	See Draft FS Report above
Field Sampling Plans	Round 2 Shorebird FSP Addendum	Describes sampling locations and procedures for Round 2 beach sampling to support ecological and human health risk assessments
	Round 2 Surface Water FSP	Describes surface water sampling locations and procedures
	Round 2A Sediment Coring FSP Addendum	Describes Round 2A sediment coring sampling locations and procedures.
	Round 2B Sediment Coring FSP Addendum	Describes Round 2B sediment coring sampling locations and procedures
	Round 2 Groundwater Impacts Sampling FSP	Describes groundwater sampling locations and procedures. Includes a QAPP, if necessary.
	Round 2 Seep Sampling FSP	Describes seep sampling locations and procedures. Includes a QAPP, if necessary.
	Round 3 Surface Water FSP (if required)	Describes surface water sampling locations and procedures. Includes a QAPP, if necessary.
	Round 3 FSP	Describes Round 3 sampling necessary to support baseline risk assessments, site characterization and/or feasibility study. Describes sampling locations and procedures. Includes a QAPP, if necessary.

Table 7-1. Overview of Data Collections to Fill Data Gaps for the Preliminary RAO and RI/FS Site Characterization Objectives.

	Site Characterization					Preliminary Remedial Action Objectives[1]				
	Understand Physical System	**Understand Chemical Distributions and Sources**	**Understand Ecological Risks**	**Understand Human Health Risks**	**Conduct Feasibility Study**	**1**	**2**	**3**	**4**	**5**
Existing Information										
Geology/Groundwater	X	X	X	X	X			G		G
Hydrology/Sediment Transport	X	X	X	X	X				G	
Bathymetry/Dredging Records	X	X			X	G			G	
Sediment/Water/Tissue Chemistry	X	X	X	X	X	G	G	G	G	G
Biology/Toxicity/Habitat/T&E Species			X						G	G
Upland Source Information (DEQ)	X	X			X	G		G	G	G
Demography				X		G	G	G		
Site Use		X	X	X	X	G	G	G		
Pre-AOC										
SPI	X	X	X		X				G	
Bathymetry - High Flow (Dec. 2001)	X	X	X		X				G	G
Salmonid Residence Time			X						G	G
Other										
Water Velocities - High Flow	X				X			G		G
Round 1										
Fish Tissue Chemistry			X	X			G		G	G
Epibenthic Multiplates			X						G	
Plants/Amphibians Reconnaissance			X							G
Adult Lamprey Reconnaissance				X			G			
Infauna/Juvenile Lamprey Reconnaissance			X						G	G
Beach Sediment Chemistry		X	X	X		G			G	
Co-located Sediment Chemistry		X	X	X			G		G	
Sediment Stakes	X		X		X				G	
Bathymetry - Low Flow (Summer 2002)	X		X		X				G	G
Bathymetry - High Flow (Spring 2003)	X		X		X				G	G
Seep Reconnaissance Survey	X	X		X				G		
Source/Groundwater Data Review	X	X	X	X	X			G	G	G
Round 2										
Surface Sediment Chemistry		X	X	X	X		G		G	
Subsurface Sediment Chemistry	X	X	X		X				G	

Table 7-1. Overview of Data Collections to Fill Data Gaps for the Preliminary RAO and RI/FS Site Characterization Objectives.

	Site Characterization					**Preliminary Remedial Action Objectives[1]**				
	Understand Physical System	**Understand Chemical Distributions and Sources**	**Understand Ecological Risks**	**Understand Human Health Risks**	**Conduct Feasibility Study**	**1**	**2**	**3**	**4**	**5**
Sediment Bioassays			X						G	
Surface Water Chemistry		X	X	X	X		G	G		G
Groundwater Screening and Data Needs Assessment		X	X	X				G	G	G
Porewater Chemistry	X	X	X						G	G
Seep Chemistry	X	X		X				G		
Pilot Natural Attenuation					X	G			G	
Round 3										
Risk Assessment Data Gaps (water, sediment, bioassays)		X	X	X		G	G	G	G	G
FS-related Sediment Chemistry Data Gaps		X			X	G			G	
Natural Attenuation Sampling	X				X	G			G	
Recontamination Sampling	X	X			X	G			G	
Sediment Physical/Engineering Properties					X	G			G	
Disposal Site Sampling					X	G			G	

Notes:

More detailed descriptions of the Preliminary Remedial Action Objectives (RAOs) are provided in Appendix A and Section 6.1 of the Work Plan, and are summarized below for the purposes of this table.

G - An RI/FS data collection effort may be needed to fill identified data gap associated with this preliminary RAO.

[1] - The preliminary RAOs are:

1. Reduce human health risks from direct contact with and incidental ingestion of chemicals of concern (COCs) in sediments in the Site to acceptable levels.
2. Reduce COC concentrations in sediments in the Site to levels that will result in acceptable risks to humans that eat fish and shellfish from the Site.
3. Reduce human health risks from direct contact with and incidental ingestion of COCs in water in the Site to acceptable levels.
4. Reduce ecological risks from contact with and ingestion of COCs in sediments or prey in the Site to acceptable levels.
5. Reduce ecological risks from contact with and ingestion of COCs in water in the Site to acceptable levels.

Table 7-2. The DQO Process for Understanding the Physical River System.

DQO Step	Output
1. State the Problem	The spatial and temporal scales of sediment movement and transport are not known. Sediment transport may affect contaminant nature and extent, source transport, recontamination potential, and ecological and human health exposure. Sediment transport processes / hydrodynamics also affect selection of remedial alternatives.
2. Identify the Decision to be Made	Determine the effect of sediment transport on risk estimates. Determine whether physical processes could expose previously buried contaminated sediment. Determine whether physical processes could result in burial of contaminated sediment. Determine physical system types for SMA development. Determine short- and long-term flow regimes for remedial alternatives development.
3. Identify the Inputs to the Decision	Time-series bathymetric surveys (high and low flow conditions). Sediment erosion/accretion stake measurements in beach areas where bathymetry cannot be measured. Temporal surface sediment chemistry comparisons in areas with appropriate historical data. Physical and chemical surface and subsurface sediment data Hydrodynamic/sediment transport model; inputs will include: • Bathymetry • Surface and subsurface bed sediment data • Tidal data • River flows • Sediment inflows (sands and fines) • Wind speed and direction • Others (TBD by modeler) The model must document uncertainties and identify which parameters most strongly affect the outcome of the model.

Table 7-2. The DQO Process for Understanding the Physical River System.

DQO Step	Output
4. Define the Boundaries	Model hydrodynamic conditions from Willamette to confluence with Columbia River, focus sediment transport modeling on RM 2 to 11. Model to span annual high and low flow conditions. Hydrodynamic portion of model needs to predict both major flood years and non-flood years.
5. Develop a Decision Rule	Define the distributions of physical system types (i.e., potential for and magnitudes of erosional, depositional, transitional transport and stable regimes under a range of flow conditions). Define peak bed velocities under a variety of flow conditions at various locations for use in remedial alternatives evaluation.
6. Specify Tolerable Limits on Decision Error (per US EPA DQO guidance)	Null Hypothesis 1: Potential sediment transport does not significantly affect risk. Alternative Hypothesis 1: Potential sediment transport does significantly affect risk (by exposing subsurface sediments). Null Hypothesis 2: Potential sediment transport does not significantly affect remedial alternatives and evaluations. Alternative Hypothesis 2: Potential sediment transport does significantly affect remedial alternatives and evaluations. Decision Error: Error rate in physical measurements cannot be greater than the depth over which a decision will be made: • Need ± 6 inches on bathymetric measurements. Based on model calibration and validation results, model must be sufficiently accurate at a reasonable confidence level. Risk assessments and remedial alternatives identification and evaluation must take into account model results and associated uncertainties.

Table 7-2. The DQO Process for Understanding the Physical River System.

DQO Step	Output
7. Optimize the Design	Collect bathymetry and flow (ADCP) data during a high flow (> 100,000 cfs) in the LWR. Continue to monitor sediment stakes in beach areas in Round 2. Select and set up hydrodynamic model using existing data during Round 2. Calibrate model to period December 2001 to September 2002 using bathymetric change data from that period. Validate the model over the period from September 2002 to February 2004 using bathymetric change data from that period. Following the preliminary modeling effort: • Identify data types and subareas where additional data are needed to meet modeling objectives • Identify subareas that may warrant additional focus due to the sediment exposure potential or for the remedial alternatives evaluation

Table 7-3. The DQO Process for Understanding Chemical Distributions in Sediments and Sources.

DQO Step	Output
1. State the Problem	Historical data show that chemicals are present in sediments in the Lower Willamette River. However, documentation of the distribution of sediment chemical concentrations, although extensive, is not complete in all areas and the influence of sources is also not well understood in all areas. Surface sediments may act as a source of chemicals to other areas of the river and the transport of chemicals into and out of the ISA is not well understood. The stability of sediment chemical distributions is uncertain, based on known physical transport processes. Chemicals bound to sediments may pose a risk to human and ecological receptors.
2. Identify the Decision to be Made	Determine the nature and extent of chemicals in sediment including in areas that have not been characterized previously. Determine whether spatial trends in chemical distributions in sediment are consistent over time. Determine whether potential source areas influence sediment chemical distributions. Determine whether contiguous contamination posing unacceptable risk extends beyond the ISA.
3. Identify the Inputs to the Decision	Existing Category 1 sediment data from the Weston (1998) study and other in-water investigations (assume historical Category 1 data are acceptable for characterization of sediment quality). Sediment physical properties based on bathymetric studies, sediment trend analysis, sediment profile imaging, sediment stakes, and hydrodynamic modeling. Information on upland sources. New surface and subsurface sediment data.

Table 7-3. The DQO Process for Understanding Chemical Distributions in Sediments and Sources.

DQO Step	Output
4. Define the Boundaries	Focus on the ISA and include limited sampling above and below the ISA. Surface sediment is defined as the surficial 1 ft (30 cm) of sediment. Subsurface sediment is defined as sediment deeper than 30 cm below the mudline. Bank areas to bottom of channel to coincide with risk assessment exposure areas. Collect new surface sediment data during low flow conditions (i.e., July – October) when physical transport processes are reduced. Detection limits will be those currently achievable by the analytical laboratory conducting the analyses under the EPA-approved QAPP. Detection limits will be lower (if analytically achievable) than risk-based values for protection of sediment.
5. Develop a Decision Rule	Areas affected by sources will be identified by an analysis of concentration gradients of COPCs. Areas exceeding risk-based thresholds will be referred to the feasibility study as potential sediment management areas.
6. Specify Tolerable Limits on Decision Error	Sampling density is sufficient to evaluate ecological receptor and human use areas. Temporal variability in chemical concentrations does not mask chemical distribution trends associated with sources.

Table 7-3. The DQO Process for Understanding Chemical Distributions in Sediments and Sources.

DQO Step	Output
7. Optimize the Design	Stratify sediment sampling by depth of the riverbed with a greater number of stations in shallower areas near known and suspected sources and fewer stations in the channel. Sample where potential human or ecological receptor exposure areas have been identified and where historical Category 1 data are lacking. Evaluate temporal trends in surface sediment concentrations by collecting data in some areas with historic data and comparing spatial trends over time. Define and sample surface sediment as the top 1 ft (30 cm) of sediment because that thickness accounts for the majority of sediment elevation changes over time and includes the biologically active zone. Sample subsurface sediments where scour may re-expose buried sediment deposits and in navigation/maintenance dredge and sediment management areas.

Table 7-4. The DQO Process for Understanding Chemical Distributions in Surface Water.

DQO Step	Output
1. State the Problem	Information on concentrations and distribution of chemicals in the water column is limited.
2. Identify the Decision to be Made	Determine the nature and extent of chemicals in surface water entering, within, and exiting the ISA. Determine whether the distribution of chemicals in surface water is spatially and temporally consistent. Determine whether chemical concentrations representing a risk extend contiguously beyond the ISA. Determine potential for widespread source effects to river water and associated risks to ecological and human receptors. Refer to EPA and DEQ for source control as appropriate.
3. Identify the Inputs to the Decision	Existing Category 1 water quality data. Distributions and concentrations of chemicals in the water column (Round 2). Risk-based water quality action levels may need to be identified.
4. Define the Boundaries	Immediately upstream, downstream, and within the ISA. Generate new water column data during an early fall "first flush" stormwater event and both low-flow and high-flow conditions near the surface and near the bottom of the river. Detection limits will be those currently achievable by the analytical laboratory conducting the analyses, as approved by EPA in the QAPP. Detection limits will be lower (if analytically achievable) than risk-based values for protection of water quality.
5. Develop a Decision Rule	If concentrations exceed risk-based water quality screening levels, refer to EPA and DEQ for source control follow-up. Time-series chemistry data for each chemical are within the same range of concentrations over time and trigger the same risk management decision.

Table 7-4. The DQO Process for Understanding Chemical Distributions in Surface Water.

DQO Step	Output
6. Specify Tolerable Limits on Decision Error	Sampling density is sufficient to estimate water quality entering, within, and exiting the ISA. Sampling frequency is sufficient to estimate water quality under low flow and high flow conditions. Detection limits for sampling and analytical methods are adequate to be below risk-based water quality screening levels. Sample location and density must be adequate to understand the potential for source effects to river water and sediments, but not for identifying and characterizing individual sources.
7. Optimize the Design	Collect water samplesusing a cross-sectional integrated flow sampling method (high-volume and grabs) suitable to achieve the target detection limits. Collect water samples using high-volume and grab sampling methods in Round 2 along three transects from shore to shore in the ISA. Locations of transects will be chosen to measure water quality parameters entering the ISA (RM 11), within the ISA (RM 6), and leaving the ISA (RM 3.5). Collect water samples using grab sampling methods at potential swimming areas. Collect water samples in Round 2 during summertime low flows and in the fall shortly after flows have increased and storm drains have potentially been flushed of particulates that accumulated over the previous summer. Collect water samples using high-volume and grab sampling methods in Round 2 at four locations (Rhone-Poulenc, Willamette Cove, ATOFINA, and Portland Shipyard) during optimum-flow sampling event.

Table 7-5. The DQO Process for Understanding the Hydrogeologic Physical System, the Effects of Groundwater Discharges on Ecological and Human Health Risks and the Distribution of Chemicals in Sediment.

DQO Step	Output
1. State the Problem	**Ecological Risk Assessment**: Potential significant contributions to risk to ecological receptors from groundwater flow through sediments within the ISA are unknown. **Human Health Risk Assessment**: The potential exposure of human receptors at potential human uses areas within the ISA to groundwater COIs is unknown. **Hydrogeologic Physical System**: A better understanding of the relationship between groundwater and surface water is necessary as a basis for the evaluation of the potential effects of the groundwater physical system on exposure pathways for the site. **Chemical Distribution and Sources**: Flow of contaminated groundwater through sediments can affect sediment quality. A better understanding of the locations of upland contaminated groundwater sources is needed to identify locations and prioritize sites where groundwater may adversely affect sediments and environmental receptors in the river.

Table 7-5. The DQO Process for Understanding the Hydrogeologic Physical System, the Effects of Groundwater Discharges on Ecological and Human Health Risks and the Distribution of Chemicals in Sediment.

DQO Step	Output
2. Identify the Decision to be Made	**Ecological Risk Assessment**: Determine where COIs in groundwater have the potential to adversely impact to sediment and/or porewater quality. Determine where potentially ecotoxic groundwater contaminants are not captured through whole sediment analysis. Determine the scale of investigation necessary for assessing ecological risks from groundwater COIs Determine whether and where collection of bulk sediment and porewater data may be necessary for ecological risk assessment purposes. Identify locations where groundwater data are lacking and where additional investigation and/or sampling may be needed to support risk-based evaluations. Determine whether contaminated groundwater in the harbor represents unacceptable risks to ecological receptors. If risk is unacceptable, determine the location and extent of source control and/or remediation. **Human Health Risk Assessment**: Determine if and where COIs in groundwater could discharge to the surface in potential human use areas. Determine if additional investigation of the groundwater pathway is necessary in potential human use areas. **Hydrogeologic Physical System**: Determine the scope of sample collection activities for the ecological and human health risk assessments based on understanding the spatial and temporal relationships between groundwater and surface water in the ISA. **Chemical Distribution and Sources**: Determine where COIs in groundwater have the potential to adversely affect sediments and environmental receptors in the river.

Table 7-5. The DQO Process for Understanding the Hydrogeologic Physical System, the Effects of Groundwater Discharges on Ecological and Human Health Risks and the Distribution of Chemicals in Sediment.

DQO Step	Output
3. Identify the Inputs to the Decisions	**Ecological Risk Assessment**: Existing regional, ISA-wide and site specific hydrogeologic data; Existing upland groundwater quality data from upland groundwater investigations under DEQ oversight including the locations and the ranges of concentrations of COIs in groundwater from upland sites adjacent to the ISA and are likely to affect sediment (including porewater) quality. Porewater data from locations where groundwater COIs in sediments are not adequately characterized by the whole sediment sampling and analysis or the benthic approach are likely present, and could cause a significant risk to ecological receptors. **Human Health Risk Assessment**: Locations of identified seeps based on seep reconnaissance survey results Locations of identified potential human use areas Existing upland groundwater quality data in areas adjacent to potential human use areas and/or groundwater quality data from the seeps. **Hydrogeologic Physical System**: Existing regional, ISA-wide and site specific hydrogeologic data; **Chemical Distribution and Sources**: Existing regional, ISA-wide and site specific hydrogeologic data; Existing upland groundwater quality data from upland groundwater investigations including the locations and the ranges of concentrations of COIs in groundwater from upland sites adjacent to the ISA and are likely to affect sediment quality.

Table 7-5. The DQO Process for Understanding the Hydrogeologic Physical System, the Effects of Groundwater Discharges on Ecological and Human Health Risks and the Distribution of Chemicals in Sediment.

DQO Step	Output
4. Define the Boundaries	**Ecological Risk Assessment**: Within the ISA The initial assessment of groundwater contributions to risks to ecological receptors will be spatially focused on areas where COIs are likely to be discharging to sediments. Porewater sample collection will be spatially focused on areas where COIs are determined to be discharging to sediments, the COIs may cause an unacceptable risk, and the risk from COIs will not be captured by bulk sediment analysis and bioassays. **Human Health Risk Assessment**: Within the ISA Assessment of potential human health risks from groundwater will be spatially focused on locations where COIs potentially discharge in seeps at potential human use areas. **Hydrogeologic Physical System**: RM 2 to 11 for hydrogeologic conceptual model refinement. The conceptual model will encompass the hydrostratigraphic units from the CRBG up through surficial soils. The shallow and intermediate groundwater systems (e.g., groundwater present in the FGF) will be the basis for determining where groundwater contaminants may affect sediment quality except at locations where available information indicates that deeper units (e.g., the CGF and CRBG) are impacted by groundwater contaminants. **Chemical Distribution and Sources**: RM 2 to 11 for identifying the locations where contaminated groundwater has the potential to adversely affect sediment quality. Locations where potential for known groundwater plumes to reach the river both in the past and present.

Table 7-5. The DQO Process for Understanding the Hydrogeologic Physical System, the Effects of Groundwater Discharges on Ecological and Human Health Risks and the Distribution of Chemicals in Sediment.

DQO Step	Output
5. Develop a Decision Rule	**Ecological Risk Assessment**: If the chemical concentration in groundwater or porewater at the point of exposure for COIs is greater than the NOEC (potential risk to sensitive species) or AWQC (for aquatic organisms), the locations will be targeted for future sediment/biota sampling (Round 2) and the area will be referred to DEQ for further evaluation or action. **Human Health Risk Assessment**: Presence of groundwater COIs adjacent to the location of a seep or in the seep itself in a potential human use area. Refer site to DEQ for further assessment under the source control program. **Hydrogeologic Physical System**: Concentrate risk assessment screening and characterization activities at the locations with COIs in groundwater where discharge to the river from the flow system is focused. **Chemical Distribution and Sources**: Locate shallow grab sediment sample stations in the vicinity of where COIs detected in upland groundwater are identified as having a potential to intersect the river

Table 7-5. The DQO Process for Understanding the Hydrogeologic Physical System, the Effects of Groundwater Discharges on Ecological and Human Health Risks and the Distribution of Chemicals in Sediment.

DQO Step	Output
6. Specify Tolerable Limits on Decision Errors	**Ecological Risk Assessment**: Existing upland groundwater COI data are representative of groundwater COI concentrations reasonably expected to reach the Transition Zone. **Human Health Risk Assessment**: Existing upland groundwater data are sufficient to assess the presence of groundwater COIs in the vicinity of seeps at potential human use areas. **Hydrogeologic Physical System**: Existing data are sufficient to assess temporal and spatial variability in groundwater interactions with the river to identify locations of potential contaminant discharge at a scale relevant to site risk decisions. **Chemical Distribution and Sources**: Existing data are sufficient to identify the types and general locations where COIs in groundwater could intersect the river at a scale relevant to site risk decisions.

Table 7-5. The DQO Process for Understanding the Hydrogeologic Physical System, the Effects of Groundwater Discharges on Ecological and Human Health Risks and the Distribution of Chemicals in Sediment.

DQO Step	Output
7. Optimize the Design for Obtaining Data	Review available upland groundwater and geologic data to identify the locations, types and concentrations of groundwater COIs that potentially could discharge to the river. Screen for groundwater COIs and identify high priority sites. Review data from the high priority sites, as available, to assess risk, identify where groundwater data are lacking, and assess the need for additional assessment and/or porewater or sediment sampling. Conduct preliminary porewater/sediment investigations at select locations to help determine the overall likelihood that contaminated groundwater affects porewater/sediment exposures in the river. Collect porewater/sediment samples at locations identified by ecological risk screening process (1) if the data are not already available from PRP efforts conducted under individual upland source control or early action programs, and (2) if and where warranted because of RI/FS timing issues. Apply the results of the ecological risk screening process and sampling results to assess if other porewater/sediment sampling is necessary within the ISA.

Table 7-6. The DQO Process for the Ecological Risk Evaluation: Fish.

DQO Step	Output
1. State the Problem	Fish may be at risk from exposure to chemicals resulting from historical and ongoing releases and / or sources within the ISA.
2. Identify the Decision to be Made	Determine whether exposure to hazardous substances in the ISA poses an unacceptable risk to fish in the area. The testable hypotheses are: Are levels of contaminants in abiotic and biotic media in the ISA sufficient to cause adverse effects to the growth, survival or reproduction of detritivorous fish utilizing the habitat within the ISA? Are levels of contaminants in abiotic and biotic media in the ISA sufficient to cause adverse effects to the growth, survival or reproduction of invertivorous fish utilizing the habitat within the ISA? Are levels of contaminants in abiotic and biotic media in the ISA sufficient to cause adverse effects to the growth, survival or reproduction of piscivorous fish utilizing the habitat within the ISA? Are levels of contaminants in abiotic and biotic media in the ISA sufficient to cause adverse effects to the growth, survival or reproduction of herbivorous fish utilizing the habitat within the ISA?
3. Identify the Inputs to the Decision	Existing Category 1 and Category 2 data were evaluated to define the conceptual site model and identify data gaps. Category 1 data will continue to be used to update the conceptual site model and re-evaluate data gaps. Existing fish life history information (described in Appendix B) will be evaluated to determine potential exposure areas. Toxicological literature will be evaluated to determine potential toxicity and/or bioavailability issues. Tissue residue data from the literature will be used to determine adverse effect levels. Surface sediment, surface water, invertebrate tissue (benthic infauna) and fish tissue (sculpin, juvenile chinook salmon, largescale sucker, peamouth, pikeminnow, smallmouth bass) data were or will be collected in exposure areas.* Tissue concentrations of dioxin-like compounds and PCB coplanars measured in carp for the human risk assessment will be used to assess risk to fish (and higher trophic levels, see Appendix B, Section 5.3).

Table 7-6. The DQO Process for the Ecological Risk Evaluation: Fish.

DQO Step	Output
4. Define the Boundaries	The ISA will be the initial geographic boundary. Spatial boundaries on exposure areas are different for each fish species and will depend on fish foraging habits within the river. Fish and invertebrate tissue and surface sediment have been collected and surface water will be collected. Detection limits will be those currently achievable by the analytical laboratory conducting the analyses. Detection limits will be lower (if analytically achievable) than risk-based values for protection of fish.
5. Develop a Decision Rule	If the COPC concentration using the 95th UCL or maximum concentration is greater than the NOEC in the special-status species assessment, the COPC will be retained for further evaluation. If the COPC concentration using the 95th UCL or maximum concentration is greater than the LOEC in the population level assessment, the COPC will be retained for further evaluation.
6. Specify Tolerable Limits on Decision Errors	Null Hypothesis: Fish may have unacceptable risk from exposure to hazardous substances within the ISA. Alternate hypothesis: There is no risk to fish from exposure to hazardous substances within the ISA. Evaluate ecosystem and receptor characteristics that may modify/impact risk management decision. Evaluate uncertainty of exposure concentrations relative to sample design. Evaluate uncertainty of toxicity values relative to decision rule.
7. Optimize the Design	Collect surface water samples for comparison to effects-based criteria (e.g., AWQC). Collect additional fish tissue, if warranted, from exposure areas to compare to tissue residue effects data. Collect additional invertebrate tissue, if warranted, and sediment grab samples to evaluate dietary pathway (dietary-based NOEAL or LOAEL) in exposure areas.

*The ecological risk assessment will also evaluate the tissue samples of carp, brown bullhead, and black crappie collected for the human health risk assessment. This evaluation will be done in the uncertainly section to provide additional information in order to address uncertainties with the risk characterization conducted on the representative species.

Table 7-7. The DQO Process for the Ecological Risk Evaluation: Birds.

DQO Step	Output
1. State the Problem	Birds may be at risk from exposure to chemicals resulting from historical and ongoing releases and / or sources within the ISA.
2. Identify the Decision to be Made	Determine whether or not exposure to hazardous substances in the ISA poses an unacceptable risk to birds that may forage in the area. The testable hypotheses are: Are levels of contaminants in abiotic and biotic media in the ISA sufficient to cause adverse effects to the growth, survival or reproduction of diving carnivorous birds utilizing the habitat within the ISA? Are levels of contaminants in abiotic and biotic media in the ISA sufficient to cause adverse effects to the growth, survival or reproduction of sediment probing invertivorous birds utilizing the habitat within the ISA? Are levels of contaminants in abiotic and biotic media in the ISA sufficient to cause adverse effects to the growth, survival or reproduction of piscivorous birds utilizing the habitat within the ISA?
3. Identify the Inputs to the Decision	Existing Category 1 and Category 2 data were evaluated to determine potential exposure areas and data gaps. Existing life history information of representative avian species will be reviewed to select appropriate representative species and exposure parameters. Toxicological literature will be searched to develop no observed adverse effects level (NOAEL) and lowest observed adverse effects level (LOAEL) for birds to determine relative sensitivities. Bird exposure areas will be determined based on a reconnaissance habitat survey and evaluation of their local life-history characteristics. Surface sediment and prey (crayfish, clams, fish) were collected in bird exposure areas.
4. Define the Boundaries	The ISA will be the initial geographic boundary. Sediment and fish and invertebrate tissue were collected in bird exposure areas within the ISA. Data was collected in summer/fall 2002. Detection limits will be those currently achievable by the analytical laboratory conducting the analyses as described in the approved QAPP. Detection limits will be lower (if analytically achievable) than risk-based values for protection of avian species.

Table 7-7. The DQO Process for the Ecological Risk Evaluation: Birds.

DQO Step	Output
5. Develop a Decision Rule	If the dose estimate using the 95th UCL or maximum concentration is greater than the NOAEL in the special-status species assessment, the COPC will be retained for further evaluation. If the dose estimate using the 95th UCL or maximum concentration is greater than the LOAEL in the population level assessment, the COPC will be retained for further evaluation.
6. Specify Tolerable Limits on Decision Errors	Null Hypothesis: Birds may have unacceptable risk from exposure to hazardous substances within the ISA. Alternate Hypothesis: There is no risk to birds from exposure to hazardous substances within the ISA. Evaluate ecosystem and receptor characteristics that may modify/impact risk management decision. Evaluate uncertainty of exposure concentrations relative to sample design. Evaluate uncertainty of toxicity values relative to decision rule.
7. Optimize the Design	Collect additional surface sediment samples, if warranted, in each shorebird bird exposure area and at other bird habitat areas. Collect additional prey tissue (invertebrate and/or fish tissue), if warranted, from each bird exposure area. Additional sampling may be conducted based on the results of the iterative risk assessment to reduce uncertainties.

Table 7-8. The DQO Process for the Ecological Risk Evaluation – Mammals.

DQO Step	Output
1. State the Problem	Mammals may be at risk from exposure to chemicals resulting from historical and ongoing releases and / or sources within the ISA.
2. Identify the Decision	Determine whether exposure to hazardous substances in the ISA poses an unacceptable risk to mammals that may forage in the area. The testable hypothesis is: Are levels of contaminants in abiotic and biotic media in the ISA sufficient to cause adverse effects to the growth, survival or reproduction of mammals utilizing the habitat within the ISA?
3. Identify the Inputs to the Decision	Existing Category 1 and Category 2 data were evaluated to determine potential exposure areas and data gaps. Existing life history information of representative mammals were reviewed to select an appropriate representative species and exposure parameters. Toxicological literature will be searched to develop no observed adverse effects level (NOAEL) and lowest observed adverse effects level (LOAEL) for mammals to determine relative sensitivities. Surface sediment and prey data (crayfish, clams, fish) were collected in mammalian exposure areas.
4. Define the Boundaries	The ISA will be the initial geographic boundary. Surface sediment and fish/invertebrate tissue chemistry data were collected from mammalian exposure areas. Detection limits will be those currently achievable by the analytical laboratory conducting the analyses as described in the approved QAPP. Detection limits will be lower (if analytically achievable) than risk-based values for protection of mammalian species.
5. Develop a Decision Rule	If the dose estimate using the 95th UCL or maximum concentration is greater than the NOAEL in the special-status species assessment, the COPC will be retained for further evaluation. If the dose estimate using the 95th UCL or maximum concentration is greater than the LOAEL in the population level assessment, the COPC will be retained for further evaluation.

Table 7-8. The DQO Process for the Ecological Risk Evaluation – Mammals.

DQO Step	Output
6. Specify Tolerable Limits on Decision Errors	Null Hypothesis: Mammals may have unacceptable risk from exposure to hazardous substances within the ISA. Alternate Hypothesis: There is no risk to mammals from exposure to hazardous substances within the ISA. Evaluate ecosystem and receptor characteristics that may modify/impact risk management decision. Evaluate uncertainty of exposure concentrations relative to sample design. Evaluate uncertainty of toxicity values relative to decision rule.
7. Optimize the Design	Collect additional surface sediment samples, if warranted, in each mammalian exposure area. Collect additional co-located prey tissue (invertebrate and/or fish tissue), if warranted, from each mammalian exposure area.

Table 7-9. The DQO Process for the Ecological Risk Evaluation: Amphibians, Reptiles, and Plants.

DQO Step	Output
1. State the Problem	Amphibians and Reptiles: Amphibians and/or reptiles may be at risk from exposure to chemicals resulting from historical and ongoing releases and/or sources within the ISA. Aquatic Plants: Aquatic plants may be at risk from exposure to chemicals resulting from historical and ongoing releases and / or sources within the ISA.
2. Identify the Decision	Determine whether exposure to hazardous substances in the ISA poses an unacceptable risk to amphibians or reptiles that may forage in the area or aquatic plants. The testable hypothesis is: Are levels of contaminants in abiotic and biotic media in the ISA sufficient to cause adverse effects to the growth, survival or reproduction of amphibians, reptiles or aquatic plants utilizing the habitat within the ISA?
3. Identify the Inputs to the Decision	Presence/absence of amphibian and aquatic plants was confirmed with field reconnaissance survey. Reptiles were not found but have been found in the ISA during other field surveys. Evaluation of existing amphibian life history information and plant community information to determine potential habitat areas and potential for exposure. Evaluation of toxicological literature to determine potential toxicity and/or bioavailability. Collection of surface water in quiescent areas and other potential exposure areas.
4. Define the Boundaries	The ISA will be the initial geographic boundary. Risk to amphibians will be assessed quantitatively if possible. Risk to aquatic plants cannot be quantitatively assessed because of lack of appropriate toxicity data. Amphibians will be used as surrogate to assess the risk to reptiles. If suitable reptile habitat is found within the ISA a comparative evaluation of toxicity will be performed using literature data. Temporal variability will influence study design. Detection limits will be those currently achievable by the analytical laboratory conducting the analyses as described in the approved QAPP. Detection limits will be lower (if analytically achievable) than risk-based values for protection of amphibians and aquatic plants.

Table 7-9. The DQO Process for the Ecological Risk Evaluation: Amphibians, Reptiles, and Plants.

DQO Step	Output
5. Develop a Decision Rule	If the COPC concentration using the maximum concentration is greater than the NOEC/LOEC for amphibians, the COPC will be retained for further evaluation (NOEC used for sensitive species). Aquatic plants will be assessed qualitatively. Amphibian assessment will be a surrogate for the reptile evaluation since the amphibians are more sensitive.
6. Specify Tolerable Limits on Decision Errors	Null Hypothesis: Amphibians and aquatic plants are exposed to hazardous substances within the ISA. Alternate Hypothesis: Amphibians and aquatic plants are not exposed to hazardous substances within the ISA. Evaluation of variability of exposure concentrations relative to sample design. Evaluation of the variability of toxicity values relative to the decision rule.
7. Optimize the Design	Surface water samples will be collected in quiescent areas and within other potential habitat areas.

Table 7-10. The DQO Process for the Human Health Risk Assessment.

DQO Step	Output
1. State the Problem	Need to estimate potential risks to human health associated with exposure to chemicals in sediment, surface water, groundwater seeps, and/or biota that are a result of historic and ongoing activities in the ISA.
2. Identify the Decision	Determine whether chemicals in sediment, surface water, groundwater seeps, or biota that are the result of historic and ongoing activities in the Site result in unacceptable risks to human health and warrant consideration of further investigation or possible response action.
3. Identify the Inputs to the Decision	Zoning maps, city plans, discussions with EPA and its partners, and site reconnaissance surveys were used to identify potential human use areas prior to Round 1 and Round 2. Beach sediment samples collected in potential human use areas during Round 1 and in-water sediment samples collected in the Site will be used to estimate potential exposure to chemicals in sediment. Surface water data will be collected during Round 2 and will be used to estimate potential exposure to chemicals in surface water. Technically defensible studies or EPA guidance that are appropriate for Portland Harbor will be used to identify ingestion rates that can be used for biota. Resident fish and shellfish tissue samples collected during Round 1, and salmon, sturgeon, and lamprey samples collected in the summer of 2003 by ODHS, ATSDR, ODF&W, City of Portland, and USEPA, Region 10 along with identified appropriate ingestion rates, will be used to estimate potential exposure to chemicals in tissue. A Seep Reconnaissance Survey was conducted to identify locations of groundwater seeps where human exposure may occur. Existing groundwater data or new groundwater or seep data collected during the RI may be used to estimate potential exposures to and risks from groundwater. Toxicity information will be derived in concordance with EPA Directive OSWER Directive 9285.7-53, Human Health Toxicity Values in Superfund Risk Assessments (December 5, 2003). Analytical concentration goals were developed to be protective of human health.

Table 7-10. The DQO Process for the Human Health Risk Assessment.

DQO Step	Output
4. Define the Boundaries	Target populations: • Sediment samples • Surface water samples • Tissue samples Spatial boundaries: • Beach sediment – Surface beach sediment within human use areas of the Site • In-water sediment – Selected in-water sediments collected in Round 2 in areas within the Site where fishing occurs or commercial diving has been documented. • Surface water – River water samples within areas of the Site adjacent to beaches potentially used for recreation (e.g., Swan Island Lagoon) • Tissue – Resident fish and shellfish collected within the Site • Tissue – Salmon, sturgeon, and lamprey collected by ODHS, ATSDR, ODF&W, City of Portland, and USEPA, Region 10 during summer 2003. Time frame: • Beach sediment – During low water when most of bank is exposed and during summer when beach use is most likely. • In-Water sediment – All times • Surface water – During summer when swimming would occur • Tissue – All times with emphasis during April through October Practical constraints: • Field samples collected during times when access is adequate • Tissue – Sufficient quantity of individual species within ISA for composite samples

Table 7-10. The DQO Process for the Human Health Risk Assessment.

DQO Step	Output
5. Develop a Decision Rule	If the risk estimate exceeds 1×10^{-6} for cancer risks and/or the hazard index exceeds 1.0 for noncancer risks, then evaluate the need for further investigations to gather additional site-specific data. The necessity for such site-specific data in making risk management decisions required for the ROD will be assessed prior to conducting further studies.
6. Specify Tolerable Limits on Decision Error	Conservative assumptions will be used and risks will be estimated using ranges of potential exposure values.
7. Optimize the Design	Collect surface sediment samples in human use areas Collect fish and shellfish tissue – whole body and fillets Collect surface water samples in human use areas

Table 8-1. The DQO Process for Natural Attenuation Potential.

DQO Step	Output
1. State the Problem	Need to understand specific elements of the physical system sufficient to make a determination of candidate natural attenuation areas.
2. Identify the Decision	Determine if natural attenuation is a viable alternative that needs further investigation. If so, identify the areas most likely to be suitable for natural attenuation that require further study.
3. Identify Inputs to the Decision	Need the following data sufficient to run proposed natural attenuation models: • Surface sediment chemistry • Water content, specific gravity, and grain size • Hydrodynamic model results • Uncertainty and sensitivity analysis of the hydrodynamic model • Sedimentation rates based on select Be^7 and Pb^{210} cores (Rounds 2 and 3) • Chemistry of incoming sediments based on select water column samples for TSS, dissolved and total chemical analyses (Round 2) and sediment trap studies (Round 3) • Mixed Layer Depth – Select Be^7 and Pb^{210}cores (Rounds 2 and 3) • Mixing Rate – Radioisotope studies (Round 3) • Biodegradation Rates – from literature values • Groundwater velocities and chemical concentrations where this process is important – Round 3 • Analysis of existing sediment chemistry trends information to understand if natural attenuation already occurring (only applies to areas where sources have been controlled).
4. Define the Boundaries to the Study	Conduct select Round 2 data gathering in areas of the ISA that may have potential for processes that support natural attenuation. Conduct Round 3 data gathering in areas that likely support natural attenuation processes including within the ISA as well as any expanded ISA areas that are at risk based on results of risk assessment

Table 8-1. The DQO Process for Natural Attenuation Potential.

DQO Step	Output
5. Develop a Decision Rule	Use existing physical information to determine most likely types of physical environments that have processes that may support natural attenuation. Conduct select sampling described in step 3, in these areas. Use resulting information to define a range of model parameter values. Input range of values into model and identify types of areas with physical processes that have a reasonable probability of supporting natural attenuation. Focus Round 3 investigations on types of areas with likely physical processes and refine natural attenuation estimates in these areas that also exhibit unacceptable risks based on the preliminary risk assessment. Define areas for the FS that may have natural attenuation as a viable remedial alternative for consideration and comparison against other remedial alternatives.
6. Specify Tolerable Limits on Decision Errors	Null hypothesis: Natural attenuation is an unacceptable remedial alternative in the ISA. Sampling and hydrodynamic modeling must be sufficient to provide a reasonable confidence that the spatial range of possible conditions has been sampled. This includes groundwater data collected through other efforts in this Work Plan and directed by DEQ at upland sites. Potential ranges of model inputs for each parameter must be established. Therefore sampling must include understanding of both spatial and temporal variability within areas that appear to support natural attenuation processes.
7. Optimize the Design for Obtaining Data	The detailed approach to natural attenuation modeling is described in the natural attenuation memorandum (Appendix A, Attachment A4). Keep Round 3 efforts flexible so that they can benefit from information gathered in Round 2.

Table 8-2. Current Site-Specific Data Gaps for Natural Attenuation Evaluation.

Data Needs	**Step 1**	**Step 2**	**Step 3**
Grain Size	+	+	Gap
STA Results	+	+	+
Bathymetry	+	+	+
Surface Sediment Chemistry	+	Gap	Gap
Water Content/Specific Gravity	NR	Gap	Gap
Hydrodynamic Modeling	NR	Gap	Gap
Sedimentation Rate	NR	Gap	Gap
Chemistry of Incoming Sediments	NR	Gap	Gap
Mixed Layer Depth	NR	Gap	Gap
Mixing Rate	NR	NR	Gap
Biodegradation Rate	NR	NR	Gap
Subsurface Sediment Chemistry	NR	NR	Gap
Groundwater Flow/Chemistry	NR	NR	Gap

+ Existing information sufficient for this step.

NR - This information not required for this step.

Table 8-3. Proposed Studies to Fill Data Gaps for Natural Attenuation Evaluation.

Data Needs	**Step 1**	**Step 2**	**Step 3**
Grain Size			Round 3 sampling
STA Results			
Bathymetry			
Surface Sediment Chemistry		Round 2 sampling	Round 3 sampling
Water Content/Specific Gravity		Round 2 sampling	Round 3 sampling
Hydrodynamic Modeling		Preliminary model runs	Detailed model runs
Sedimentation Rate		Water column samples and selection of radioisotope cores (Round 2)	Water column samples, sediment traps, and/or radioisotope studies (Round 3)
Chemistry of Incoming Sediments		Water column samples (Round 2)	Water column samples/sediment traps (Round 3)
Mixed Layer Depth		Selection of radioisotope cores (Round 2)/redox boundary in cores	Radioisotope cores (Round 3)/redox boundary in cores
Mixing Rate			Radioisotope cores (Round 3)
Biodegradation Rate		Literature values	Literature values
Subsurface Sediment Chemistry			From Round 2 and 3 Subsurface Cores
Groundwater Flow/Chemistry		LWG Lead and DEQ Lead Groundwater Studies	LWG Lead and DEQ Lead Groundwater Studies

Table 9-1. Contact Information for Designated Project Coordinators.

Name/Affliation	**Address**	**Phone/FAX**	**Email**
Chip Humphrey Project Coordinator U.S. Environmental Protection Agency	811 SW 6th Avenue, 3rd Floor Portland, OR 97204	Ph: (503) 326-2678 Fax: (503) 326-3399	humphrey.chip@epa.gov
Tara Martich Project Coordinator U.S. Environmental Protection Agency	1200 Sixth Avenue, M/S ECL-115 Seattle, WA 98101	Ph: (206) 553-0039 Fax: (206) 553-0124	martich.tara@epa.gov
Jim Anderson Project Coordinator Oregon Department of Environmental Quality	2020 SW 4th Ave. #400 Portland, OR 97201	Ph: (503) 229-6825 Fax: (503) 229-6899	anderson.jim@deq.state.or.us
Bob Wyatt LWG Co-Chair	Northwest Natural 220 NW Second Avenue Portland, OR 97209	Ph: (503) 226-4211 ext. 5425 Fax: (503) 273-4815	rjw@nwnatural.com
Jim McKenna LWG Co-Chair	Port of Portland 121 NW Everett St., P.O. Box 3529 Portland, OR 97208	Ph: (503) 944-7325 Fax: (503) 944-7353	mckenj@portptld.com
Rick Kepler Oregon Department of Fish & Wildlife	2501 SW First Avenue Portland, OR 97207	Ph: (503) 872-5255 ext.5426 Fax: (503) 872-5269	rick.j.kepler@state.or.us
Helen Hillman NOAA Resources Coordinator	c/o EPA Region 10 1200 Sixth Avenue (M/S ECL 17) Seattle, WA 98101	Ph: (206) 553-4974 Fax: (206) 553-0124	hillman.helen@noaa.gov
Preston Sleeger U.S. Department of Interior, Regional Environmental Officer Pacific Northwest Region	500 NE Multnomah St. Suite 356 Portland, OR 97232	Ph: (503) 321-6157 Fax: (503) 231-2361	preston_sleeger@ios.doi.gov
Brian Cunninghame Confederated Tribes of the Warm Springs Reservation of Oregon Natural Resources Department	5520 Skyline Drive Hood River, OR 97031	Ph: (541) 490-2009	(b) (6)
Paul Ward Confederated Tribes and Bands of the Yakama Nation,	P.O. Box 151 4690 SR 22 Toppenish, WA 98948	Ph: (509) 949-4129 Fax: (509) 865-6293	ward@yakama.com
Rod Thompson Confederated Tribes of the Grand Ronde Community of Oregon	47010 W Hebo Rd., P.O. Box 10 Grand Ronde, OR 97347	Ph: (503) 879-2385	rod.thompson@grandronde.org
Tom Downey Environmental Specialist Confederated Tribes of the Siletz Indians of Oregon	P.O. Box 549 Siletz, OR 97380	Ph: (541) 444-8226 Fax: (541) 444-9688	tomd@ctsi.nsn.us
Audie Huber Confederated Tribes of the Umatilla Indian Reservation Department of Natural Resources	73239 Confederated Way Pendelton, OR 97801	Ph: (541) 966-2334 Fax: (503) 276-3317	audiehuber@ctuir.com
Rick Eichstaedt Nez Perce Tribe	P.O. Box 305 Lapwai, ID 83540	Ph: (208) 843-7355	ricke@nezperce.org

Table 9-2. Portland Harbor RI/FS Deliverable Descriptions and Submittal Deadlines

Phase	Deliverable[1]	Purpose	Submittal Deadline[2]
Project Scoping	**Process to Identify COPCs TM**	Describes the process and timing for identifying COPCs based on Round 1 and Round 2A data. Result of the screening will be identification of COPCs that will be the focus of future sampling rounds and risk analysis and will be limited to those chemicals that are identified as COPCs by screening methods or based on preliminary risk estimates. Descriptions of COPC screening methods used in the ERA and HHRA will be included. This technical memorandum will identify the steps in the RI process at which COPC identification will occur (e.g., the Ecological Preliminary Risk Evaluation and Round 2 Site Characterization and Summary Report). The technical memorandum will also identify potential interim steps where additional risk evaluation may be needed to support data gaps analysis or risk communication needs.	7/28/2004
	Process for Derivation of PRGs TM	Explains the approach to be used for developing PRGs. Development of initial PRGs is expected to occur after Round 2, which will be used in identifying data gaps for Round 3. These initial PRGs will be revised based on results of Round 3 and used to develop refined PRGs for use in the FS. In addition to addressing the requirements of the SOW, the possible approaches include deriving site-specific BSAFs, using an aquatic food web model, using the benthic predictive model, and/or evaluating potential reduction in risk under various exposure scenarios.	1/20/2005
	Ecological and Human Health Groundwater Pathways Assessment/ Groundwater Sampling Approach TM	Specifies a framework for identifying data uses and data needs for evaluating the effects of COIs in groundwater discharging to the Transition Zone and surface water. Identifies which sites to conduct additional evaluation of the groundwater pathway to the river, summarizes exposure scenarios to COIs discharging to the Transition Zone and surface water, identifies how existing data and field data collected as part of the RI/FS will be used, establishes a process for identifying locations where additional data to assess groundwater discharge are needed, and identifies data needs from those locations.	7/12/2004

Table 9-2. Portland Harbor RI/FS Deliverable Descriptions and Submittal Deadlines

Phase	Deliverable[1]	Purpose	Submittal Deadline[2]
Project Scoping	*Approach to Determining Background for the Portland Harbor Superfund Site / Process for Delineating the Extent of Contamination Upstream and Downstream of the ISA*	Describes the definition and approach for determining background levels for the Site. This information will be used, following the risk characterization in the risk assessment, as a risk management tool, consistent with EPA guidelines (EPA 2002c). Describes the general approach to determine the data and analyses needed upstream and downstream of the ISA for EPA to determine Site boundaries.	6/21/2005
	Conceptual Site Model Update	Presents existing upland site information for potential sources and source-related data as well as data on potential past and/or current pathways to sediment, surface water, and Transition Zone water, from groundwater, storm and wastewater discharges, erosion, and over-water activities. The update will focus on providing detailed data on the groundwater transport pathway to facilitate scoping of Round 2B subsurface sediment sampling. The CSM will be more completely updated in the Comprehensive Round 2 Site Characterization Summary and Data Gaps Analysis Report.	8/17/2004
	Round 2 Quality Assurance Project Plan	Describes laboratory and QA/QC procedures applicable to Round 2 sediment and surface water sampling	4/12/2004
	Cultural Resource Survey	Reviews agency records, historical documents, and other published and unpublished materials to define locations of known or reported cultural resources and locations where cultural resources are likely to be present. The survey area extends from the mouth of the Willamette River to Willamette Falls. Will include information gathered by certain Tribes on traditional and present cultural use of the study area.	300 days following receipt of scope from EPA
Hydrodynamic Modeling	Hydrodynamic Modeling TM	Presents and analyzes existing data about physical processes that could influence hydrodynamic and sedimentation in the Lower Willamette River. Identifies those processes that should be included in a model description of the study area. Proposes the model to be used to simulate hydrodynamic and sedimentation processes in the Lower Willamette River. Proposes the extent of the area to be modeled and the approach to model calibration and application.	4/4/2003

Table 9-2. Portland Harbor RI/FS Deliverable Descriptions and Submittal Deadlines

Phase	Deliverable[1]	Purpose	Submittal Deadline[2]
Hydrodynamic Modeling	Step 1 Hydrodynamic Modeling Results	Presents the development of the model grid to the Lower Willamette River and Multnomah Channel. Presents the preparation of model input and calibration data. Presents and analyzes the model calibration to observations (hydrodynamic and sediment). Presents a sensitivity analysis of study area processes. Recommends whether the 2-D model is adequate for application to evaluate remedial alternatives or whether a 3-D model should be developed from the 2-D model grid. Identifies types and locations of additional data that could benefit the modeling processes.	120 days following EPA approval of Hydrodynamic Model TM
	Step 2 Hydrodynamic Modeling Results	Assuming that the 2-D model adequately represents hydrodynamic and sedimentation processes in the study area, the report presents the development of hydrodynamic and sediment conditions to be used to evaluate remedial alternatives. Presents and analyzes the results of the simulation of remedial alternatives. (If a 3-D model is needed, or if significant additional data are needed to validate either the 2-D or 3-D model, the report also presents the re-calibration of the model.)	180 days following receipt of EPA comments on Step 1 Hydrodynamic Modeling Results
Ecological Risk Assessment	**TRV Selection TM**	Explains the identification process of chemicals of interest and the selection process of TRVs based on Round 1 data to be used in the ERA. The methods and guidelines used to prioritize the available literature for TRV selection, detailed discussion of the selection process for each TRV, and the results of the TRV selection process for each receptor (i.e., benthic invertebrate tissue-based approach, fish, bird, and mammals) will also be included. For wildlife and dietary update to fish, TRVs will be based on conservative assumptions using a food-web model. For whole-body fish tissue and invertebrate tissue, tissue-based TRVs will be developed for direct comparison to Round 1 tissue data. The technical memorandum will present the recommended TRVs for wildlife, fish, and invertebrate tissue. Amphibian and plant TRVs will be developed following collection of Round 2 surface water and sediment data.	4/28/2004
	Preliminary Risk Evaluation Approach TM	Explains the approach for Preliminary Risk Evaluation (PRE). Includes outline of PRE and description of how risks to aquatic feeding wildlife and fish and invertebrates will be assessed in the PRE. Describes how the various receptor groups (i.e., fish, birds, mammals) will be assessed with respect to potential exposure and how data from each medium will be aggregated to estimate exposure point concentrations (EPCs). (Note: TRVs for wildlife, fish, and invertebrate tissue will be approved by EPA before this TM is approved.)	5/28/2004

Table 9-2. Portland Harbor RI/FS Deliverable Descriptions and Submittal Deadlines

Phase	Deliverable[1]	Purpose	Submittal Deadline[2]
Ecological Risk Assessment	**Benthic Assessment Interpretive Approach TM**	Describes the development and application of a predictive relationship model between chemical concentrations in the sediment and bioassay responses. Several different explorative approaches to evaluate the relationship will be described including, but not limited to, determining the reliability of published sediment quality guidelines to predict toxicity in Portland Harbor sediments, and developing site-specific relationships between chemical contaminants detected in sediment and toxicity (e.g. logistic regression model). Other models may be identified. The appropriate model or approach may vary for different COPCs, receptors, or uses. This technical memorandum will also propose the collection of bioassay samples at reference locations for later use in risk characterization and risk management.	5/28/2004
	Comprehensive ERA Approach TM	Characterizes how the various receptor groups (i.e., benthic invertebrates, fish, birds, mammals, and plants) will be assessed with respect to potential exposure and how data from each medium will be aggregated to estimate EPCs. Linkage between assessment endpoints and measures, including prioritization of lines-of-evidence for risk management decisions, will be presented. This memorandum will also describe the analysis framework for assessing each assessment endpoint in the risk characterization. Spatial data analysis methods that account for habitat preferences for each species to be evaluated in the baseline ERA will also be presented. Chemical-specific evaluation methods will be discussed.	6/27/2004

Table 9-2. Portland Harbor RI/FS Deliverable Descriptions and Submittal Deadlines

Phase	Deliverable[1]	Purpose	Submittal Deadline[2]
Ecological Risk Assessment	Food Web Model TM	Provides details on the use of BSAFs and/or a food web model for the RI/FS. The TM will include the objectives for selection of either the BSAFs and/or a food web model, including the need to assess steady-state versus time-varying conditions at the site as well as spatially varying conditions. The TM will describe the model selection process, including the use of historical data and data collected in Round 1 (e.g., co-located sediment and tissue samples) to perform initial runs of the candidate food web models. The following components of the model will be described: model setup, model calibration, model validation, sensitivity analysis, and uncertainty analysis. The sensitivity and uncertainty analyses will identify parameters that have the greatest impact on the results. The results of this initial modeling effort, as well as the results of the sensitivity and uncertainty analyses, will be used to select the preferred food web model that will be further evaluated after collection of Round 2 data and to identify data gaps in the food web model. The level of effort needed to apply the model should be discussed for both the modeling itself as well as for collecting additional site-specific data (other than Round 2 data, which will be incorporated into the food web model report), if needed. The TM should also give examples of other sites where the selected food web model has been calibrated and validated in an environment similar to the Portland Harbor site.	7/28/2004
	Ecological Preliminary Risk Evaluation (PRE)	Includes a risk characterization based on historical, pre-AOC, and Round 1 data for benthic invertebrates using the tissue-residue approach, fish, and wildlife. Results will be used, in part, to help identify COPCs related to contaminant concentrations in fish and invertebrate tissue. This applies primarily to risks to aquatic-feeding wildlife that consume fish or invertebrates from the river, and risks to invertebrates and fish containing the compounds. This COPC identification is narrowly focused because sediment data from Round 2 are needed to identify a comprehensive list of COPCs. The PRE will not rely on the benthic assessment technical memorandum, which addresses the analysis framework for the sediment toxicity data to be collected during Round 2. The preliminary risk estimates and the associated uncertainty will help to identify ERA data and information gaps that may be filled during subsequent investigations/evaluations prior to the baseline ERA.	90 days following EPA approval of PRE Approach TM

Table 9-2. Portland Harbor RI/FS Deliverable Descriptions and Submittal Deadlines

Phase	Deliverable[1]	Purpose	Submittal Deadline[2]
Ecological Risk Assessment	*Round 2 Benthic Assessment Report*	Uses the results of Round 2 sediment bioassays to implement the analyses described in the Benthic Assessment Interpretive Approach TM. Objectives are to 1) develop and apply a predictive relationship model between chemical concentrations in the sediment and bioassay responses, and 2) confirm toxicity in high priority areas.	180 days following completion of Round 2 bioassay sampling
	Food Web Modeling Report	Uses Round 2 data to supplement Round 1 data to perform additional runs of food web model identified in the food web model TM. If the available data were insufficient for selecting a food web model in the TM, a model will be selected after incorporation of the Round 2 data. If none of the steady-state models evaluated can be used to achieve the objectives outlined in the food web model TM, the need for the collection of additional data and/or the evaluation of non-steady-state (i.e., time-varying) models that incorporate the results of hydrodynamic and fate and transport modeling will be discussed with EPA and its partners. Additional data needs for model calibration and validation (which will be separate from those data used to develop the model) will also be discussed. An approach and schedule for collecting additional data and food web model reports, if necessary, will be included.	90 days following completion of Round 2 surface sediment and summer 2004 surface water sampling and analysis
Human Health Risk Assessment	*Fish Tissue Exposure Point Concentrations Interim Deliverable*	Provides exposure point concentrations (EPCs) for fish and crayfish tissue for human health evaluation. Information will be provided in a format agreed to by EPA and the LWG. EPCs will be calculated as described in Appendix C.	6/1/2004
	Round 1 Data Gaps Analysis Interim Deliverable	Analyzes Round 1 data to determine if data gaps for fish tissue or beach sediment exist for the HHRA.	7/28/2004
	COPC Selection Interim Deliverable	Describes COPC selection methods for beach sediment, in-water sediment and surface water (see Section 2.3 of Appendix C). This interim deliverable will include a description of these procedures and the resulting COPC lists for these media. A list of detected chemicals in fish tissues will be included. Any other media that may be included in the HHRA will be screened for COPCs according to methods determined through future discussions with EPA and its partners. For purposes of the RI/FS and associated baseline risk assessment, COPC identification will be developed for the Comprehensive Round 2 Site Characterization Summary Report. However, additional COPC selection may be needed to support interim risk communication needs outside of the RI/FS, such as the ODH public health assessment that is scheduled to be completed before the RI/FS.	8/21/2005

Table 9-2. Portland Harbor RI/FS Deliverable Descriptions and Submittal Deadlines

Phase	Deliverable[1]	Purpose	Submittal Deadline[2]
Human Health Risk Assessment	**EPC Calculation Approach TM**	Describes the process for calculating EPCs for in-water sediment, surface water, and seep water (see Section 3.4 of Appendix C).	9/15/2004
	Summary of Exposure Factors Interim Deliverable	Provides a summary of all exposure factors developed for use in the HHRA by receptor and exposure pathway. Exposure factors are discussed qualitatively in several parts of Appendix C and specifically in Section 3.5.1 (Receptor Specific Assumptions) and are presented in Tables 5 through 14 of Appendix C for beach sediment and surface water. Exposure factors for media and pathways not included in the Work Plan (i.e., in-water sediment, seep water) also will be included in the interim deliverable and will be developed through discussions with EPA.	12/1/2004
	Toxicity Values Interim Deliverable	Presents a summary of selected toxicity values for chemicals detected in Round 1 beach sediment and biota evaluated for human health. Toxicity values for additional COPCs identified from subsequent sampling rounds will be added; any values updated prior to future risk evaluations will be revised, as needed, through discussion with EPA. The hierarchy of sources for toxicity values for the HHRA is defined in Section 4.1 of Appendix C.	7/1/2004
	HHRA Uncertainty Analysis Outline	Discusses the areas of uncertainty inherent in the risk assessment process (such as estimates of exposure and toxicity).	3/1/2005
Site Characterization	*Validated Analytical Results*	Provides validated analytical data in electronic format showing locations, media, and results. As specified in the AOC, and upon request, analytical data will be made available to EPA within 60 days of each sampling activity.	90 days following completion of each sampling activity, 180 days following completion of natural attenuation sampling
	Field Sampling Reports	Summarizes field sampling activities, including sampling locations (maps), requested sample analyses, sample collection methods, and any deviations from the FSP.	60 days following completion of each sampling activity
	Site Characterization Summary Reports	Provides validated sample analysis results in tabular format. Provides chemical concentration maps showing the distribution of sample analysis results for selected COIs. Data validation reports and a summary of data validation results also will be included in each site characterization summary report. EPCs for human health will be submitted as interim deliverables with site characterization summary reports.	120 days following completion of each sampling and analysis activity

Table 9-2. Portland Harbor RI/FS Deliverable Descriptions and Submittal Deadlines

Phase	Deliverable[1]	Purpose	Submittal Deadline[2]
Site Characterization	Bioassay Data Report	Documents all activities associated with the collection, handling, and analysis of Round 2 bioassay samples. Includes a brief review of the study design and methods, data tables summarizing the testing, deviations from the protocols appended to the approved QAPP, copies of chain-of-custody forms, data validation reports, and tables of all raw data.	60 days following completion of Round 2 bioassay sampling and analysis
	Comprehensive Round 2 Site Characterization Summary and Data Gaps Analysis Report	Summarizes pre-AOC, Round 1, and Round 2 investigation results; presents preliminary evaluation of risks to human health (as described in Appendix C of Work Plan) and ecological receptors (as described in Appendix B of Work Plan and associated technical memoranda) based on site-specific data for purposes of identifying COPCs 'risk drivers' and data gaps to be addressed in Round 3 sampling; provides a comprehensive update of the CSM; provides initial PRGs; presents a screening of pre-AOC, Round 1, and Round 2 data relative to PRGs; and identifies any data gaps to be addressed in Round 3. Also provides the most current results of the food web model, its application to development of initial PRGs, and food web modeling data gaps. This summary reviews the investigative activities and displays Site information and data documenting the location and characteristics of surface and subsurface features and contamination at the Site, including sample locations, chemical concentration distributions, and the results of any biological testing. This evaluation will include, to the extent practicable, COPC concentration distributions relative to known sources, and the extent of contaminant migration through the in-water portion of the Site. The data compilation and summary will provide EPA with a preliminary reference for evaluating the risk assessments, the development and screening of remedial alternatives, and the further identification of ARARs.	180 days from completion of all Round 2 sampling, excluding groundwater impacts sampling
	Draft RI Report and Baseline Risk Assessment Reports	Includes 1) a characterization of the distribution of chemicals and sources that affect the river; 2) an assessment of ecological risk including risks to benthos, fish, wildlife, and other receptors of concern; 3) an assessment of human health risks from contact with sediment and water, and fish and shellfish ingestion; 4) a preliminary delineation of SMAs and sediment volumes that pose unacceptable risks; 5) a preliminary delineation of principal threat areas, and 6) a preliminary understanding of the potential for natural attenuation as a remedial alternative.	180 days from completion of Round 3 sampling

Table 9-2. Portland Harbor RI/FS Deliverable Descriptions and Submittal Deadlines

Phase	Deliverable[1]	Purpose	Submittal Deadline[2]
Site Characterization	**Final RI Report and Baseline Risk Assessment Reports**	See draft RI Report above.	90 days from receipt of EPA comments on Draft RI Report and Baseline Risk Assessment Reports
Feasibility Study	*2003 Sediment Stake Results Report*	Describes data collected in 2003 from shoreline stakes that measure changes in sediment elevation changes throughout the ISA. These data will be compared to available bathymetry changes in deeper waters near these stations.	4/16/2004
	Step 1 Natural Attenuation Evaluation and Step 2 Field Sampling Plan and Data Evaluation Methods TM	Describes the selection of sampling locations and types based on Step 1 of the Natural Attenuation Evaluation process described in Appendix A. Also describes the field sampling plan for Step 2 of the process as well as the data evaluation procedures that will be employed once Step 2 data are received. EPA may request that the field sampling plan be separated from the data evaluation procedures, resulting in two separate submittals (Round 2 FSP Addendum and Natural Attenuation Data Evaluation Methods TM).	4/1/2004
	Step 2 Natural Attenuation Evaluation Report	Presents results from the data collected per the Step 1 Evaluation and Step 2 Field Sampling Plan and Data Evaluation Methods memorandum above. In addition, it will present data evaluations, including any necessary modeling efforts to identify potential areas for further investigation of natural attenuation as a remedial technology.	270 days following completion of Step 2 natural attenuation sampling activity
	Step 3 Natural Attenuation TM and Field Sampling Plan	Presents proposed methods for determination of candidate areas for natural attenuation as a remedial technology. Includes methods for selection of sampling locations and types as well as data evaluation procedures (including any modeling) that will be employed once Step 3 data are received.	60 days following EPA approval of Step 2 Natural Attenuation Evaluation Report
	Step 3 Natural Attenuation Field Sampling Report	Presents results from the data collected per the Step 3 Natural Attenuation TM and Field Sampling Plan (above). Additionally presents data evaluations, including any necessary modeling efforts to identify candidate areas for natural attenuation as a remedial technology to be considered in the FS Report.	60 days following completion of Step 3 natural attenuation sampling
	Facility Siting Inventory Report	Presents an inventory of possible disposal sites and screens those sites based on several criteria (see Appendix A) to obtain a refined list of potential disposal sites for contaminated sediments.	7/12/2004

Table 9-2. Portland Harbor RI/FS Deliverable Descriptions and Submittal Deadlines

Phase	Deliverable[1]	Purpose	Submittal Deadline[2]
Feasibility Study	Facility Siting Re-Screen Report	Presents an additional screening of potential disposal sites identified from the Inventory Report (above) based on Portland Harbor-specific information that will be available later in the RI/FS process (e.g., areas and volumes of sediments that are potentially contaminated). The report will present a refined list of disposal sites for further evaluation (see Appendix A).	3/14/2005
	Facility Siting Final Ranking Report	Uses the list of disposal sites from the Facility Siting Re-Screen Report (above), and criteria and methods described in Appendix A, to obtain a final ranking of potential disposal sites for Portland Harbor contaminated sediments.	4/12/2006
	Recontamination Potential Modeling Approach TM	Presents the types of sampling and data evaluation procedures that will be used to determine the level and extent of recontamination potential that may exist at the site. Includes the general types of sampling, the target locations of such sampling, and the data evaluation procedures (including any modeling) that will be used to determine the potential for recontamination after remediation of sediments takes place.	150 days following completion of all Round 2 sampling activities
	Literature Survey of Treatability Studies	This memorandum (described in detail in Appendix A)will contain a review of literature to determine: 1) which treatment technologies are effective and cost competitive (potentially suitable) as compared to other remedial technologies, and 2) for those potentially suitable technologies, whether treatability studies would be needed to determine the appropriateness of the technologies for this specific site. The survey will contain a conclusion section that will describe whether further treatability studies are needed, and if so, the general extent of those studies.	9/9/2005
	Refined Preliminary RAOs TM	Includes updated RAOs and PRGs to be used in the FS. As required by the SOW, general types of PRGs (e.g., national or regional numeric sediment guidelines) will be considered when refining PRGs. However, refined PRGs will be primarily based on the results of the risk assessment and other work (e.g., food web modeling) conducted during the RI. As with the preliminary RAOs, the refined RAOs will specify the chemicals and media of interest, exposure pathways and receptors, and an acceptable chemical level or range of levels (i.e., a PRG). PRGs will be location-specific within the project study area where risks estimates vary across the study area due to differences in exposure levels/routes or other site-specific risk parameters.	90 days from receipt of EPA comments on Round 2 Groundwater Impacts Site Characterization Summary Report

Table 9-2. Portland Harbor RI/FS Deliverable Descriptions and Submittal Deadlines

Phase	Deliverable[1]	Purpose	Submittal Deadline[2]
Feasibility Study	Alternatives Development and Screening Report	Per Section 9.2 of the SOW, this task summarizes results of the identification, assembly, refinement, and screening of remedial alternatives. It will contain the results of Sections 5.3 through 5.7 of Appendix A, which describes these studies in detail.	90 days from receipt of EPA comments on Refined Preliminary RAOs TM
	Draft FS Report	As described in Appendix A, the LWG will complete the detailed analysis of remedial alternatives including recommending remedial alternatives that meet the refined RAOs and include any appropriate restoration components. A justification for the selection of this recommendation will also be included. This recommendation, along with all the supporting analysis and information developed in Sections 3, 4 and 5 of Appendix A, will be submitted in a Draft Feasibility Study Report to EPA.	150 days from receipt of EPA comments on Draft RI Report and Baseline Risk Assessment Reports
	Final FS Report	See Draft FS Report above	60 days from receipt of EPA comments on Draft FS Report
Field Sampling Plans	**Round 2 Shorebird FSP Addendum**	Describes sampling locations and procedures for Round 2 beach sampling to support ecological and human health risk assessments	2/24/2004
	Round 2 Surface Water FSP	Describes surface water sampling locations and procedures	4/2/2004
	Round 2A Sediment Coring FSP Addendum	Describes Round 2A sediment coring sampling locations and procedures.	6/5/2004
	Round 2B Sediment Coring FSP Addendum	Describes Round 2B sediment coring sampling locations and procedures	60 days following receipt of EPA comments on Revised CSM
	Round 2 Groundwater Impacts Sampling FSP	Describes groundwater sampling locations and procedures. Includes a QAPP, if necessary.	60 days following EPA approval of Groundwater Pathways TM
	Round 2 Seep Sampling FSP	Describes seep sampling locations and procedures. Includes a QAPP, if necessary.	60 days following EPA approval of Groundwater Pathways TM
	Round 3 Surface Water FSP (if required)	Describes surface water sampling locations and procedures. Includes a QAPP, if necessary.	120 days following completion of Round 2 surface water sampling if directed by EPA

Table 9-2. Portland Harbor RI/FS Deliverable Descriptions and Submittal Deadlines

Phase	**Deliverable**[1]	**Purpose**	**Submittal Deadline**[2]
Field Sampling Plans	**Round 3 FSP**	Describes Round 3 sampling necessary to support baseline risk assessments, site characterization and/or feasibility study. Describes sampling locations and procedures. Includes a QAPP, if necessary.	180 days following completion of all Round 2 sampling
Sampling Programs	*Not Applicable*	Initiate Sampling	30 days following EPA approval of applicable FSP or as directed by EPA

Notes:

[1] - **Bolded Deliverables** are primary deliverables per Section XIX., Paragraph 4, of AOC (EPA 2001a).
Unbolded Deliverables are secondary deliverables per Section XIX, Paragraph 5, of AOC.
Italicized Deliverables do not have stipulated penalty amounts.

[2] - Listed Submittal Deadlines are for draft documents. Unless otherwise specified, all final documents are due to EPA 30 days following receipt of comments from EPA.

TAB 2

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10
OREGON OPERATIONS OFFICE
811 S.W. 6th Avenue
Portland, Oregon 97204

June 29, 2004

Mr. Jim McKenna
Port of Portland & Co-Chairman, Lower Willamette Group
121 NW Everett
Portland, Oregon 97209

Mr. Robert Wyatt
Northwest Natural & Co-Chairman, Lower Willamette Group
220 Northwest Second Avenue
Portland, Oregon 97209

Re: Portland Harbor Superfund Site; Administrative Order on Consent for Remedial Investigation and Feasibility Study; Docket No. CERCLA-10-2001-0240
RI/FS Work Plan Approval

Dear Messrs. Wyatt and McKenna:

We have completed our review of the April 23, 2004 Work Plan for the Portland Harbor RI/FS (RI/FS Work Plan). We have determined that the Respondents have met the conditions in our March 15, 2004 conditional approval letter, including the directed changes to the Work Plan specified in EPA's comments that were attached to our conditional approval letter. The RI/FS Work Plan is approved.

Please note that, as described in our conditional approval letter, some of the assumptions and statements in the RI/FS Work Plan, particularly with respect to fish biology, habitat, and the physical system, may need to be verified or modified based on future investigations. EPA will evaluate additional data and other information that will be developed during the RI/FS to verify or re-consider the assumptions and conclusions described in the Work Plan.

EPA appreciates the Respondents' efforts to resolve the outstanding issues from the previous draft and we look forward to moving ahead with this important work under the approved schedule. If you have any questions, please call Chip Humphrey at (503) 326-2678 or Eric Blischke (503) 326-4006. All legal inquiries should be directed to Lori Cora at (206) 553-1115.

Sincerely,

Chip Humphrey
Eric Blischke
Remedial Project Managers

cc: John Crellin, ATSDR
Helen Hillman, NOAA
Ted Buerger, US Fish and Wildlife Service
Preston Sleeger, Department of Interior
Jim Anderson, DEQ
Kurt Burkholder, Oregon DOJ
Rick Keppler, Oregon Department of Fish and Wildlife
David Stone, Oregon Public Health Branch
Rod Thompson, Confederated Tribes of Grand Ronde
Tom Downey, Confederated Tribes of Siletz
Audie Huber, Confederated Tribes of Umatilla
Brian Cunninghame, Confederated Tribes of Warm Springs
Rick Eichstaedt, Nez Perce Tribe
Paul Ward, Confederated Tribes of Yakama Nation
Valerie Lee, Environment International
Keith Pine, Integral Consultants

TAB 3

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10
OREGON OPERATIONS OFFICE
811 S.W. 6th Avenue
Portland, Oregon 97204

December 2, 2005

Mr. Jim McKenna
Port of Portland & Co-Chairman, Lower Willamette Group
121 NW Everett
Portland, Oregon 07209

Mr. Robert Wyatt
Northwest Natural & Co-Chairman, Lower Willamette Group
220 Northwest Second Avenue
Portland, Oregon 97209

Re: Portland Harbor RI/FS
Identification of Round 3 Data Gaps

Dear Mr. McKenna and Mr. Wyatt:

As you are aware, EPA and its partners have been reviewing the data from the Round 1 and Round 2 sampling events, as well as information in other project deliverables, to develop an understanding of the existing data and to identify additional data that is needed to complete the RI/FS. The purpose of this letter is to provide the Lower Willamette Group (LWG) with the results of our review and to provide guidance on the approach to filling the data gaps in the upcoming Round 3 sampling in 2006 ("Identification of Round 3 Data Gaps" enclosed).

EPA has identified a significant number of data gaps that need to be addressed during Round 3 of the RI/FS sampling. As we have discussed in our recent management team meetings, we have developed a scoping-level approach that does not identify specific numbers and locations of samples. Rather, it provides a framework for the development of specific data collection efforts. EPA and its partners will be working through mid-January to further refine Round 3 data gaps and develop the details needed for the preparation of sampling plans. We understand that the LWG has also been reviewing the existing data and may have identified specific data gaps as well.

The current project schedule calls for the submittal of the Comprehensive Round 2 Site Characterization Summary and Data Gaps Analysis Report in April 2006, followed by a Round 3 Field Sampling Plan in May 2006. EPA and its partners have taken this time and effort to work on Round 3 data gaps in anticipation of these deliverables and to expedite the turnaround of the report and sampling plans that EPA can approve. We have included some general direction on the process for the next few months, which may require adjustments to current deliverable schedules in order to keep the overall project on schedule.

Round 2 data gathering that has been completed has been focused on sediment and surface water chemistry, benthic toxicity, and surface water chemistry, and ongoing work related to site characterization within the currently identified Portland Harbor study area. The Round 3 needs include additional data to complete the characterization, refine the conceptual site model, complete the ecological and human health risk assessments, and support the feasibility study.

Please note that while our data scoping exercise focused on identifying the data needed to complete the RI/FS, several Round 2 data gathering and analysis efforts are still underway. As a result, there may be additional data needs based on review of the data currently being gathered, and the development of the food web model, the hydrodynamic model, the benthic assessment, and alternatives development and analysis for the feasibility study.

We are looking forward to our upcoming meeting on December 13th to discuss the results of EPA's identification of Round 3 data gaps and the process for moving forward with the development of appropriate field sampling plans. If you have any questions, please call Chip Humphrey at (503) 326-2678 or Eric Blischke at (503) 326-0039. All legal inquiries should be directed to Lori Cora at (206) 553-1115.

Sincerely,

Chip Humphrey
Eric Blischke
Remedial Project Managers

Enclosures
Identification of Round 3 Data Gaps
Tables and Figures

cc: Greg Ulirsch, ATSDR
Rob Neely, NOAA
Ted Buerger, US Fish and Wildlife Service
Preston Sleeger, Department of Interior
Jim Anderson, DEQ
Kurt Burkholder, Oregon DOJ
Rick Keppler, Oregon Department of Fish and Wildlife
Amanda Guay, Oregon Public Health Branch
Jeff Baker, Confederated Tribes of Grand Ronde
Tom Downey, Confederated Tribes of Siletz
Audie Huber, Confederated Tribes of Umatilla
Brian Cunninghame, Confederated Tribes of Warm Springs
Erin Madden, Nez Perce Tribe
Paul Ward, Confederated Tribes of Yakama Nation
Valerie Lee, Environment International
Keith Pine, Integral Consulting

IDENTIFICATION OF ROUND 3 DATA GAPS

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IDENTIFICATION OF ROUND 3 DATA GAPS

Section 1 Introduction

1.1 Scope and Purpose

The Portland Harbor Remedial Investigation and Feasibility Study (RI/FS) began in 2001 with the collection of data to assess physical conditions at the site. Since that time, additional data collection efforts have included fish, shellfish and invertebrate tissue chemistry, surface and subsurface sediment chemistry, sediment toxicity testing, surface water chemistry and transition zone water chemistry. Fish and shellfish tissue chemistry and initial sediment chemistry data were collected in 2002 and submitted to EPA in a Round 1 Site Characterization Summary Report dated October 12, 2004. The majority of the Round 2 data were collected in 2004 and submitted to EPA in the Round 2A Sediment Site Characterization Summary Report dated July 15, 2005. Round 2 data collection efforts still underway include transition zone water sampling, analysis of archived sediment samples, Round 2B sediment cores and the collection of benthic tissue for chemistry and bioaccumulation testing. Round 2 data collection efforts are expected to be completed by the end of 2005.

The current project schedule calls for completing RI/FS characterization efforts by December 2006. To ensure that the project remains on schedule, EPA determined that a data gaps scoping exercise was necessary to guide the development of field sampling plans in early 2006 and to assist the Lower Willamette Group (LWG) with project planning. In addition to reviewing current and historic data collected in the Lower Willamette River, EPA has also revisited the Human Health and Ecological Risk Assessments to determine if any modifications to the work plans are necessary and, if so, what additional data may be required to complete these assessments.

1.2 Methodology

The data gaps scoping exercise focused on 4 key areas: Data necessary to confirm the existing conceptual site model, data necessary to support the feasibility study, data necessary to complete the ecological risk assessment (ERA) and data needed to support the human health risk assessment (HHRA). Information reviewed during the data gaps identification process included: Round 1 Data Report (2004), Round 2 Data Report (2005), Programmatic Work Plan (2004), GeoSea Sediment Trends Analysis Report (2001), SPI Survey Repot (2002), Acoustic Doppler Current Profile Survey Reports and Bathymetric Survey Reports (2001 – 2004), Conceptual Site Model Update – Site Summary Reports (2004, 2005), Preliminary Risk Evaluation (2005), Groundwater Pathway Assessment Sampling and Analysis Plan (2005).

Two work groups were formed: An Ecological Risk Assessment (ECO) Team and a Conceptual Site Model (CSM) Team. Team members included representatives of the Oregon Department of Environmental Quality (DEQ) U.S. Fish and Wildlife (USFW), National Oceanic and Atmospheric Agency (NOAA), and Tribal Governments. CSM Team meetings were held on September 6, 7, 22, 28, and November 7. ECO Team meetings were held September 19, October 3, 4, 17, 24 and 25, November 1, 2 and 7. Joint ECO Team and CSM Team meetings were held

on October 19, November 9 and 30. The purpose of the meetings was to review existing information and identify next steps and data needs.

1.2.1 Conceptual Site Model

Data needs relative to the conceptual site model were identified through a review of Round 1, Round 2 and historic sediment and surface water data collected up and downstream of the Portland Harbor site. In addition, DEQ staffs were consulted regarding knowledge of potential sources of contamination.

1.2.2 Areas of Potential Concern

Round 1, Round 2 and historic sediment data were mapped using a range of GIS tools. All data were uploaded into NOAA's Query Manager data base. Data were screened against a number of screening criteria including PECs, TECs and DEQ bioaccumulation screening criteria. In addition, fish tissue data were compared to tissue residue values (TRVs) developed in the PRE and human health screening values. Surface water data were compared to ambient water quality criteria for the protection of aquatic life and human health fish consumption values. Both surface and subsurface surface sediment data were screened. Data were evaluated in conjunction with knowledge of upland sources of contamination and physical features such as habitat and areas of deposition and erosion and mapped to identify areas of potential concern.

1.2.3 Ecological Risk Assessment

In order to properly identify data needs relative to the ecological risk assessment (ERA), a systematic approach was employed starting with the conceptual site model CSM and the Assessment Endpoint table from the programmatic work plan. The ERA CSM was refined to more accurately reflect the relationship between sources, pathways, exposure media and biological receptors. This information was used to refine the Assessment Endpoint Table. In addition, EPA reviewed the risk assessment approach described in Appendix B of the Programmatic Work Plan (April 2004) to identify elements of the risk assessment where modifications to the risk assessment approach are necessary. Through this process, EPA has developed the following items: 1) A management goal and objectives to guide the ERA; 2) a revised ecological conceptual site model; 3) revised food web structures; 4) changes to the Assessment Endpoint Table; 5) direction on the ERA approach; and 6) high priority data needs to be filled during Round 3 of the Remedial Investigation.

1.2.4 Human Health Risk Assessment

To be consistent with the ecological risk assessment section, a management goal and management objectives were developed to guide the HHRA. These management goals also reflect refinements to the preliminary Human Health Conceptual Site Model (CSM) that was proposed by the LWG in the RI/FS Programmatic Work Plan (April 23, 2004, Figure 5-6). These changes in the CSM are consistent with the revised ecological CSM and incorporate new exposure media, pathways and receptors that will require evaluation in the human health baseline risk assessment. The majorities of these revisions do not require the collection of new data, but

rather require additional analysis of existing data collected during 2005. However, as discussed in this document, additional biota tissue data is necessary to support the human health risk assessment.

Section 2 Conceptual Site Model

The Portland Harbor Superfund Site is located at the lower end of the Willamette River. The Willamette River is approximately 185 miles long and drains a 12,000 square mile watershed that is home to the majority of Oregon's residents and industry. The Lower Willamette River below Willamette Falls is tidally influenced. River flows within this reach vary seasonally from observed lows in the 8000 cubic feet per second (cfs) range to over 400,000 cfs during the 1996 flood. Due to the size and complexity of the Willamette River system, a robust conceptual site model is required. The conceptual site model must consider the physical factors that control the movement of material within the system as well as sources and pathways of contamination, exposure media and receptors is required.

Although a key component of the upcoming Comprehensive Round 2 Site Characterization Summary and Data Gaps Analysis Report is a refined CSM, a detailed conceptual site model that incorporates physical features, sources, pathways, exposure media and receptors does not currently exist. The current conceptual site model is generally focused on groundwater and includes detailed summaries of upland facilities within the Portland Harbor study area. EPA has reviewed historic, Round 1 and Round 2 RI/FS data to develop a better understanding of how the physical system functions and what information is necessary to confirm or refine this understanding. The following sections describe the data and assessment tools necessary to develop a comprehensive understanding of contaminant fate and transport processes within Portland Harbor and the Lower Willamette River. Data needs are summarized in Table 1.

2.1 Contaminant Loading and Movement

Understanding contaminant loading and movement within the Portland Harbor study area is considered fundamental to the conceptual site model. A contaminant fate and transport model (described in Section 6.1) is required to support this understanding. Sources of contaminant loading include upstream contaminants transported by the Willamette River, stormwater discharges within Portland Harbor, groundwater flux and overland transport (e.g., sheet flow and river bank erosion. A field sampling plan to gather additional data to support the hydrodynamic sedimentation model (Hydrodynamic Sedimentation Model FSP) was submitted to EPA in November 2005. However, the proposed data collection efforts do not include the collection of contaminant information.

Estimates of contaminant loading will require data from specific upland source areas (See Section 3.2) as well as estimates of upstream loading. Suspended sediment data is currently proposed to be collected at river mile 23.7. This location is just downstream from the confluence of Clackamas River with the Willamette River (RM 24.8) and Willamette Falls (RM 26). In addition, suspended sediment data is also proposed to be collected along four transects in the study area (RM 11, 6.3 and 2) and in the Multnomah Channel. This information should be used in conjunction with the surface water data collected at the three transects with the study area to

develop estimates of upstream loading, facilitate understanding sediment transport within the Lower Willamette River and improve performance of the hydrodynamic sedimentation model. Data should be collected during high flow events or other events that are expected to transport significant amounts of material to and within the Lower Willamette River.

Evaluation of site data suggests that contamination from the Portland Harbor site may be transported into and through Multnomah Channel. This is evidenced by surface water flow measurements that suggest that a significant proportion of the Willamette River flow enters Multnomah Channel and an evaluation of sediment data collected along the west bank of the Willamette River that shows a marked decline in contaminant concentrations between sediment samples collected just upstream and downstream of the entrance to Multnomah Channel.

The current Round 2 Hydrodynamic Sedimentation Model FSP calls for the TSS measurements at the entrance to Multnomah Channel. This data should be supplemented with contaminant concentrations and acoustic Doppler current profile (ADCP) measurements to further understand the role of Multnomah Channel in transporting contaminants out of Portland Harbor. (See Section 2.3.2 for additional data needs relative to Multnomah Channel.)

2.2 Upstream Conditions

Developing an understanding of upstream conditions is required to validate our current understanding of the site and refine the conceptual site model. Specifically, an understanding of upstream conditions is required to:

- Estimate contaminant loading from upstream;
- Determine whether contaminant sources upstream of Portland Harbor are being transported into Portland Harbor during episodic (high flow) events;
- Determine background concentrations of naturally occurring substances (e.g., metals) and anthropogenic contaminants in the Lower Willamette River watershed.
- Establishing site boundary;
- Assessing recontamination potential; and
- Evaluating monitored natural recovery;

As a first step, existing data collected within the Lower Willamette River watershed should be evaluated. Data sets that should be considered include:

- Semi-Permeable Membrane Device data collected by Oregon State University Researchers;
- Data collected by the USGS through its National Water Quality Assessment Program;
- Data collected as part of the Ross Island remedial investigation performed under DEQ oversight;
- Data collected as part of the Schnitzer and Zidell remedial Investigations performed under DEQ oversight;
- Data collected by the U.S. Army Corps of Engineers to support is Dredged Material Management Program; and
- Mid-Willamette Study performed by DEQ.

To facilitate the identification of additional upstream data needs, EPA has divided the river into the following reaches: Upstream of RM 14, RM 11 – 14, RM 2 – 11 (the current Portland Harbor study area), RM 0 – 2, and the upper reaches of Multnomah Channel. These reaches are depicted on Figure 1 and discussed in the following Sections.

2.2.1 Upstream of RM 14

Willamette Falls (RM 26) represents the upstream end of the Lower Willamette River. Under most conditions, Willamette Falls represents a barrier to the transport of sediment contaminants. However, under certain conditions (i.e., high flow events), contaminants present in sediment behind Willamette Falls may be transported to the Lower Willamette River. This assumption should be verified through the collection of surface water data at RM 23.7 over a range of river conditions and through the collection of sediment data above Willamette Falls. These data can be used to develop an understanding of sediment levels relative to levels below Willamette Falls and within the Portland Harbor study area.

Below Willamette Falls, the river is relatively narrow and in many areas flows through zones of exposed basalt. In addition, sources of contamination within this reach are limited. Known or suspected sources include non-point run-off, permitted NPDES discharges (e.g., POTWs), inputs from tributaries (e.g., Clackamas River, Johnson Creek, Kellog Creek) and the Blue Heron and West Linn paper mills located at Oregon City just below Willamette Falls.

Additional sediment, surface water and biota data should be collected upstream of RM 14 to help estimate background concentrations upstream of the Portland Harbor site. Samples collected to estimate background conditions should be collected away from known inputs of chemicals. In addition to understanding background conditions, this data will also be useful for assessing recontamination potential, evaluating the effectiveness of monitored natural recovery as a remedial technology, and establishing site boundaries.

2.2.2 RM 11 to 14 - Data for Source Identification

This is the reach of the river that runs through downtown Portland. Although a number of sources have been identified in this reach, because the river is relatively narrow and channelized through the downtown Portland area, it is unclear whether contamination has accumulated in sediments. Key potential sources in this reach include Zidell and Schnitzer, South Waterfront/Lincoln Steam Plant, PGE Substation L, municipal and private outfalls, the historic Portland MGP, Tanner Creek and the historic Pearl District, and Cargill. These sources are summarized in Table 2 and presented in Figure 2. Although many of these sources are or have been addressed by DEQ, limited data are available to understand whether significant, uncontrolled, sources of sediment contamination are present within this reach. Additional data collection efforts are required at some locations to determine whether contaminants present in this reach of the river are impacting the Portland Harbor Study area and help establish the site boundary. In addition, fish tissue data should be collected upstream of RM 11 to determine how fish tissue concentrations within the Portland Harbor study area compare to fish tissue concentrations upstream of the Portland Harbor study area.

2.2.3 RM 9.2 – 11 – Data to Complete Characterization

With the exception of the Fireboat Dock (RM 9.7) no subsurface sediment data has been collected within this reach of the Willamette River as part of the Portland Harbor RI/FS. However, during the summer of 2005, the U.S. Army Corps of Engineers (USACE) collected approximately 30 sediment cores within this reach. EPA has identified 3 potential areas of sediment contamination within this reach of the Willamette River. Potential areas of contamination are describe in Section 3 and presented in Figure 3. USACE data should be evaluated and additional subsurface sediment cores should be collected as necessary to evaluate potential areas of sediment contamination within this reach of the Willamette River.

Other than the collection of benthic invertebrate tissue, no fish tissue has been collected for chemical analysis between river mile 9.2 and 11. Additional fish tissue is required in this reach to evaluate localized sources of contamination and to provide the spatial coverage necessary to support the food web model.

2.3 Downstream Conditions

Round 2 data collection efforts extended to RM 2. Additional data collection efforts are required to delineate the extent of downstream contamination. As described in Section 2.1.4 above, contaminants from in-water sources along the west bank of the Willamette River may have been transported downstream into Multnomah Channel. In addition, contaminants present in the lower reaches of the Portland Harbor Study Area may extend downstream of RM 2.

2.3.1 RM 0 to 2 – Surface and Subsurface Sediment Data to Delineate Extent of Downstream Contamination

Limited sampling has been performed in this reach of the river. Key potential sources within this reach of the river include Columbia Slough and Port of Portland Terminal 5. In addition, elevated levels of PCBs have been detected in sediments offshore of the Oregon Steel Mills site (OSM - located at RM 2). These contaminants may have been transported downstream. Additional surface and subsurface sediment data is required to determine whether this reach of the river has been or is currently being impacted by contamination migrating downstream from the study area or from sources within this reach of the Willamette River. In addition, fish tissue data should be collected downstream of RM 2 to determine how fish tissue concentrations within the Portland Harbor study area compare to fish tissue concentrations downstream of the Portland Harbor study area.

2.3.2 Multnomah Channel – Delineate Extent of Downstream Contamination

Multnomah Channel begins at RM 3 of the Willamette River and discharges to the Columbia River approximately 15 miles downstream from the confluence of the Willamette and the Columbia Rivers. It is unclear the extent to which contaminants from Portland Harbor are impacting Multnomah Channel or where these contaminants may settle out. Additional sediment sampling in depositional areas in the upper end of Multnomah Channel is required to determine

whether contaminants released from Portland Harbor may be accumulating in Multnomah Channel.

Section 3 Areas of Potential Concern

To facilitate the identification of data needed to complete the Portland Harbor RI/FS, areas of potential concern were identified. Surface and subsurface sediment data were screened against sediment quality guidelines. A summary of the criteria used to identify area of potential concern is included in Table 3. Generally, non-conservative screening criteria were utilized. For example, probable effect concentrations (PECs) and multiples of DEQ freshwater sediment screening level values (SLVs) were used in order to provide the resolution necessary to distinguish localized areas of sediment contamination from the surrounding sediments. In addition to comparison to sediment quality guidelines, other information was considered such as the relative concentrations of PCB Aroclors and DDT metabolites, comparison of fish tissue data to tissue residue values (TRVs), knowledge of upland sources, plant, amphibian and shorebird habitat areas, human use areas, sediment transport patters, sediment grain size distribution and river bathymetry.

Areas of potential concern are expected to be refined based on additional data collection and cleanup levels generated through the human health and ecological risk assessments. The purpose of the evaluation was to focus on sources of contamination for the purpose of identifying source specific data gaps in addition to data gaps relative to site-wide processes and the human health and ecological risk assessments.

Twenty four areas of potential concern were identified. The names selected for the areas of potential concern are for identification purposes only. For each area, EPA has identified preliminary COIs, mapped the area and developed a size estimate and identified preliminary data gaps. This information is summarized in Table 4 and Figures 3a through 3e. Data gaps are presented in Table 5 and discussed generally in the following sections.

3.1 Nature and Extent of Contamination

Data gaps related to the nature and extent of contamination include: 1) Contaminants of interest; 2) lateral extent of contamination; 3) vertical extent of contamination; 4) the need for additional surface water data; and 5) the need for transition zone water characterization.

3.1.1 Contaminants of Interest

Although the Round 1 and Round 2 sampling efforts included a large number of analytes, not all chemicals were analyzed for in all locations. For example, volatile organic compounds (VOCs) and polychlorinated dibenzo-p-dioxins and furans (PCDD/PCDF) were analyzed for in a subset of samples. In addition, some contaminants for which sources within Portland may exist were not analyzed for at all. These include manganese and polybrominated diphenyl ethers (PBDEs).

Volatile Organic Compounds: VOCs were analyzed in a subset of sediment samples based on whether upland sources of VOCs were expected to impact the Willamette River. This included

sites such as bulk fuel facilities or where chlorinated solvent plumes. VOCs were identified as a data gap at the Willbridge and Willamette Cove facilities due to the likely presence of VOCs in the upland portion of the facility adjacent to the Willamette River and the lack of offshore VOC data. At the Gunderson facility, previous VOC sampling focused on the location of the 1,1,1-TCA groundwater plume. Additional VOC sampling is required in the vicinity of the Shell dock and City of Portland Outfall 18.

Polybrominated Diphenyl Ethers: PBDEs were not analyzed in sediment. Fish tissue samples collected with the support of the Oregon Department of Human Services (DHS) ATSDR, the City of Portland and EPA detected the presence of PBDEs in fish tissue. PBDEs are a concern due to their potential to cause adverse health effects in humans and bald eagles. A study of PBDEs in the Columbia River included one sample collected off-shore of the Schnitzer Burgard facility. Analysis of this sample revealed the presence of PBDEs at concentrations ten times higher than samples collected with the Columbia River. As a result, PBDEs were identified as a data gap at the Schnitzer facility due the potential for releases associated with scrapping operations. Further evaluation of other potential sources of PBDEs should be performed to identify additional areas where sediment samples should be analyzed for PBDEs. In addition, a subset of sediment samples collected during Round 3 should be analyzed for PBDEs to PBDEs levels across the site.

Polychlorinated Dibenzo-p-dioxins and Furans: PCDD/PCDF were analyzed in a limited number of sediment samples. PCDD/PCDF samples focused on known sources of dioxin (e.g., Rhone Poulenc) and to develop an understanding of dioxin levels across the site. EPA has identified PCDD/PCDF as a potential data gap at PCB source areas. EPA recently requested PCDD/PCDF analysis on a number of archived sediment core samples. This information should be evaluated to determine the extent to which additional PCDD/PCDF data are necessary to complete the RI/FS.

Manganese: Manganese was not included in either the sediment or surface water sampling. However, manganese was analyzed for during the 1997 Portland Harbor Sediment Investigation and the DEQ water quality program has been analyzing Willamette River water collected from the Hawthorne (RM 13) and BNSF (RM 7) railroad bridge since 1990. Manganese was detected above screening criteria in four sediment samples. Manganese was identified as a data gap at sites where manganese was detected above sediment screening criteria or is expected to be present based on upland data (e.g., OSM).

Total Petroleum Hydrocarbons: Total petroleum hydrocarbons (TPH) were not analyzed for in the upstream of RM 9.2. In addition, limited TPH data was collected off shore of Gunderson and within Swan Island Lagoon. However, TPH was analyzed for at 39 locations between RM 10 and 12. This data should be evaluated to determine the extent of additional TPH data required upstream of RM 9.2.

3.1.2 Lateral Extent of Contamination

The lateral extent of contamination was identified as a data gap at sites where additional data was needed upstream, downstream or towards the navigation channel. The degree to which

additional data is needed to determine the lateral extent of contamination will depend on cleanup levels determined through the human health and ecological risk assessments, assumptions regarding how far contamination above target cleanup levels may extend and the degree of certainty required in the feasibility study. In addition to the delineation of sediment contamination, riverbank soils between the Mean High Water Mark (MHWM) and the Ordinary High Water Mark (OHWM) will require evaluation to assess risk and develop integrated approaches to sediment remediation that consider riverbank contamination. EPA has provided general guidance on the degree to which additional sampling to delineate the lateral extent of contamination is required at areas of potential concern. Further evaluation of this data gap will have to take place on a location-by-location basis.

3.1.3 Vertical Extent of Contamination

The vertical extent of contamination was identified as a data gap at sites where insufficient subsurface sediment cores were installed. The degree to which additional data to determine the vertical extent of contamination will depend on cleanup levels determined through the human health and ecological risk assessments, assumptions regarding how far contamination above target cleanup levels may extend and the degree of certainty required in the feasibility study. EPA has provided general guidance on the degree to which additional sampling to delineate the vertical extent of contamination is required at areas of potential concern. Round 2B and U.S. Army Corps of Engineers (USACE) Dredged Material Management Plan (DMMP) sediment cores may fill some of these data gaps. Further evaluation of this data gap will have to take place on a location by location basis.

3.1.4 Surface Water

Surface water collected to date has identified exceedances of chronic ambient water quality criteria for the protection of aquatic life at only a few locations. However, ambient water quality criteria for the protection of human health via the fish consumption pathway were exceeded at locations throughout the Portland Harbor. As discussed in Section 2.1.1, contaminant loading data will be needed for Portland Harbor. These data could be used to support the fate and transport model, food web model (predict fish tissue concentrations in response to remedial measures to address sediment contamination) or to support TMDL-like efforts aimed at source control efforts. As a result, surface water sampling was identified as a data gap at sites where PBTs are present above screening criteria and/or where additional data to understand contaminant loading to surface water (e.g., via stormwater discharge) from areas of potential concern is required.

3.1.5 Transition Zone Water

Current efforts to collect transition zone water for chemical analysis have been limited to areas where contaminated groundwater plumes are suspected of discharging to the Willamette River. EPA expects this effort to continue as necessary. EPA will determine what additional data are required to assess this pathway following a review of the round 2 transition zone water results. As described in the LWG's letter dated July 25, 2005, after the results of the Round 2 groundwater pathway assessment field sampling program have been evaluated, EPA and the

LWG will determine the extent to which additional GeoProbe work is necessary. The evaluation of transition zone water data, must include the following elements:

- A comprehensive assessment of ground-water plumes with the potential to reach the river (this task has largely been completed);
- An assessment of the trajectory of contaminated groundwater plumes through the sediment package surrounding the river;
- Development of contaminant flux estimates based on groundwater flux measurements and contaminant concentrations.

As discussed in Sections 2.1.1. and 3.1.4 above, contaminant loading data will be needed to support the contaminant fate and transport model. Evaluation of Round 2 transition zone water will be required to determine whether the current effort to characterize transition zone water in areas of contaminated groundwater discharge will be adequate to estimate risk and contaminant loading associated with contaminated groundwater plumes. In order to properly assess the risk and contaminant loading, location specific tissue samples or insitu toxicity (e.g., Hyalella) and/or bioaccumulation tests (e.g., Lumbriculus) may be required to assess the risk of accumulation and toxicity associated with contaminated groundwater discharges.

In many areas across the site, clean groundwater discharging to the Willamette River has the potential for transporting sediment contaminants to the water column where they may accumulate in tissue at concentrations that pose a threat to human health or the environment. In areas where clean groundwater is moving through contaminated sediment, EPA expects that the risks associated with contaminated transition zone water will be addressed by the risk evaluation methods utilized to assess bulk sediment and contaminant loading can be estimated through an equilibrium partitioning approach. However some consideration of the relationship between groundwater and surface water may be required to refine risk estimates and transition zone water sampling may be required to validate the partition model(s) selected.

3.2 Contaminant Source Areas and Migration Pathways

Characterization of upland contaminant source areas and migration pathways is generally considered an upland task to be completed under DEQ oversight. Upland characterization information will need to be considered as part of the Portland Harbor FS to evaluate the potential for recontamination. In some cases integrated remedies that consider both upland source control and in-water sediment remediation will be necessary. For each Area of Potential Concern identified in Table 4, individual conceptual site models should be developed. A key element of these individual conceptual site models is to understand the relationship between upland sources of contamination and in-water contaminant levels and associated risks. Upland information that must be considered are outlined in the following sections.

3.2.1 Contaminant Source Areas

Contaminant source areas at upland sites must be identified to ensure that the in-water characterization is adequate. For example, upland and offshore source areas must be identified to determine whether sediment samples were properly located and to identify the appropriate

suite of analytes for offshore characterization. In general, contaminant source areas were identified as a data gap at sites where the remedial investigation is incomplete or more information is needed to identify potential sources associated with City of Portland and/or private outfalls

3.2.2 Stormwater

Stormwater is expected to be a significant source of contamination to Portland Harbor. Contaminant loading data will be required to support the fate and transport model, food web model and evaluate the potential for recontamination. Due to the large number of outfalls present within the Portland Harbor Study Area (more than 300 private and municipal outfalls have been identified to date), a comprehensive plan for characterizing a stormwater outfalls and developing stormwater loading estimates should be developed and implemented as part of upland source control efforts.

3.2.3 Bank Erosion and Overland Runoff

Bank erosion and overland runoff (sheet flow) is another key mechanism for transporting contaminants to the Willamette River. This data will be needed to estimate contaminant loading to the system and evaluate recontamination potential. Upland sites where additional data is required to estimate contaminant loading as a result of bank erosion and/or overland runoff have been identified in Table 5.

3.2.4 Groundwater

Groundwater discharges may transport contaminants to the Willamette River. Characterization of groundwater discharges by sampling transition zone water is currently underway (See Section 3.1.5). However, it is critical that upland groundwater be characterized sufficiently to determine whether a complete transport pathway to the Willamette River exists. Upland sites where additional groundwater characterization is required to complete the upland source control evaluation have been identified in Table 5.

3.2.5 Integration with Upland Source Control Activities:

The Joint Source Control Strategy is expected to become final in December 2005. The initial Source Control Milestone Report is expected to be submitted in March 2006. The Milestone Report will include the following information: Potential upland sources identified through site discovery activities, a list of confirmed sources of contamination to the river (including the basis for that determination, and the priority of the site for source control), a summary of upland source control decisions, the status of on going source control measures, a summary of completed source control measures and a source control schedule. Information presented in the Milestone Report should be used to integrate upland and in-water data collection effort.

3.3 Evaluation of Remedial Action Technologies

Remedial action technologies that are applicable to contaminated sediments generally include the removal of contaminated sediments through dredging activities, capping of contaminated sediments with clean material, treatment of contaminated sediments and monitored natural recovery. These technologies may be applied alone or in combination. Data needs relative to the evaluation of these technologies must be identified and filled in order to complete the feasibility study.

3.3.1 Monitored Natural Recovery

Additional sampling is required across the site to evaluate monitored natural recovery (MNR) at area of potential concern. This should include Sedflume measurements and the placement of sediment traps at representative areas across the Portland Harbor Study area that can be used to monitor MNR at each area of potential concern. In addition, upstream surface water and sediment monitoring is required as described in Sections 2.1 and 2.2.

3.3.2 Recontamination Potential

Recontamination potential must be evaluated by incorporating Sedflume, sediment trap and contaminant loading (upstream, groundwater, surface water and bank erosion and overland runoff – see Sections 2.1 and 2.2). Data must be sufficient to evaluate recontamination of clean sediment following dredging activities or placement of cap materials. Estimates of recontamination associated with cleanup activities (e.g., dredging and capping operations) will also need to be developed to evaluate pre and post cleanup recontamination potential as part of the FS. The FS should include a cleanup sequence that minimizes recontamination potential during the development of remedial action alternatives.

3.3.3 Treatability Studies

Additional sediment sampling may be required to evaluate sediment treatment methods as part of the feasibility study. The current project schedule calls for submittal of a literature survey of treatability studies. This document should be the vehicle for identifying any data collection efforts necessary to support treatability studies at the Portland Harbor site during Round 3 of the RI/FS.

Section 4 Ecological Risk Assessment

The Programmatic Work Plan included an Ecological Risk Assessment Work Plan as Appendix B. Refinements to the ecological risk assessment were contemplated through a series of technical memoranda culminating with the Comprehensive Ecological Risk Assessment Technical Memorandum (Comprehensive ERA TM). EPA comments on the draft Comprehensive ERA TM were submitted in October 2004. At that time, it was agreed that finalization of the Comprehensive ERA TM would take place following approval of the Preliminary Risk Evaluation (PRE) Approach Technical Memorandum. The PRE Approach Technical Memorandum was subsequently incorporated into the PRE itself.

EPA has reviewed the Round 2 data and information presented in the PRE to determine if revisions to the ecological risk assessment were required. The ECO Team held focused work sessions in September, October and November to develop a management goal and objectives to guide the ERA, refine the approach for the Ecological Risk Assessment (ERA) and identify data gaps. Through this process, EPA determined that the ERA should be modified to include revisions to the ecological conceptual site model, revised food web structures, changes to the Assessment Endpoint Table, and changes in certain elements of the ERA approach. Round 3 data collection efforts to complete the characterization phase of the Remedial Investigation and support the ERA were identified based on these modifications to the ERA.

4.1 Management Goal and Objectives

EPA developed a management goal and management objectives to guide the ERA, as shown below. The goal and objectives provide rationale for cleaning up the Portland Harbor Superfund Site from an ecological perspective. The goal and objectives flow from the Problem Formulation statement in the Programmatic Portland Harbor Work Plan, and provide guidance for the Ecological Conceptual Site Model and Assessment Endpoints. They provide direction and priority for current and future characterization efforts necessary to support the ERA.

A management goal and management objectives should be used as overall guidance for planning ERA sampling efforts, for justifying studies to fill data gaps, and for providing direction related to the level of acceptable uncertainty in the ERA. They should be incorporated in the rationale or problem formulation sections of all technical memoranda or working documents that relate to Ecological Risk, including the PRE, the Baseline ERA, and the Comprehensive ERA.

Management Goal

Restore, maintain and improve water quality, sediment quality, biological integrity and habitat conditions necessary to support a sustainable and functional ecosystem within the Lower Willamette River, considering current and potential future shoreline and water way use, by reducing or eliminating the potential for exposure to contamination in water, sediments and biota, facilitating restoration activities, and integrating with other regulatory programs.

Management Objectives

1. Reduce contaminant concentrations in riparian soils, sediments, surface water, groundwater, and transition zone water to levels that are protective of the environment and support the restoration and maintenance aquatic and riparian habitats

2. Reduce contaminant concentrations and/or eliminate the availability of contaminants to protect semi-aquatic and aquatic plants from deleterious effects.

3. Reduce contaminant concentrations and/or eliminate the availability of contaminants to protect benthic and epibenthic species and their food sources from deleterious effects.

4. Reduce contaminant concentrations and/or eliminate the availability of contaminants to protect resident and anadromous fish and their food sources from deleterious effects and maintain a safe fish migration corridor.

5. Reduce contaminant concentrations and/or eliminate the availability of contaminants to protect aquatic-dependent birds and mammals and their food sources from deleterious effects.

6. Ensure protection of threatened and endangered species, including candidate species, and species of special status and their habitats from the deleterious effects of contaminants.

7. Ensure protection of species and their habitats that are of cultural significance to Tribes from the deleterious effects of contaminants.

4.2 Conceptual Site Model

EPA reviewed the preliminary Ecological Conceptual Site Model (CSM) that was included in the Programmatic Work Plan (April 2004). Changes to the CSM were made to reflect the management goal and objectives and to better guide the food web model, dietary model, and overall approach for the ERA. The major changes are summarized below, and the revised Ecological CSM is included as Figure 4.

The "source side" (the left side) of the CSM was refined to better represent the complexity of the physical system: 1) Primary, secondary and tertiary sources and release mechanisms were added; 2) Air, Riparian Soil, Seeps, and Transition Zone Water were added as exposure media; and 3) Willamette River Surface Water, Willamette River Sediment, and Riparian Soil were defined. In addition, 'biota" was changed from an Exposure Media to and Exposure Route, as captured by the "dietary" component to incorporate trophic transfer. These changes were made to incorporate a wider range of potential contaminant-receptor interactions.

On the "receptor side" (the right side) of the CSM, the following changes were made: Three other plant categories: phytoplankton, periphyton, and terrestrial plants were added. Phytoplankton and periphyton were added because they will be assessed as potential contaminant pathways in the food web and dietary models, and terrestrial plants were added for completeness in the ecological system (upland responsible parties are responsible for assessing risk to these species). For invertebrates, zooplankton was added and shellfish were specified under macrofauna because these species will be assessed as potential contaminant pathways in the food web and dietary models. For fish, adult Chinook salmon and adult Pacific Lamprey were added because the adults represent distinct, significant receptor-exposure scenarios that were not addressed in the juvenile life stages. In addition, pathway significance determinations were redefined and some changes were made regarding the completeness and significance of these pathways.

4.3 Measures of Exposure and Effect

EPA has reviewed the Assessment Endpoint Table included in the Programmatic Work Plan Proposed changes to the Assessment Endpoint Table are include in Table 6. The left three columns of Table 6 provide information from the Assessment Endpoint Table in the Programmatic Work Plan. The right three columns of Table 6 describe necessary changes to the table provide changes and comments from EPA and partners, including justification and data needs. The data need numbers listed in the table correlate to the data needs identified in the Data Needs Table (Table 7).

4.4 Food Web Model Approach

EPA and partners reviewed the preliminary Fish and Wildlife Food Web Models proposed by the LWG in the April 2004 Programmatic Work Plan (Figures 5-4 and 5-5). EPA proposed changes to the preliminary Fish and Wildlife Food Web Models are summarized below. These models are sufficient as general guidance to represent the food web, but they may not provide adequate detail for the Food Web Model and the Dietary Approach.

The following changes to the Fish Food Web Model (Figure 5-4) are required:

- Box shading: all boxes should be shaded, except the "Surface water, sediment, and porewater (transition zone)" box, the "Primary producers" box, and the "Zooplankton and drift organisms" box. Add a footnote to the "Primary producers" box and the "Zooplankton and drift organisms" box that states: "These receptors will be assessed as potential pathways for contaminant migration through the food web. They will not be assessed as endpoints themselves."
- Add an arrow from "Detritivorous fish" to "Omnivorous/herbivorous fish," to represent sturgeon consuming detritivorous fish.
- Add an arrow from Epibenthic invertebrates to Piscivorous fish to represent bass and pikeminnow eating crayfish.
- Add arrows from "Zooplankton and drift organisms" to both "Infaunal invertebrates" and "Epibenthic Invertebrates."
- Add a footnote to Epibenthic invertebrates that states "For crayfish, consider scavenging at higher trophic levels."
- Add a footnote to sculpin in the Invertivorous fish category that states "For sculpin, consider feeding within the same trophic level."

In addition, the following changes to the Wildlife Food Web Model (Figure 5-5) are also required:

- Add arrows from "Zooplankton and drift organisms" to both "Infaunal invertebrates" and "Epibenthic Invertebrates."
- Add an arrow from "Reptiles" to "Amphibians."

In addition, a "real-life" visual, colorful image of the food web is needed as a communication tool for public audiences and interested stakeholders. The visual image should include a cross section of the river in Portland Harbor showing habitat areas, and representatives of the benthic

and epibenthic communities, native resident and anadromous fish species, and key wildlife receptors.

In addition to changes in the food web model structure, EPA has determined that additional data is needed to support the food web model. Key data gaps include: *Add data gaps based on FWM meeting.*

4.5 Risk Assessment Approach

EPA has identified a number of refinements to the ecological risk assessment approach. These refinements focus on the approaches required to assess certain types of chemicals (e.g., PAHs and metals) and certain receptors (e.g., sturgeon, Chinook salmon and lamprey) and are described below.

4.5.1 Approach for assessing risk from PAHs to resident and anadromous fish

Assessing risk to resident and anadromous fish from PAH exposure in the Portland Harbor is a critical aspect of the ERA due to the prevalence of PAH contamination in Portland Harbor and because literature data indicate that some fish may be more representative of PAH exposure or more sensitive to the effects induced by PAHs than other fish. For example, strong associations between PAH concentrations and measures of exposure and effect have been demonstrated in the literature. Effects potentially associated with PAH exposure include: 1) depressed immune system function (immunosuppression), increased susceptibility to disease, and impaired growth in experimentally-exposed juvenile salmonids; 2) increased prevalence of liver and skin lesions in brown bullhead exposed to sediment PAHs in the field; and 3) increased liver lesions, hepatic cytochrome P4501A (CYP1A) induction, and xenobiotic-DNA adduct formation in experimentally-exposed flounder and sole. These studies indicate that juvenile salmonids are sensitive to PAH toxicity and resident fish exposed to high concentrations of PAHs from river sediment can be good indicators of exposure and effects.

The current approach for assessing risk to fish from PAHs is based on: 1) the dietary approach, using a concentration-based exposure rather than dose-based exposures; and 2) water exposure related only to a single PAH compound compared to Ambient Water Quality Criteria (AWQC). EPA has determined that these methods alone will not be sufficient for assessing PAH risk to fish due to a paucity of dietary TRVs and the ability to accurately model dietary exposure based solely on concentrations in food items limits the effectiveness of the dietary approach. In addition, PAHs may have a *combined* effect on fish and it is important to consider potential combined effects in assessing risk.

EPA has determined that a multiple line of evidence approach is required to properly assess risks associated with PAH exposure. The lines of evidence listed below are essential to reduce uncertainty in the proposed approach for assessing risks associated with PAH exposure.

- Modify the dietary approach: Express the concentration received by the fish as a dose (e.g., mg chemical/kg fish per day) rather than solely the concentration in the prey item. There are more reliable TRVs available for comparison when diet is expressed as a dose. Include water

concentrations as a dietary dose in the model (incorporating water temperature and gill ventilation rates) because a small concentration of PAHs in water can result in a very large dose (i.e., uptake efficiency of PAHs can be as high as 50%).

- Chemically analyze stomach contents: Chemical analysis for PAHs in stomach contents of resident fish will better represent what the fish are actually exposed to as compared to only evaluating PAHs in potential prey items. Uptake of PAHs by invertebrates is highly variable and the type of prey evaluated by LWG may not represent what the fish actually eat or the PAHs in the actual prey items. Stomach content analysis will provide a much more realistic exposure scenario and will be used to help verify dietary approach parameters, provide information on the type of prey items the fish consumed that are contaminated (important for the food web model), and better represent the specific types of PAHs the fish was exposed to (needed for attributing PAH groupings to sources). Analysis of stomach contents is critical if resident fish are to be used as a representative for sturgeon, and should be conducted on any sturgeon collected from the site.
- Sediment thresholds derived by the NOAA Science Center: These thresholds will be helpful for assessing risks to individual fish by linking the incidence of fish lesions with sediment concentrations (i.e., use existing sediment data and sediment quality guidelines to help predict if and where lesions would be expected). Round 1 fish tissue data and fish lesion data collected as part of the McCormick and Baxter Remedial Investigation and any additional fish collected during Round 3 should be reviewed to determine the prevalence of fish lesions in Portland Harbor.
- Use invertebrate surrogate toxicity: Using invertebrate toxicity associated with PAH sediment contamination could be used to predict whether effects on fish are expected.
- Develop species sensitivity distributions: Although the data are limited, a species sensitivity distribution could be developed to create or refine sediment guidelines. This could take the form of a probabilistic comparison of species sensitivity to the distribution of potential PAH exposures.
- Water concentration approach: Compare water column PAH data to pseudo screening numbers presented in: "Procedures for the Derivation of Equilibrium Partitioning Sediment Benchmarks (ESBs) for the Protection of Benthic Organisms: PAH Mixtures" (EPA, 2003).

4.5.2 Approach for Assessing Risk from PAHs to Birds and Mammals

Because many PAHs are metabolized in fish and do not readily transfer up the food chain, exposure to higher trophic level receptors such as birds and mammals from ingesting contaminated prey is difficult to measure and considered complete and insignificant in most cases. However, ingestion of PAHs for birds lower in the food chain such as sandpipers and mergansers should be modeled through a dietary approach if appropriate TRVs are available.

4.5.3 Approach for Assessing Risk from Metals to Fish

Currently, to assess risk to fish from metals, the LWG proposes to use (1) the dietary approach and (2) comparisons of dissolved metal concentrations to Ambient Water Quality Criteria (AWQC), with the assumption that AWQC will be protective of all fish. These methods are not adequate for assessing risk to fish from metals exposure because our understanding of gill uptake efficiencies and ventilation rates resulting in toxicity are somewhat limited. To help resolve this

data gap, LWG should analyze metals in fish stomach content (see the additional line of evidence noted above under *Approach for assessing risk from PAHs to resident and anadromous fish*) which will help reduce uncertainty in the dietary approach for assessing risk to fish from metals. Options to improve the assessment include using biomarkers such as metallothionene and using the Biotic Ligand model that EPA is developing.

In order to reduce uncertainty in assessing risk to fish from metals without losing focus on the more prevalent contaminants (PAHs and PCBs), we will (1) rely on toxicity to the benthic community to assess metals risk as opposed to tissue residue levels (tissue residue levels for metals are less reliable because fish regulate metals), (2) look at fish-specific water TRVs, which are more reliable and cost-effective than doing biomarker-specific metals evaluations for fish, and (3) refine the dietary approach for metals using data collected from fish stomach contents analysis.

EPA expects that PCBs (and other organochlorine compounds) and PAHs will be a primary focus of the risk assessment due to their prevalence at Portland Harbor. Rather than pursuing the additional lines of evidence noted above for assessing risk from metals, ERA efforts should focus on PCBs and PAHs except in localized areas of metal contamination. In metal-contaminated areas, the ERA should rely on toxicity to the benthic community to assess metals risk as opposed to tissue residue levels (tissue residue levels for metals are less reliable because fish regulate metals), and look at fish-specific water TRVs.

4.5.4 Approach to Assessing Risk from Metals to Birds:

For birds, the proposed dietary approach for assessing metals risk is sufficient, with the possible exception of getting verifiable tissue data. Options for getting bird tissue data include evaluating prey items fed to nestlings using a dietary ligature approach. This approach would allow for identification and chemical analysis of prey items and can be used to assess metals risk as well as other contaminants, and this approach may be most needed at specific site locations. Swallows are commonly used to assess risk at PCB sites based on dietary ligature information as well as assessing reproductive endpoints.

4.5.5 Approach for assessing risk from organometals to fish

The current approach for assessing risk to fish from organometals (e.g., tributyltin [TBT] and other butyltin compounds) relies primarily on assessing risk to clams and mussels. TBT is highly toxic to gastropods and is bioaccumulative in invertebrates. However, it does not appear likely that native gastropods are present in the Portland Harbor area. The current approach should include an assessment of risks to fish from TBT exposure based on Meador, JP (2000)[1], and a localized TBT risk assessment for TBT contaminated sites.[2]

[1] Meador, J.P. 2000. An analysis in support of a sediment quality threshold for tributyltin to species for juvenile salmonids listed by the Endangered Species Act. Final Report. Northwest Fisheries Science Center, NOAA, Seattle, WA. 19 p

[2] Note: The Meador paper may not be protective of gastropods or mollusks. For gastropods, the assessment should focus on the gastropod bioaccumulation and how this affects birds. For mollusks, TRV approach for assessing risk from TBT should be compared to Meador's recommendation of a sediment cleanup level that is ten or more times lower than 6,000 ng/g organic carbon.

4.5.6 Approach for assessing risk to sturgeon, Chinook and lamprey

The Assessment Endpoint Table and the Ecological CSM identify sturgeon, juvenile lamprey and juvenile Chinook as receptors of concern. Adult lamprey and adult Chinook were added as receptors of concern because complete pathways exist to these receptors that are not represented by other species or by the juveniles, and because these species are culturally significant to the Tribes.

- Assessing Sturgeon

  The current approach for assessing risk to sturgeon focuses on assessing resident species such as largescale sucker and pikeminnow as sturgeon representatives. In addition, the PRE evaluated fillet tissue data collected from prebreeding sturgeon. However, because sturgeon are culturally significant and phylogenetically unique, they must receive special consideration in the ecological risk assessment. Key factors regarding sturgeon include:

  - Sturgeon are unique in their life history and physiology (being evolutionarily distant from all other fish species in the Portland Harbor study area);
  - Sturgeon can live to at least 100 years of age and therefore have a much longer time to be exposed to and accumulate persistent contaminants compared to shorter-lived resident species;
  - TRVs are not available for either prebreeding or adult sturgeon. In the absence of sturgeon specific TRVs, it is not possible to determine whether the TRVs utilized in the ecological risk assessment over or underestimate risk to sturgeon.
  - Although data from laboratory-exposure studies would be helpful in gaining a better understanding of the relative sensitivity of sturgeon compared to other species, because sturgeon are long-lived, development of TRVs for sturgeon is technically challenging.

  Resident fish, such as the largescale sucker, have a much different dietary pathway than sturgeon. As a result, other parameters will be needed to model the dietary pathway for contaminant exposure in sturgeon. Since sturgeon consume prey in Portland Harbor, the dietary pathway for sub-adults and adults is complete and significant, but it will be difficult to determine the relative contribution of contaminants to sturgeon from areas within and outside of Portland Harbor.

  The current proposed approach for assessing risk to sturgeon is not adequate alone, and should be supplemented as follows: Largescale sucker and pikeminnow should be used in preliminary food web analyses as the representative of all species, including sturgeon, in the "omnivore/herbivore" guild to estimate tissue concentrations in pre-breeding and adult sturgeon. However, because of ecological and natural history differences between largescale sucker/pikeminnow and sturgeon, protection of these surrogate species may not provide adequate protection for sturgeon. Because the available sturgeon data within the Portland Harbor study area only includes fillet tissue from pre-breeding sturgeon and does not include

any adult sturgeon tissue data, the collection of additional sturgeon tissue within the Portland Harbor study area is necessary. Sturgeon sampling should focus on the size range believed to represent resident pre-breeding individuals. Concentrations of analytes obtained from empirical tissue analyses from these individuals can then be compared to (1) levels in composite tissue samples of other fish receptors, and (2) estimated tissue levels for other fish species (methods yet to be determined) to assess whether protection of other fish species will also be protective of sturgeon. In addition, contaminants in adult sturgeon must be estimated based on a model using empirical data from prebreeding sturgeon that incorporates the potential for greater bioaccumulation in the longer-lived adults. As with prebreeding sturgeon data, these estimates of adult tissue contaminant concentrations must also be compared to levels in composite tissue samples of other fish receptors and estimated tissue levels for other fish species.

It is likely that the estimates of tissue concentrations in adult sturgeon from the above analyses will be highly protective of adult sturgeon because of the 100% residency assumption and the modeling of juvenile tissue concentrations over the lifetime of adults (50 to 100 years). If it is determined that these results are overly conservative, risk estimates may be reduced by changing the adult residency assumption to less than 100% if supported by empirical data. If appropriate empirical data already exist (e.g. Columbia River radiotelemetry studies), EPA will evaluate these data and determine whether they are sufficient or whether additional data collection from the Portland Harbor study area is needed. Alternatively, the LWG may choose to begin gathering Portland Harbor study area specific data on adult sturgeon residency before the above analyses are complete, because one to three years of data collection will be required to gain useful information.

- Assessing Chinook

  Although adult Chinook take up contaminants during migration through the Portland Harbor study area, protecting juvenile Chinook is expected to be sufficiently conservative to ensure protection of all life states with respect to survival, growth or reproduction from contaminant exposure. However, protection of juvenile Chinook does not take into account the effect of contaminants on returning, pre-spawning adults that may suffer impaired olfactory function from copper and other metals. Impaired olfactory function affects the ability of adults to find spawning sites and effectively reproduce. Surface water metal concentrations should be compared to known effect levels for adult olfactory function to assess risk to adult Chinook.

  The dietary pathway for bioaccumulative contaminants for adults is considered to be insignificant and as a result does not need to be assessed for adult Chinook. This pathway is significant primarily to yearlings and sub-yearlings that are eating invertebrates during their time in the Portland Harbor study area.

  The process for assessing risk to juvenile Chinook should include collecting data on juvenile Chinook tissue and diet, and using peamouth as a surrogate. Peamouth should provide conservative risk estimates because it is a resident species, but the juvenile Chinook and peamouth diets differ enough to warrant using a dietary model to estimate risk to juvenile

Chinook based on their actual diet (which primarily includes daphnia based on existing studies).

- Assessing lamprey

  Pacific Lamprey are unique due to their cultural significance to the tribes, life history and high lipid content. As are result, careful consideration must be given to assessing lamprey in the ERA. EPA will submit a supplemental memorandum that outlines an assessment approach for lamprey in January 2006.

4.5.7 Approach for developing BSAFs for clams, crayfish and sculpin

BSAFs for clams, crayfish and sculpin are needed to describe the relationship between contaminant concentrations in tissue and sediment in the Portland Harbor study area. In addition, if a sufficiently robust relationship can be developed, BSAFs will assist with estimating tissue concentrations in areas in which receptor tissue samples were not collected, developing clean up levels for bioaccumulative contaminants, and informing the ERA Dietary Approach and Food Web Model. BSAFs can be used on a Harbor-wide basis and developed for specific sites to represent localized sediment-tissue contaminant concentration relationships. Data analysis will tell us whether we have a strong sediment-tissue relationship Harbor-wide, and data outliers could indicate areas where additional site-specific BSAFs should be developed for local areas (additional sampling may be needed in these areas). We also will consider possibly developing BSAFs for lamprey ammocoetes and sucker.

The current approach for developing BSAFs is to use field-collected clams and conduct laboratory bioaccumulation tests with clams and *Lumbriculus*. EPA and partners will need to evaluate the data generated from this effort to determine whether the various sediment-tissue relationships are strong enough, and to decide whether additional sampling is needed. In addition, we need to evaluate the existing crayfish-sediment data and sculpin-sediment data to determine the strength/quality of the tissue-sediment relationships. Additional data collection may be needed to improve the sculpin-sediment contaminant concentration relationship and provide additional information to explain some of the outliers. In the future, the LWG needs to analyze for Acid Volatile Sulfides and Simultaneously Extracted Metals.

4.5.8 Approach for assessing risk to the benthic community:

The proposed approach for assessing risk to the benthic community includes (1) laboratory toxicity tests as the primary line of evidence (an empirical and predictive approach), and (2) comparing tissue concentrations from field collected clams and crayfish to tissue based TRVs. This approach may require additional data collection efforts because (1) lab toxicity tests may not be of sufficient density to delineate areas of contamination requiring remediation, and (2) field collected tissue is spatially limited and informative for only two species that may not adequately represent other benthic organisms. In addition, this approach does not consider analyses of the benthic infaunal community.

At this time, it is unclear how successful the proposed approach for predicting sediment toxicity will be. Additional sediment toxicity testing may be required to supplement the predictive approach.

In addition to the proposed approach, the Equilibrium Partitioning (EQP) approach, which takes into account bioavailability, should be considered as an additional line of evidence for assessing risk from metals. This approach typically requires K_{OC} data, water quality criteria, and pore water data. Following the approach described in Section 3.2.4, locations of pore-water discharge through the sediment package need to be identified and then site specific pore water data should be collected to refine our estimates. Also, benthic tissue concentrations should be compared to TRVs.

4.5.9 Approach for assessing risk in the riparian area

A portion of the lower riparian area within the Portland Harbor study area provides important habitat for receptors of concern, and as such, it must be considered in the ERA. EPA and partners defined the lower riparian area as river bank that extends up to the Ordinary High Water Mark (OHWM), and agreed that the Portland Harbor Remedial Investigation must include assessment of this area. Some upland Responsible Parties are responsible for assessing the upland area down to the Mean High Water Mark, but these assessments are done relative to discrete sources, rather than being designed to assess continuous risk to aquatic receptors in the Portland Harbor study area. Assessment of the lower riparian area by the LWG is important to provide consistency in the assessment and in protection of the species that use the area throughout the Portland Harbor study area.

4.5.10 Scale of the ERA

The current approach to the ecological risk assessment tends to focus on site-wide risks. While the development of site-wide cleanup levels has some utility, it is important that the ecological risk assessment considers localized impacts as well. Many of the data elements described in earlier sections (e.g., transition zone water) may be used to develop a better understanding of localized risk. In addition, the Round 2 benthic tissue sampling efforts currently underway will also help with this assessment. Additional data needs should include the collection of sculpin at key sources where sculpin currently do not exist.

4.5.11 Weighting different lines of evidence for the ERA

For certain chemical-receptor pairs, a line of evidence approach is proposed to assess ecological risks. A weighting approach will be needed to focus the risk assessment (beyond the screening level) on those exposure pathways that are most important for driving risk to different receptors.

4.6 Data Gaps

Based on a review of the data collected to date and the approach outlined above, EPA identified the data necessary to complete the ERA for the Portland Harbor site. Table 7 summarizes these

data needs and includes justification for the data need, information on how the data should be used, and potential methodologies for filling the data need.

EPA will provide direction on the approach for assessing Pacific Lamprey, and additional data needs for lamprey in a supplemental data gaps memorandum to be delivered in January 2006. In addition, EPA and partners are evaluating the LWG's proposed Food Web Model, and additional data needs for the model may accompany our comments on the proposal.

Section 5 Human Health Risk Assessment

A management goal and management objectives were developed to guide the ERA. To be consistent with the ERA, a management goal and management objectives have also been developed for human health risk assessment (HHRA). The management objectives are a modification of the Remedial Action Objectives listed for human health in the PH RI/FS Programmatic Work plan (Section 6.1). The goal and objectives provide rationale for cleaning up the Portland Harbor Superfund Site from a human health perspective. They provide direction and priority for current and future sampling and analysis work related to human health

5.1 Management Goal and Objectives

The following management goal and objectives should be used to guide the Human Health Risk Assessment (HHRA).

5.1.1 Management Goal:

Restore, maintain, and improve water and sediment quality and reduce or eliminate the potential for human exposure to contaminants in water, sediments, and biota in the Lower Willamette River to ensure protection of public health considering current and future river and shoreline use.

5.1.2 Management Objectives:

Management objectives include:

1. Reduce contaminant concentrations in surface water to levels that are protective of human health, including tribal and subsistence populations, from ingestion of and dermal absorption of contaminants in surface water, and from ingestion of fish and shellfish that bioconcentrate or bioaccumulate contaminants in surface water.
2. Reduce contaminant concentrations in transition zone water to levels that are protective of human health, including tribal and subsistence populations, from ingestion of shellfish and to levels that would attain the surface water management objective.
3. Reduce contaminant concentrations in sediments to levels that are protective of human health, including tribal and subsistence populations, from incidental ingestion of and dermal absorption of contaminants in sediments, and from ingestion of fish and shellfish that bioaccumulate contaminants from sediments.

4. Reduce contaminant concentrations in beach sediments and beach seeps to levels that are protective of human health from incidental ingestion of and dermal absorption of contaminants in beach seeps and sediments.

5.2 Conceptual Site Model

EPA reviewed the preliminary Human Health Conceptual Site Model (CSM) that was proposed by the LWG in the RI/FS Programmatic Work Plan (April 23, 2004, Figure 5-6) and made a number of revisions primarily related to the addition of new exposure pathways (e.g., residential drinking water and human consumption of bivalves). The major changes are summarized below, and the revised Human Health CSM is provided in Figure 5.

Consistent with the CSM for the ecological risk assessment, for the "source side" (the left side) of the CSM, additional detail has been provided to better represent the complexity of the physical system. Primary, secondary and tertiary sources and release mechanisms were specified. For exposure media for human health, fish/shellfish were removed and added as an exposure route; porewater was renamed transition zone water; air and seeps were added; and sediment is now distinguished as beach versus in-water sediments.

To be consistent with the eco CSM for exposure routes, inhalation was added. However, as shown in the human health CSM, this pathway is not expected to be a complete or significant one for the human health PH risk assessment. Other changes to exposure routes are: ingestion and dermal absorption from beach sediments are evaluated separately from in-water sediments; ingestion and dermal exposure to seeps was added; and exposure to fish/shellfish contaminated as a result of exposure to sediments, transition zone water, and surface water are included. Shellfish now include bivalves as well as crayfish. Breastfeeding was also added as an exposure route. For receptors, two new worker categories (on-site and in-water workers) as well as divers and residents were added.

5.3 HHRA Approach

EPA has determined that a number of refinements are necessary to complete the human health risk assessment (HHRA). Refinements include the inclusion of worker and residential drinking water exposure scenarios, the evaluation of human consumption of clams and mussels using the biota data that is currently being collected; the addition of a diver scenario; the evaluation of indirect exposure to transition zone water (from bivalves and crayfish) and surface water (from fish); a distinction between in-water versus dockside workers; and an assessment of persistent, bioaccumlative, toxic-chemicals (PBTs) in breast milk. These refinements are described in the following sections.

5.3.1 Drinking Water

EPA has determined that the Willamette River represents a potential future source of drinking water. This determination is supported by state water quality rules that include drinking water as a designated beneficial water use of the Lower Willamette River and the fact that the City of Wilsonville (RM 38) is currently utilizing the Willamette River as a drinking water source. The

HHRA CSM has been revised to reflect this potential future route of exposure by adding residential and industrial drinking water exposure scenarios.

Surface water COPCs for evaluation in the baseline risk assessment should be identified by screening the maximum concentration of any chemical detected against federal Safe Drinking Water Act Maximum Contaminant Levels (SDWA MCLs) and EPA Region 9 residential drinking water PRGs based upon a residential exposure scenario (assuming a cancer risk of 10^{-6} and a HQ of 0.1). For the risk characterization in the baseline risk assessment, exposure point concentrations (EPCs) should be calculated by combining individual data points for all surface water data to estimate the 95th% UCL on the arithmetic mean of all surface water data collected. EPCs should also be calculated for other data sets including surface water data collected off shore of specific facilities or sources, in selected exposure areas (e.g., areas selected for transient and recreational exposure) and within specific areas of the river (e.g., river transects). EPCs should be used in the standard drinking water residential and worker scenarios provided in EPA's Superfund guidance.

Exposure to surface water for transients (as a drinking water source) and for recreational users (inadvertent ingestion) is already in the CSM and screening criteria and exposure methods and parameters for the risk characterization are already described in the programmatic work plan. Exposures are assumed to occur in only selected parts of the Portland Harbor Site for transients and recreational beach users. These exposure scenarios do not require modification.

5.3.2 Consumption of Clams and Mussels

Ongoing Round 2 RI/FS data collection efforts include collection of benthic invertebrate tissue. In particular, freshwater clams, *Corbicula*, and freshwater mussels will be collected at a range of locations across the site. Although the current HHRA work plan does not include as assessment of the risks associated with human consumption of bivalves, bivalves should be included in the HHRA because: 1) A discussion with one diver has verified that he has collected bivalves from the Lower Willamette River for consumption by himself and his family (he no longer collects bivalves from Portland Harbor because of concerns about the effects of pollution); 2) information provided by the Oregon Department of Human Services (DHS) documents that transients living along the river sometimes collect clams for human consumption; 3) bivalves should be a resource that is available for consumption now and in the future; 4) unlike fish species, bivalves do not metabolize PAHs, as a result, these compounds are more likely to be detected with the analytical methods being used; and 5) evaluation of risk for bivalves will provide information to DHS about the need for a consumption advisory.

The HHRA CSM as been modified to include crayfish and bivalves under the term "shellfish." The consumption rate agreed upon for crayfish (18 g/day) should be used for evaluating the risks associated with bivalve consumption. Because the ongoing benthic tissue sampling (clams and mussels) will result in samples collected over a relatively large area, EPA has determined that each composite sample (station location) should be evaluated individually. This is consistent with our evaluation of the Round 1 biota data and will aid our understanding of localized impacts associated with specific sources of contamination.

5.3.3 Indirect Exposure to Transition Zone Water and Surface Water

The Programmatic Work Plan includes the following statement: "Contaminants in surface water may be a source of contaminants in biota tissue. For the risk assessment, exposure to contaminants in surface water via biota tissue will be assessed as a part of the risk assessment for fish and shellfish. However, as a part of the RI/FS for Portland Harbor, surface water data collected in all areas of the site will be compared to EPA's Ambient Water Quality Criteria for fish consumption and Oregon Water Quality Standards." This statement should be modified. For evaluating the risks of consuming biota contaminated by transition zone water (TZW) and surface water, the HHRA should include use of the WQC for screening of TZW and for selection of COPCs for surface water.

From Curt: The approach for estimating risks to human health resulting from indirect exposure to transition zone water has not been agreed upon. We identify as a data gap the need for a more systematic approach to the assessment of transition zone water than has been taken to date. In the past, expedience and contracting opportunities have borne more weight in decisions on the scope of assessment activities than actual data needs. The approach for assessing the significance of transition zone water discharge needs to include the items listed in Section 3.2.4.

The approach for estimating risks to human health resulting from indirect exposure to transition zone water has not been agreed upon. Transition zone water data will only be available offshore of facilities where movement of contaminated groundwater into the surface water is suspected. TZW data will not be available from many other areas including those areas where clean water may be moving through contaminated sediments and where contaminated groundwater is discharging farther offshore. EPA has determined that transition zone water should be evaluated by comparing transition zone water results in areas of contaminated groundwater discharge to human health AWQC (based on 17.5 g/day) as a surrogate for bioconcentration of contaminants into bivalves and crayfish (the agreed upon crayfish consumption rate is18 g/day). This comparison should be performed for all chemicals for which fish consumption AWQC are available. For other chemicals (e.g. perchlorate) a WQC for human health may need to be calculated. Transition zone water data should be evaluated as individual data points as well as calculated averages (i.e. the 95^{th} % UCL on the arithmetic mean over the area of the contaminated plume discharge). This data should be used to evaluate consumption of crayfish, clams and mussels. This screening evaluation may not adequately represent the loading of bioaccumulative contaminants into biota in these areas where contaminated groundwater is discharging; therefore, additional data (e.g., in situ bioaccumulation tests) may be needed for such compounds.

The current efforts to characterize transition zone water in areas of contaminated groundwater discharge will not address the issue of contaminant levels in TZW in areas where clean groundwater is moving through contaminated sediment or in areas where groundwater is in equilibrium with clean or contaminated sediments. In these other areas, alternative methods (e.g., assumptions of partitioning between sediments and TZW) and/or sampling will be needed to evaluate the uptake of contaminants by crayfish, clams and mussels.

For surface water, both a screening to select COPCs and a risk characterization should be performed. Individual sampling points should be screened against AWQC calculated using a fish consumption rate of 175 g/day to select COPCs. AWQC based upon 175 g/day should be used as a surrogate for bioconcentration/bioaccumulation of contaminants into fish tissue. AWQC may need to be calculated for some chemicals, such as perchlorate. For the risk characterization in the baseline risk assessment, exposure point concentrations (EPCs) should be calculated by calculating the 95th% UCL on the arithmetic mean of all surface water data collected. In addition, other data sets should also be assessed. These include surface water data collected off shore of specific facilities or sources, in selected exposure areas (e.g., areas selected for transient and recreational exposure) and within specific areas of the river (e.g., river transects). EPCs should be used with BCFs from the WQC documents to calculate biota concentrations. For SW, all fish consumption rates specified in the programmatic work plan should be used (17.5 g/day, 73 g/day, 142 g/day and 175 g/day for adults). These results should be compared to the biota tissue that has been collected for the Portland Harbor site.

5.3.4 Direct Exposure to Sediment

On February 24, 2005, EPA commented on the LWG's interim deliverable on exposure to in-water sediments: "Exposure Point Concentration Calculations Approach and Summary of Exposure Factors" (EPC Interim Deliverable) dated December 3, 2004. During a subsequent conference all, EPA and the LWG were unable to resolve our differences. EPA has revisited our February 24, 2005 comment letter. In the near future, EPA will be providing direction to the LWG regarding resolution of EPA's February 24, 2005 comments.

Exposures to divers were not addressed in the EPC Interim Deliverable, however, the HHRA work plan states: "It is assumed that the recreational beach user, which includes exposure to surface water during swimming activities, will be protective of divers in Portland Harbor. This assumption will be reassessed when additional information regarding divers in Portland Harbor becomes available, and, if needed, a diver receptor may be included in the HHRA." The diver scenario has now been added to the HHRA CSM. Further discussion is required to determine the appropriate exposure assumptions for this scenario.

5.3.5 PBTs in Breast Milk

The HHRA Work Plan states: "Within the consumption fisher receptors, pregnant and nursing women are a subgroup of potential concern due to potential exposures to fetuses and nursing infants and will be discussed further with EPA and its partners."

EPA has determined that this exposure should be included in the risk assessment. It is very likely to be an issue of concern for the public. In addition, EPA risk assessments (e.g., the Housatonic River) and EPA guidance (e.g., OSWER Combustion Guidance) include this pathway. And finally, evaluation of this pathway does not require that additional data be collected. Rather, Round 1 biota data, bivalve data now being collected, and the data from the ODHS study (salmon, sturgeon and lamprey collected and analyzed by Oregon Department of Human Services, ATSDR, the City of Portland and EPA) would be used to calculate infant exposures. Further discussion between EPA and its partners is required to determine which methods and

exposure assumptions will be proposed to estimate exposures and to characterize the risks from this pathway. EPA will provide this information to the LWG for discussion prior to finalizing the approach.

5.4 Data Gaps

EPA has determined that additional data are needed to complete the HHRA. Data gaps are discussed in the following sections.

5.4.1 Fish Tissue

Fish and shellfish samples can be used for many human health related objectives at the PH site, including, but not limited to the following: (1) Identify and assess the risks from contaminants in fish and shellfish within the Portland Harbor site on site-wide and source specific basis; (2) Identify concentration gradients in fish and shellfish upstream (up to RM 14) and downstream (RM 0 to 2 and the Multnomah Channel) of the Portland Harbor study area to assist in identifying site boundaries; (3) Identify ambient or background levels of contaminants in fish and shellfish; (4) Calibrate the food web model and verify its outputs; (5) Measure changes in fish and shellfish contaminant levels before and after remediation to evaluate its effectiveness; and (6) Provide data for ODHS to evaluate the need for additional fish advisories and /or to modify existing advisories. Data needs relative to each objective are described below.

Smallmouth bass, black crappie, common carp, brown bullhead, and crayfish were the resident fish and shellfish species collected and analyzed during Round 1 to support the HHRA. Preliminary evaluations of the Round 1 data show that smallmouth bass, carp and brown bullhead result in the highest cancer risk and non-cancer hazards at the Portland Harbor Site from fish consumption. Smallmouth bass were selected in part because they have a smaller home range than the other fish species and would more likely reflect site specific sources. Crappie, carp and bullhead composite samples were collected over a three mile stretch of the Portland Harbor study area (RM 3-6 and RM 6-9); while composite samples of bass were comprised of individual fish collected throughout a 1 mile reach from both sides of the river. Although the smallmouth bass data do show some differences in contaminant levels between river miles, because the bass composite included fish from both sides of each river mile, the potential impacts of individual sources are difficult to evaluate. As a result, these fish data are useful primarily for assessing risks on a site-wide basis, but provide limited information on source specific risks. Therefore, EPA has determined that additional smallmouth bass should be collected off-shore of selected facilities to estimate localized risk from specific sources of contamination. Fish tissue sampling efforts should be focused on areas where persistent bioaccumlative toxicants (PBTs) are present (e.g., Gunderson, Arkema, Rhone Poulenc, GASCO and Oregon Steel Mills).

To identify concentration gradients in fish and shellfish and identify ambient or background levels of contaminants in fish and shellfish, bass and other fish species, such as carp, or brown bullhead and bivalves will need to be collected. Existing biota from these areas should be reviewed before a sampling plan is developed. Also, some concurrent sampling within the Portland Harbor study area will be required so that any comparison between Portland Harbor

study area biota levels and those outside the Portland Harbor study area are done with samples collected in the same time period.

The need for sampling to calibrate the food web model and verify its outputs has been discussed in Section 4.4. EPA has not yet determined how biota data might be used to measure changes in fish and shellfish contaminant levels before and after remediation to determine when fish are safe to eat or what additional measures may be needed to reduce contaminant levels in fish. Although sampling for biota as a part of the RI/FS is not being done specifically for objective 6 (provide data for ODHS to evaluate the need for additional fish advisories and /or to modify existing advisories), any future data collected will be assessed by the ODHS.

Any field sampling plan for additional biota sampling for human health should consider all of the objectives discussed above as well as any other that may be identified in the next few months. This should help to define the sampling strategy and focus resources. Also, coordination is needed with any ecological sampling efforts and any data collected in the future for the ERA (e.g. sturgeon) should be collected in a manner that would also provide data for the HHRA (e.g., by analyzing fillet separately from the rest of fish).

5.4.2 High Detection Limits for PAHs in Fish Tissue

As stated in previous EPA comments, PAH fish tissue detection limits did not achieve the specified ACGs. As a result, future biota tissue collection efforts that will be used for assessment of human health risk should attempt to achieve detection limits for the carcinogenic PAHs that are close to the ACGs calculated for the Round 1 QAPP as practicable. This may require use of high resolution GC/MS methods as was done for analysis of biota as part of DEQ's Mid-Willamette study.

5.4.3 PBDEs

Polybrominated diphenyl ethers (PBDEs) were detected in fish tissue samples collected through the Oregon Department of Human Services, ATSDR, the City of Portland and EPA. In addition, elevated levels of PBDEs were detected in a sediment sample collected off shore of the Schnitzer Burgard facility. PBDEs may represent a risk to human health. As a result, future biota tissue collection efforts that will be used for assessment of human health risk should include analysis of PBDEs. Sediment data collection should also be considered to evaluate potential source areas. High resolution GC/MS analysis will be required to properly analyze tissue samples; low resolution GC/MS may be adequate for sediment.

Section 6 Modeling Needs

Two models are proposed for the Portland Harbor RI/FS. These include a hydrodynamic sedimentation model and a food web model. The hydrodynamic sedimentation model is designed to provide estimates of flow velocities and sediment transport during high flow events. The modeling will be performed using a depth averaged, two dimensional Environmental Fluid Dynamics Code (EFDC) model. The food web model will be used to develop and understanding

of the relationship between chemical concentrations in sediment and water and in the tissue of aquatic species at the Portland Harbor site. The food web modeling will performed using the Arnot and Gobas model (2004).

A contaminant fate and transport model for the Lower Willamette River does not exist. EPA believes that a contaminant fate and transport model is critical to the Portland Harbor RI/FS. A contaminant fate and transport model will help identify and understand the impact of sources of contamination both within and outside of the Portland Harbor Study Area and evaluate remedial action alternatives in the Feasibility Study (FS). The following sections describe the data necessary to develop a comprehensive understanding of contaminant fate and transport processes within Portland Harbor and the Lower Willamette River and to support the food web model. Data needs relative to the fate and transport model are summarized in Table 1.

6.1 Contaminant Fate and Transport Modeling

A contaminant fate and transport model is required to help identify and understand the impact of sources of contamination both within and outside of the Portland Harbor Study Area (e.g., upstream loading, upland stormwater runoff, sediments, and groundwater) and evaluate remedial action alternatives in the Feasibility Study (e.g., understand the time required to reduce fish tissue concentrations in response to various remediation options and source control efforts). A simple, time-dependent, mass balance contaminant fate and transport model that can be linked to the food web model is needed to meet these objectives.

The contaminant fate and transport model can be developed from several variations available in the literature, all of which have proven useful in situations similar to Portland Harbor.[3, 4] The model domain should extend from river mile (RM) 12 to RM 0, with a separate compartment for Swan Island Lagoon. The domain should initially be divided into ½-mile segments, at right-angles to the river flow. Each ½ mile segment should be further divided parallel to river flow into east and west sides of the river. Following this initial effort, the river may be divided into other segments that consider physical features and contaminant sources within Portland Harbor. The existing EFDC hydrodynamic model can be used to provide data inputs and quality assurance checks for the contaminant fate and transport model hydrodynamics and sediment movement.

USGS flow data collected at RM 12.8 should be used to provide measures of flow on a monthly basis. During the summer low flow period, flow reversals and intrusion of Columbia River water can occur. As a result, the contaminant fate and transport model must be able to accommodate these phenomena at least to the point where there impact on contaminant movement can be assessed.

Key contaminant fate and transport processes that must be considered include upstream boundary inflows, external loads (including contaminated groundwater flux, continuous point

[3] Davis JA. 2003. The long term fate of PCBs in San Francisco Bay. RMP Technical Report: SFEI Contribution 47. San Francisco Estuary Institute, Oakland, CA.

[4] Davis JA. 2004. The long term fate of PCBs in San Francisco Bay. *Environmental Toxicology and Chemistry* 23(10): 2396-2409.

source discharges, stormwater discharges, bank erosion and overland runoff , and atmospheric deposition/volatilization), and processes that affect sediments such as diffusion, resuspension settling and burial. These processes are summarized in Figure 6.

6.1.1 Water Column Data Needs

A contaminant fate and transport model sufficient to predict future sediment and surface water concentrations will require estimates of contaminant loading. Contaminant loading should consider both dissolved and suspended contaminants. Loading estimates should be based on monthly averages. Simple algorithms tied to precipitation data may be used to estimate average monthly stormwater flows in areas of concern. Water column data will be required to estimate loadings from specific source areas and estimate upstream loadings. In addition, water column data will be required from the lower river to compare against model estimates. Data should be collected such that monthly average loadings can be estimated for inclusion as model inputs. The dynamic nature of stormwater discharges may necessitate system monitoring under both base flow and storm conditions. For all contaminants of concern, water samples should be analyzed for both total and dissolved forms of the contaminant. This allows for estimation of contaminants sorbed to particles, which are subject to settling in the contaminant fate and transport model.

Some model inputs and processes may not be characterized on the basis of direct measurements. For example, atmospheric deposition/volatilization and bank erosion are likely to be characterized using general information and assumptions.

6.1.2 Sediment Data Needs

In the Fate and Transport model, sediment processes (e.g., resuspension, settling) will be addressed in generalized manner on a coarse spatial grid. In addition, work has begun on a more complex sediment transport model. This EFDC model will provide information at a finer grid scale and shorter time periods; for example, it can be used in estimating sediment stability in specific near-shore locations of concern under high flow conditions. The sediment measurements and tests below will aid in the development of both models.

Settling Tests: The settling rate of cohesive sediments in the river is an area of uncertainty in the sediment transport analysis. In-situ measurements of suspended sediment grain size distribution will be made at 5 locations with the Portland Harbor study area. Grain size distribution measurements can be used to calculate suspended sediment settling velocity.

Erosion Rate Tests: Erosion rates of bed sediments are key area of uncertainty in sediment transport analysis. Sheer stress, bulk grain size (roughness), and sediment cohesiveness are needed to determine resuspension rates. Sedflume measurements (which include sediment erosion rate, critical shear stress, particle size and bulk density with depth) are proposed at 15 locations within the Portland Harbor study area to reduce the uncertainty in this important process. The depth of the cores will be based on vertical extent of contamination and potential range of erosion in a large event. This information will be useful for understanding sediment transport within the Lower Willamette River and improve performance of the hydrodynamic sedimentation model.

Physical Bed Property Measurements: Duplicate cores from each Sedflume sampling location will be analyzed for bulk sediment properties, including grain size, bulk density, and total organic carbon with depth.

Event-based Sampling: To assess system changes during short term, high flow events, a mobilization and sampling plan for measurement of bed elevation changes and total suspended solids will be implemented. This information can be used to evaluate the performance of the sediment transport model.

Sediment Traps: Data necessary to estimate upstream loading include sediment traps placed at the upstream end of the Portland Harbor Study area and at selected locations throughout the study area.

River Bathymetry: High flow bathymetry is proposed for 3 transects in the Draft Round 2 Field Sampling Plan – Hydrodynamic/Sediment Transport Modeling Data Needs. This effort needs to be expanded to a full multibeam survey of the Portland Harbor study area or as much as can be accomplished during the next high flow (>100,00cfs) event.

6.2 Food Web Modeling

A draft Food Web Modeling Report was submitted to EPA on November 4, 2005. The model evaluates the application of TrophicTrace and the Arnot and Gobas models to the Portland Harbor site. EPA is still in the process of reviewing this document and will provide specific comments on the report in January 2006.

One of the key purposes of the food web model will be to predict future fish tissue concentrations following the completion of sediment remediation and source control measures. EPA agrees that food web models of the form initially established by Gobas and subsequently improved by him and others should be applied in Portland Harbor.[5]

The Willamette River should be divided into segments within the contaminant fate and transport model as described above. A food web model should be developed for each segment. For mobile receptors, exposure should be apportioned based on its estimated residence time in each segment. The relationship between the two models is presented in Figure 7.

Because the primary purpose of the food web model is to inform remediation decisions and not precisely predict tissue residues, EPA recommends the use of a simplified food web encompassing representative pelagic and benthic species. However, EPA has determined that additional fish tissue data are required to support the food web modeling effort. Fish tissue samples from individual fish should be collected across the Portland Harbor study area. Individual fish are required to develop a relationship between contaminant levels and fish size. Fish species that should be targeted for collection include: Northern Pikeminnow, Smallmouth Bass, Black Crappie, Largescale Sucker and Sculpin. Due to their small size, sculpin will need

[5] Arnot JA and Gobas FAPC. 2004. A food web bioaccumulation model for organic chemicals in aquatic ecosystems. *Environmental Toxicology and Chemistry* 23(10): 2343-2355.

to be composited. Benthic tissue collected during Round 2 of the RI/FS will also be of great use in the food web model. Other biota tissue that should be considered for collection include phytoplankton and zooplankton.

Section 7 Recommendations for Moving Forward

EPA has identified a number of data needs necessary for completion of the Portland Harbor RI/FS. In addition, EPA has refined elements of the human health and ecological risk assessment approach. EPA has determined that the identified data gaps and refinements to the risk assessment approach are necessary to complete the Portland Harbor RI/FS. EPA has not specified the precise level of sampling required to complete the characterization phase of the RI/FS. EPA recognizes that further discussion with the Lower Willamette Group is necessary to develop the specificity required to produce field sampling plans and complete the human health and ecological risk assessments.

The current project schedule calls for the submittal of the Comprehensive Round 2 Site Characterization Summary and Data Gaps Analysis Report (Comprehensive Round 2 Summary Report) in April 2006 followed by a Round 3 Field Sampling Plan (FSP) in May 2006. EPA has determined that the Comprehensive Round 2 Summary Report and Round 3 FSP should be submitted concurrently. Outstanding deliverables (Revised Groundwater Pathway Assessment Sampling and Analysis Plan, Step 2 Natural Attenuation Report, Approach to Determining Background for the Portland Harbor Superfund Site Technical Memorandum, COPC Selection Interim Deliverable, Round 2 Benthic Assessment Interpretation Report, and Literature Survey of Treatability Studies should be submitted no later than February 1, 2006 to facilitate the refinement of Round 3 data gaps. A summary of EPA's proposal for submitting the deliverables described above is include in Table 8. The Round 3 FSP should include data collection efforts to address the four categories of data gaps identified in this document (Conceptual Site Model, Areas of Potential Concern, Ecological Risk Assessment and Human Health Risk Assessment). Ongoing Round 2 sampling efforts (e.g., archived sediment core sample analysis, Round 2B sediment cores, transition zone water and benthic tissue sampling) should be incorporated into the data gap analysis and development of the Round 2 FSP as data becomes available. A summary of the data necessary to complete the RI/FS is included in Table 9.

7.1 Conceptual Site Model

The next iteration of the conceptual site model is scheduled to be included in the Comprehensive Round 2 Summary Report. This is a key element of the Comprehensive Round 2 Summary Report. All relevant existing data must be consulted to develop a comprehensive understanding of the relationship between contaminant sources, pathways, exposure media and receptors.

The Round 3 FSP should include a conceptual site model component that addresses the data gaps identified in Table 1 and any other needs identified based on the refined CSM to be included in the Comprehensive Round 2 Summary Report and other relevant documents. The conceptual site model CSM FSP must include the following elements:

- Upstream sampling for the purpose of determining background and ambient conditions

- Upstream sampling between RM 11 and 14 for the purpose of determining whether upstream sources that may impact the Portland Harbor Study Area are present and to assist the identification of site boundary conditions.
- The collection of data necessary to estimate contaminant loading and to support the development of a robust contaminant fate and transport model.

This data will be used to further refine the CSM to be included in the Draft Remedial Investigation Report currently scheduled for delivery in early 2007.

7.2 Areas of Potential Concern:

The Comprehensive Round 2 Site Summary Report should be used to refine Area of Potential Concern data gaps. The Comprehensive Round 2 Summary Report should include conceptual site models for each area of concern identified by EPA in Section 3 above. These conceptual site models should be used to further refine the data gaps identified for each area of concern. The Round 3 FSP should include an Areas of Potential Concern component that addresses the in-water data gaps identified by EPA in Table 5. The FSP must address the following data needs for each Area of Potential Concern:

- Contaminants of Interest
- Lateral Extent of Contamination
- Vertical Extent of Contamination
- Surface Water
- Transition Zone Water

Contaminant Source Area and Transport Pathway data gaps data gaps are expected to be filled by upland parties as part of upland remedial investigations and source control evaluations. This data will be used to support the draft feasibility study currently scheduled for delivery in late 2007.

7.3 Ecological Risk Assessment

EPA has identified a number of refinements to the ecological risk assessment approach. In some cases, this has generated the need for additional data to complete the ecological risk assessment. However, in other cases, further discussion between EPA and the LWG is needed to develop the appropriate sampling approach.

Changes in the risk assessment approach described in section 4.5 should be incorporated into a revised Comprehensive Ecological Risk Assessment Approach Technical Memorandum. This document should be submitted along with the Comprehensive Round 2 Summary Report. Further discussion between EPA and LWG is required to refine the approach for assessing lamprey, identifying data needs relative to the food web model and the benthic interpretative model. EPA comments on the Food Web Model Report received on November 4, 2005 should be used to identify data gaps relative to the food web modeling effort. The benthic Assessment Interpretation Report should be submitted by February 1, 2005 and should be used to identify additional data needs relative to evaluating sediment toxicity. As stated previously, a

supplemental data gaps memorandum outlining the approach for assessing risks to lamprey will be submitted in January 2006 and should be used to identify data needs relative to the lamprey assessment.

The Round 3 FSP should include an Ecological Risk Assessment component that addresses the data gaps identified in Table 7 and any additional data gaps relative to the lamprey assessment, the food web mode and the assessment of risks to the benthic community through sediment toxicity testing.

7.4 Human Health Risk Assessment

A key element of the Comprehensive Round 2 Data Summary Report is the development of Preliminary Remediation Goals (PRGs) and the identification of data gaps necessary to complete the human health and ecological risk assessments. EPA is in the process of finalizing its comments on the Process for Derivation of PRGs Technical Memorandum. This should be used as the basis for developing PRGs in the Round 2 Data Summary Report. As stated in Section 5.3.1 above, EPA has determined that the Willamette River represents a potential future source of drinking water. As a result, Round 2 surface water should be compared to Region 9 tap water PRGs and SDWA MCLs in the Round 2 Data Report and drinking water should be evaluated in the baseline human health risk assessment. In addition, EPA comments on the Groundwater Pathway Assessment Sampling and Analysis Plan (GW SAP) remain unresolved. The GW SAP should be the vehicle for resolving issues related to the fish consumption exposure pathway and transition zone water.

The Comprehensive Round 2 Summary Report should also consider human consumption of bivalves (clams and mussels). Clam and mussel tissue chemistry results should be compared to a PRG based on a fish consumption rate of 18 g/day.

The need for additional fish tissue data has been identified as a key data gap for the human health risk assessment. The Round 3 FSP should include the collection of additional smallmouth bass tissue for chemical analysis. Chemical analysis should include improved detection limits for PAHs and the analysis of PBDEs.

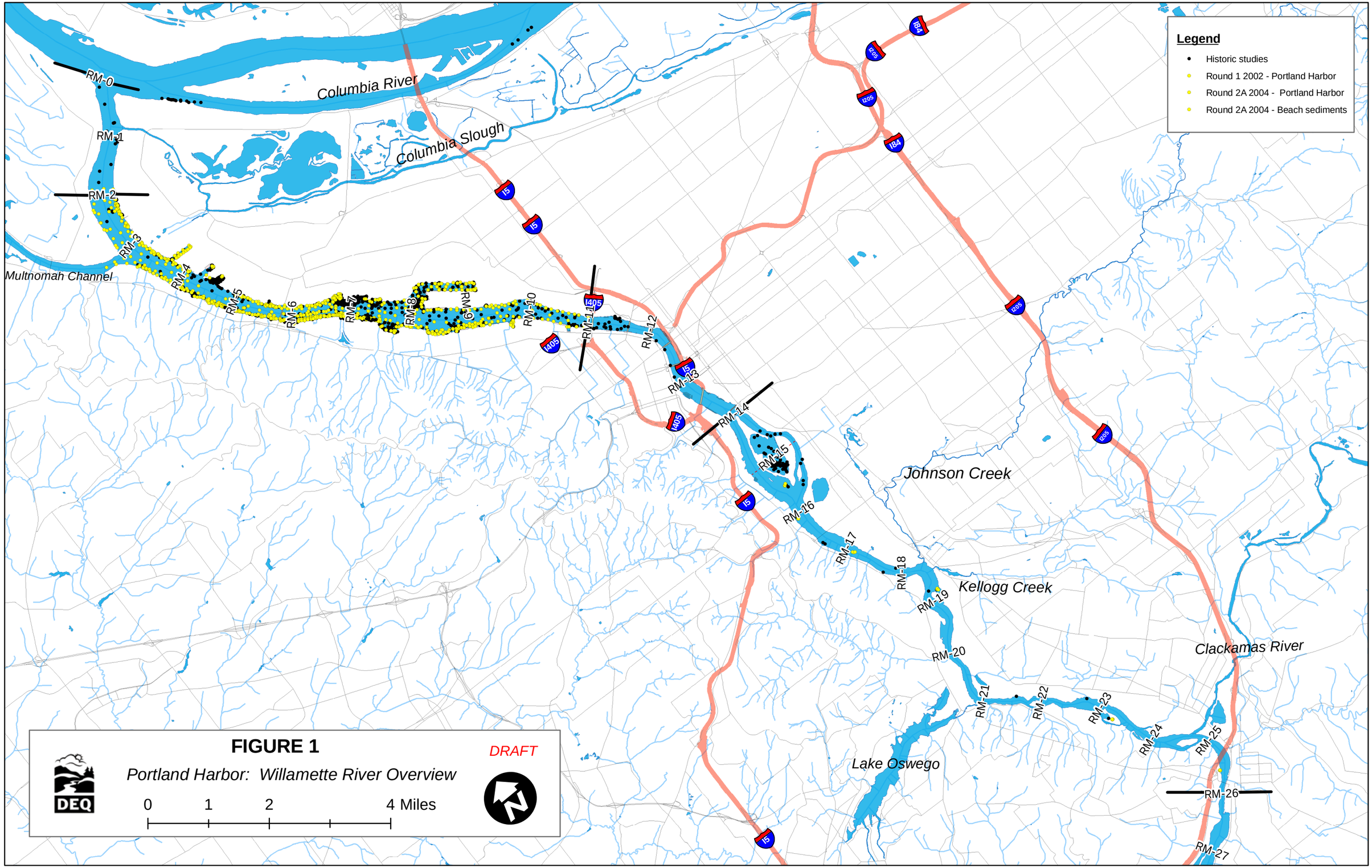
7.5 Summary:

To date, a significant amount of historic and RI/FS data has been collected within and adjacent to the Portland Harbor site. This information has increased our understanding of the nature and extent of contamination within Portland Harbor and the associated risks to human health and the environment. However, given the size and complexity of the Portland Harbor site, it is also clear that additional data efforts are required to refine the site conceptual model, to evaluate contaminant fate and transport, to support the human health and ecological risk assessments and to evaluate remedial action alternatives in the feasibility study.

EPA has taken the time to review the existing data as well as the current risk assessment approaches identify the steps necessary to complete the Portland Harbor RI/FS. We have taken these steps in advance of the Comprehensive Round 2 Site Summary Report in order to be able

to identify data gaps and develop field sampling plans that will allow completion of the site characterization phase of the RI/FS by the end of 2006.

Section 8 Tables and Figures


Legend
Historic studies
Round 1 2002 - Portland Harbor
Round 2A 2004 - Portland Harbor
Round 2A 2004 - Beach sediments
Columbia River
Columbia Slough
Multnomah Channel
Johnson Creek
Kellogg Creek
Clackamas River
Lake Oswego
RM-0
RM-1
RM-2
RM-3
RM-4
RM-5
RM-6
RM-7
RM-8
RM-9
RM-10
RM-11
RM-12
RM-13
RM-14
RM-15
RM-16
RM-17
RM-18
RM-19
RM-20
RM-21
RM-22
RM-23
RM-24
RM-25
RM-26
RM-27
I-5
I-405
I-205
I-84
FIGURE 1
Portland Harbor: Willamette River Overview
DRAFT
DEQ
0 1 2 4 Miles

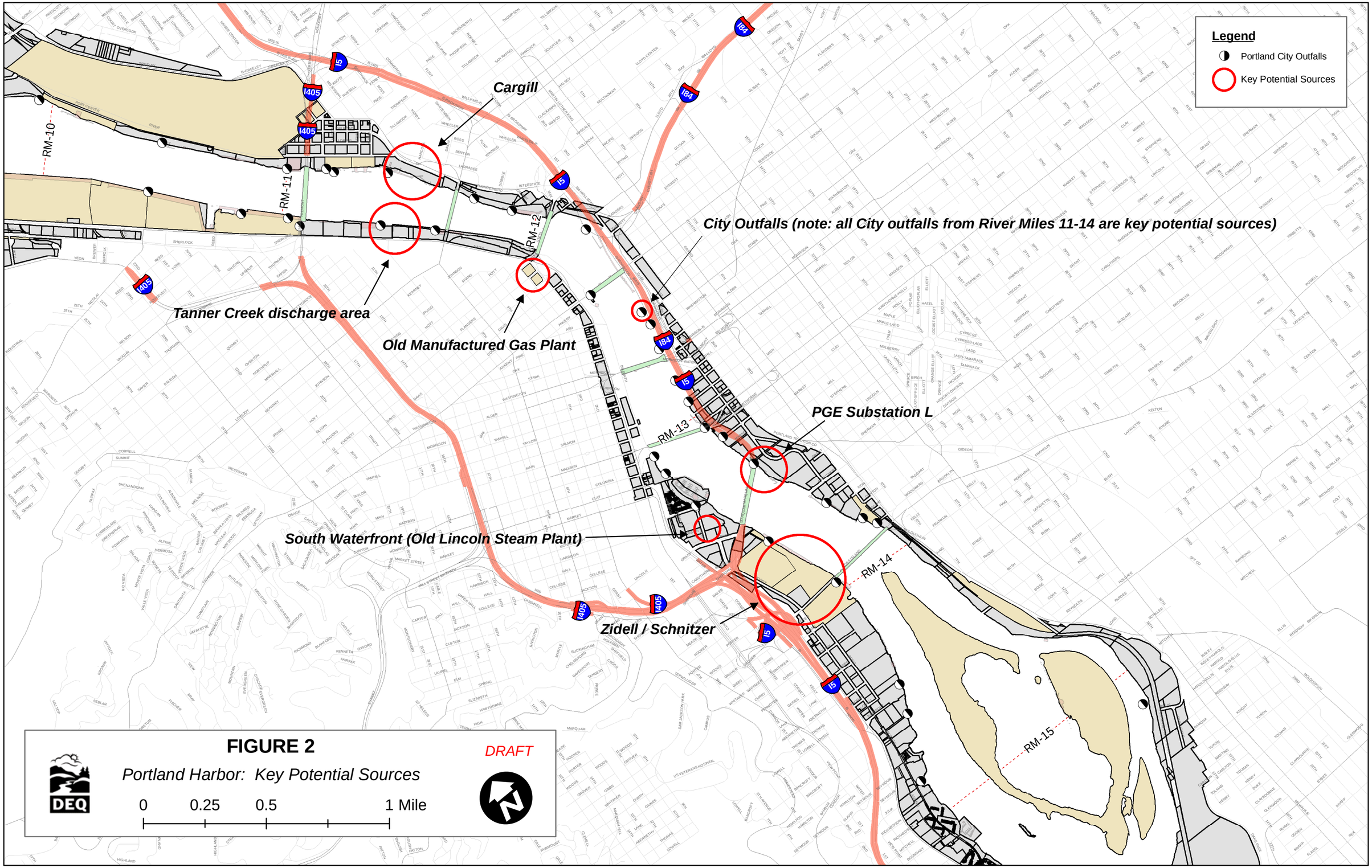


FIGURE 2

Portland Harbor: Key Potential Sources

Port of Portland-Terminal 5 (Blue Lagoon)
Oregon Steel Mills, Inc. - Rivergate
Consolidated Metco - Rivergate Facility
Union Chemical Div. Of Union Oil Co
Port/Shaver Oil Sump
JR Simplot Co.
Ashgrove Cement Co.
Fort James/Northwest Service Center
TSG Trucking & OnLine Roofing
Romar Transportation Systems
Portland Container Repair
Boydston Metal Works
Northwest Pipe #1
Joseph T. Ryerson & Son
Western Machine Works
Northwest Pipe #3
Northwest Pipe #4
Northwest Pipe #2
Slip Remnant
Northwest Pipe #5
Port of Portland-Terminal 4 Slip 1
North Remnant (N. Burgard)
Calbag Metals
Morgan (N. Burgard)
Schnitzer Steel
Jefferson Smurfit
Portland Blast Media
International Terminal Area
Premier Edible Oils
Time Oil-Northwest Terminal
RM-2
RM-3
RM-4
OSM
PCBs, Cr, Zn, Pb, toxicity, PAH
Schnitzer Burgard
PCBs, TBT, PAH, Zn, Pb, Cu, Cr, Ni, toxicity, phthalates
Time Premier
Toxicity (bioassay), dioxin, Hg
2.2
2.3
2.4
2.5
2.6
2.7
2.8
2.9
3.0
3.1
3.2
3.3
3.4
3.5
3.6
3.7
3.8
3.9
4.0
4.1
4.2
4.3
RK Storage & Warehousing
Kinder Morgan Liquid Terminals (formerly GATX ST. Helens Rd facility). Olympic Pipeline transfer station in SW corner of property Also Santa Fe pipeline
Olympic Pipeline at Kinder Morgan Linnton Terminal
Owens Corning - Linnton
Georgia-Pacific - Linnton Fiber Terminal
Morse Brothers (see G-P Linnton)
Linnton Oil Fire Training Grounds
ACF Industries
Portland General Electric - Harborton Substn.
Co., Inc.

FIGURE 3a

Portland Harbor: Areas of Potential Concern

0 370 740 1,480 Feet

DEQ

DRAFT

Marcom
PCB, TBT, Cu, Zn, Pb, Cr, PAH

Crawford/ BES
Cu, Pb, Cr, Zn, TBT

Willamette Cove
PCBs, PAH, Hg, Cu, Zn, Cr, Ni, TBT, DDT

Outfall 48
Zn, Cr, Cu, Pb, Ni, PAH

McCormick & Baxter Superfund Site

Triangle Park LLC

Willamette Cove - Central Parcel

MarCom, Inc.

Crawford Street Corp.

City of Portland BES Water Pollution Control Lab

Triangle Park
TBT

Northwest Natural
PAH (napthalene), Benzene, cyanide, Ni, Pb, phthalates

RM-7

St. Johns West
Pb, Cu, phthalaltes, PAH

RM-6

RPAC / Arkema
DDT and breakdown products, PAH, Pb, Hg, Ni

Transloader Int'l Co.

General Construction

Herdren Tow Boats

Marine Finance Corporation (see Transloader International)

5.6 5.7 5.8 5.9 6.0 6.1 6.2 6.3 6.4 6.5 6.6 6.8 6.9 7.0 7.1 7.5 7.6

Koppers Industries, Inc.

U.S. ACOE- Portland Moorings

GASCO (Northwest Natural)

Wacker Siltronics Corp.

Siltronic chlorinated VOCs
TCE, PAH

Arkema

GS Roofing Products (Genstar)

Kinder Morgan (formerly GATX, formerly Shell)

Schnitzer-Doane Lake (Air Liquide American Corp.)

Gould Industries

US Moorings
TBT, Zn, Cr, PAH

FIGURE 3b

Portland Harbor: Areas of Potential Concern

0 375 750 1,500 Feet

DEQ

DRAFT

Fred Divine Diving & Salvage Co.

Cascade General (see Swan Island Shipyard)

Shipyard / Lagoon
TBT, PCBs, Zn, Cu, Pb, Hg, PAH, phthalates

Cascade General Ship Repair Yard

RM-8

RM-9

S-5 outfall
Cu, Zn, toxicity (bioassay)

Willbridge
PCBs, Cd, toxicity (bioassay)

Gunderson / Shell
PCBs, Zn, Cu, Pb, TBT, DDT, PAH, phthalates

7.5 7.9 8.0 8.1 8.2 8.3 8.4 8.5 8.7 8.8 8.9 9.0 9.1 9.2 9.3 9.4

Willbridge Bulk Fuel Area (Shell, UNOCAL, GATX). Olympic Pipeline and Santa Fe Pipeline also cross facility.

McCall Oil & Great Western Chemical

Front Ave. LLP/Glacier NW

Kinder Morgan (formerly GATX, formerly Shell)

Chevron

ConocoPhillips Co.

Shell/Texaco Portland Bulk Dock

CMI Northwest/Front Ave. LLP

Shaver Transportation Co.

Lakeside Industries

Front Ave. LLP/Tube Forgings

Kinder Morgan (formerly GATX, formerly Shell)

Chevron

Chevron USA Asphalt Refinery

Calbag Metals - Front Avenue

Schnitzer-Kittridge site

Kleen Blast (lessee)

Gresham Transfer (lessee)

Schnitzer-near NW Yeon (formerly Chase Bag, Great Western Chemical and Willard Storage Battery)

Eastman Chemical (current lessee)

McCloskey Corporation (former lessee; see Eastman)

Trumbull Asphalt Plant

FIGURE 3c

Portland Harbor: Areas of Potential Concern

0 375 750 1,500 Feet

DRAFT

Outfall 47
PCBs (Aroclor 1221)

Goldendale / UPRR
PCBs, PAH

Fireboat / GE
PCBs, Zn, phthalates

Sultzer
PCBs, Cu,

Union Pacific Railroad-Albina Yard

Goldendale Aluminum Co.

Port of Portland-Terminal 2

Sulzer Bingham Pumps

Port of Portland-Terminal 1 North

Riverscape/Former 1 South

RM-10

RM-11

9.4 9.5 9.6 9.7 9.8 9.9 10.0 10.1 10.2 10.3 10.4 10.5 10.6 10.7 10.8 10.9 11.0

I5 I405

FIGURE 3d

Portland Harbor: Areas of Potential Concern

0 375 750 1,500 Feet

DEQ

DRAFT

Legend

- Riverwide bioaccumulation AOPC
- Downstream DDT
- Downstream PAHs

RM-1 RM-2 RM-3 RM-4 RM-5 RM-6 RM-7 RM-8 RM-9 RM-10 RM-11 RM-12

FIGURE 3e

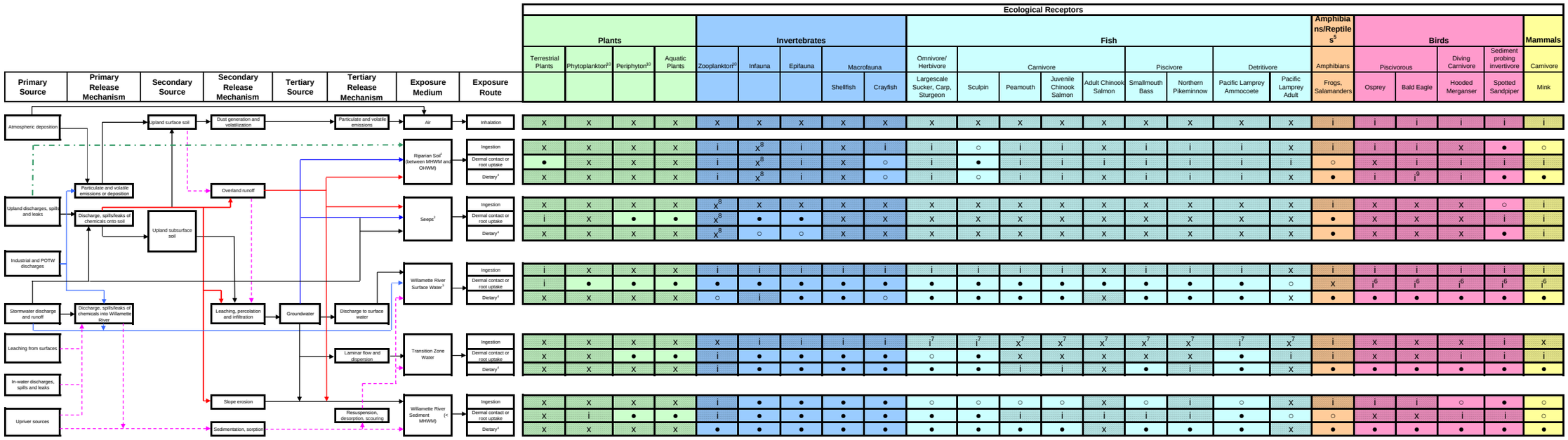
Portland Harbor: Large Scale Areas of Potential Concern

DRAFT

DEQ

0 0.25 0.5 1 Mile

Figure 4 - Conceptual Site Model for the Ecological Risk Assessment



Legend

- ● = Complete and significant pathway
- ○ = Complete and significance unknown
- i = Complete and insignificant pathway
- x = Incomplete pathway
- MHWM = mean high water mark
- OHWM = ordinary high water mark

The absence of shading indicates a complete pathway.

Complete and Significant

The following criteria should be met before the pathway of a contaminant should be considered complete and significant:

- The pathway is theoretically or potentially complete; pathway can be supported by the scientific literature .
- Both the receptor and the exposure media are known, based on site-specific information, or can reasonably be assumed to co-occur in Portland Harbor.
- The pathway has been shown to be a primary route of exposure for any life stage of a receptor or surrogate organism based on laboratory, field, or site-specific data, and there is a high potential that the receptor will receive a significant proportion of the contaminant dose via the proposed route.

For example, exposure of fish to dissolved metals via uptake through the gill, and exposure of fish-eating birds to PCBs by consuming contaminated prey.

Pathways that are complete and significant will be assessed quantitatively. For example, the concentration of metals measured in the water column will be compared to concentrations shown to cause adverse effects to fish (in the scientific literature) to calculate a hazard quotient. If information needed to calculate a hazard quotient is not available, the preference will be to collect the needed information. If the information cannot be collected, a conservative value will be used in the hazard quotient calculation.

Complete and Significance Unknown

A pathway should be classified as complete and significance unknown if it meets the following criteria:

- The pathway is theoretically or potentially complete; pathway can be supported by the scientific literature.
- Both the receptor and the exposure media are assumed to co-occur in the Portland Harbor, but it is unknown whether or not the receptor uses the area sufficiently enough to be exposed to contaminants at effect levels.
- The pathway has been shown to be a primary route of exposure for any life stage of a receptor or surrogate organism, but no laboratory, field or site-specific data are available to indicate that the receptor will receive a significant proportion of the contaminant dose.
- It is unknown if the receptor will receive a significant proportion of the contaminant dose when combined with other pathways or contaminants.

For example, it is unknown how sturgeon use Portland Harbor. While exposure to sediment is likely, data are not available to assess quantitatively the extent that this receptor and exposure media co-occur.

For pathways that are classified as complete and significance unknown, additional site-specific data will be required to determine if they can be reclassified as complete and significant or complete and insignificant.

Complete and Insignificant

A pathway should be classified as complete and insignificant if it meets the following criteria:

- The pathway is theoretically or potentially complete; pathway can be supported by the scientific literature.
- The pathway is known to be a primary route of exposure for any life stage of a receptor or surrogate organism. However, laboratory, field or site-specific data indicate contaminants are unlikely to contribute a significant proportion of the contaminant dose solely by the proposed route or pathway, or it can be reasonably assumed that data would demonstrate that exposure via the pathway is insignificant compared to other pathways.

For example, while theoretically freshwater fish ingest water when feeding they do not actively drink due to the osmotic conditions in which they exist. Therefore, exposure to surface water via ingestion would be minor relative to other pathways. Also, PCB uptake from the water column is probably a complete pathway for piscivorous birds, but compared to the uptake of PCBs in contaminated prey items, the exposure is not significant.

Pathways that are complete and insignificant will not be assessed unless additional data become available that changes the significance value. Studies will not be specifically designed to address the complete and insignificant pathway combination. A hazard quotient will be calculated if data are readily available, and some

Incomplete

A pathway should be classified as incomplete if it meets the following criteria:

- The pathway is theoretically and/or practically not possible or not likely to occur in the area evaluated.
- Both the receptor and the exposure media are known, based on site-specific data, or can reasonably be assumed not to co-occur in Portland Harbor or would not use the area to the extent where exposure would occur.
- The pathway is not a primary route of exposure for any life stage of a receptor or surrogate organism based on laboratory, field, or site-specific data.

For example, juvenile salmon would not be eating fish.

Pathways that are incomplete will not be assessed.

Footnotes

[1]Riparian Soil = The bank area between the Mean High Water Mark (MHWM) and the Ordinary High Water Mark (OHWM). Upland soil above the Ordinary High Water Mark will be assessed by upland facilities under DEQ oversight.

[2]Seeps = Seeps is water discharging on the bank area aboive the MHWM. It inclues the in-point of small tributaries to the river, groundwater seeping up to the bank area, and small piped discharges running over the bank.

[5]Willamette River Surface Water includes fish bearing tributaries and the in-point of year-round, significant flow outfalls.

[4]Dietary = Dietary means any tissue that is consumed by the species of interest within the exposure medium, and it includes trophic transfer.

[9]Reptiles = There is likely limited use of the ISA by only a few reptiles (garter snake, painted turtle and pond turtle). We have no surrogate species for reptiles, but protecting sensitive life stages of amphibians and birds is considered protective of reptiles.

[6] Areas with significant sheen could be a "complete and significant" pathway.

[7] Fish exposure to discharging Transition Zone Water will be assessed by focused surface water sampling.

[8] This is a "complete and significant" pathway for terrestrial invertebrates.

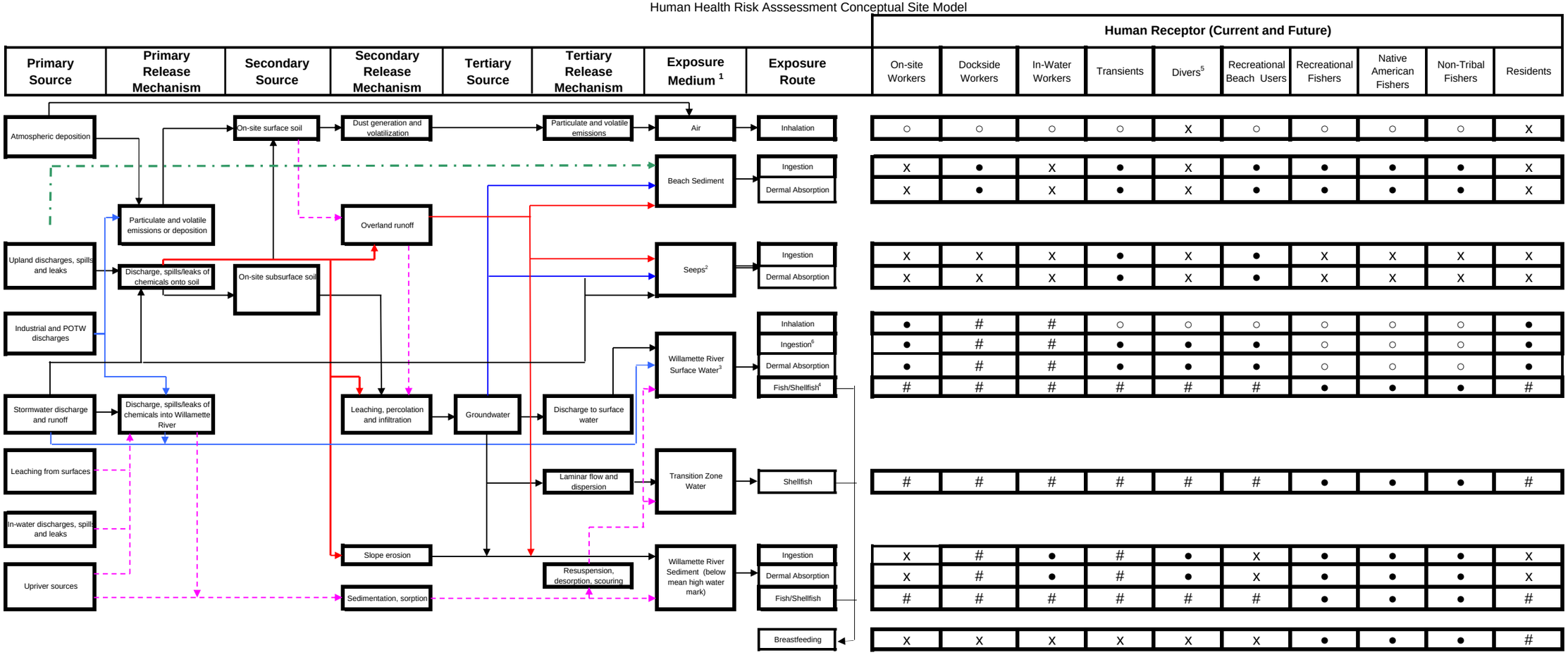
[3] This could be a "complete and significant" pathway for the terrestrial riparian area.

[10]These receptors will be assessed as potential pathways for contaminant movement through the food web. They will not be assessed as endpoints

Definitions

A **Complete** pathway means there is a potential for a contaminant to reach a receptor via the proposed route.
An **Incomplete** pathway means there is no potential for a contaminant to reach a receptor via the proposed route.
A **Significant** pathway means there is a high potential that the receptor will receive a significant proportion of the contaminant dose via the proposed route.
An **Insignificant** pathway means there is a low potential that the receptor will receive a significant proportion of the contaminant dose via the proposed route.
Significance Unknown means that it is unknown if the receptor will receive a significant proportion of the contaminant dose via the proposed route alone. However, the receptor could receive a significant proportion of the contaminant dose when combined with other pathways or other contaminants.

Figure 5
Human Health Risk Asssessment Conceptual Site Model



Primary Source	Primary Release Mechanism	Secondary Source	Secondary Release Mechanism	Tertiary Source	Tertiary Release Mechanism	Exposure Medium [1]	Exposure Route	On-site Workers	Dockside Workers	In-Water Workers	Transients	Divers[5]	Recreational Beach Users	Recreational Fishers	Native American Fishers	Non-Tribal Fishers	Residents
Atmospheric deposition		On-site surface soil	Dust generation and volatilization		Particulate and volatile emissions	Air	Inhalation	○	○	○	○	X	○	○	○	○	X
						Beach Sediment	Ingestion	X	●	X	●	X	●	●	●	●	X
							Dermal Absorption	X	●	X	●	X	●	●	●	●	X
	Particulate and volatile emissions or deposition		Overland runoff														
Upland discharges, spills and leaks						Seeps[2]	Ingestion	X	X	X	●	X	●	X	X	X	X
	Discharge, spills/leaks of chemicals onto soil	On-site subsurface soil					Dermal Absorption	X	X	X	●	X	●	X	X	X	X
Industrial and POTW discharges						Willamette River Surface Water[3]	Inhalation	●	#	#	○	○	○	○	○	○	●
							Ingestion[6]	●	#	#	●	●	●	○	○	○	●
							Dermal Absorption	●	#	#	●	●	●	○	○	○	●
							Fish/Shellfish[4]	#	#	#	#	#	#	●	●	●	#
Stormwater discharge and runoff	Discharge, spills/leaks of chemicals into Willamette River		Leaching, percolation and infiltration	Groundwater	Discharge to surface water												
Leaching from surfaces					Laminar flow and dispersion	Transition Zone Water	Shellfish	#	#	#	#	#	#	●	●	●	#
In-water discharges, spill and leaks																	
			Slope erosion			Willamette River Sediment (below mean high water mark)	Ingestion	X	#	●	#	●	X	●	●	●	X
Upriver sources					Resuspension, desorption, scouring		Dermal Absorption	X	#	●	#	●	X	●	●	●	X
			Sedimentation, sorption				Fish/Shellfish	#	#	#	#	#	#	●	●	●	#
							Breastfeeding	X	X	X	X	X	X	●	●	●	#

Legend

● = Potentially complete pathway. Will be evaluated in the HHRA.

x = Incomplete pathway

= Potentially complete pathway but evaluated under a different receptor category in the PH HHRA

○ = Potentially complete pathway but not evaluated in the PH HHRA because exposure is expected to be insignificant

Footnotes

[1] This CSM includes exposure to media considered a part of the Portland Harbor RI/FS. It does not include media that will be evaluated as a part of the specific upland site evaluations and risk assessments.

[2] Seeps = Seeps is water discharging on the bank area aboive the MHWM. It inclues the in-point of small tributaries to the river, groundwater seeping up to the bank area, and small piped discharges running over the bank.

[3] Willamette River Surface Water includes fish bearing tributaries and the in-point of year-round, significant flow outfalls.

[4] Shellfish now inlcudes bivalves as well as crayfish.

[5] It is assumed that divers could enter the water from the shore or from a boat.

[6] For on-site workers, transients, and residents, the Willamette River is assumed to be a drinking water source. Other receptors (divers and recreational beach users) are assumed to be exposed through incidental ingestion.

Figure 6
Contaminant Fate and Transport Model

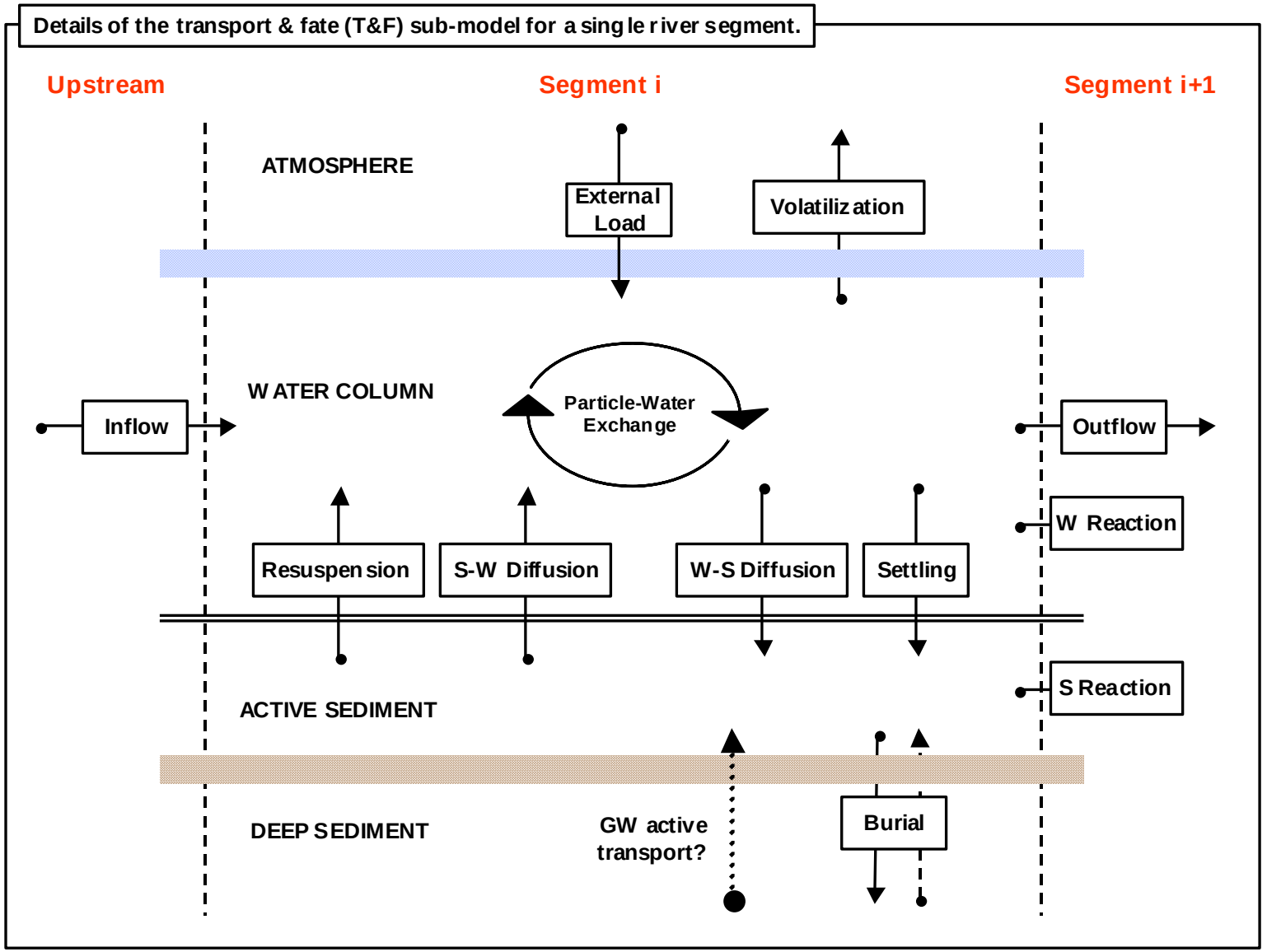


Figure 7
Relationship of Contaminant Fate and Transport Model and Food Web Models

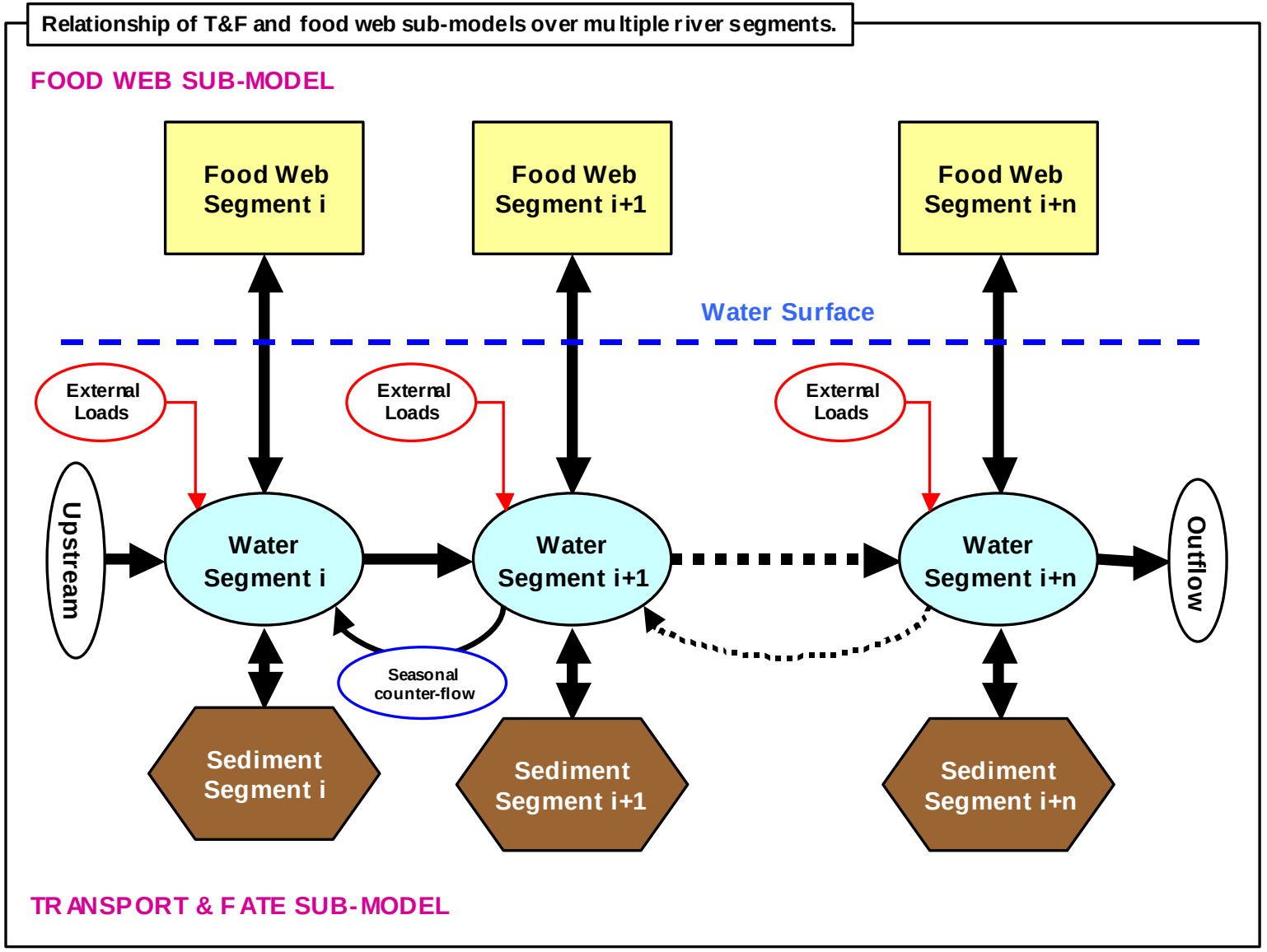


Table 1
Conceptual Site Model Data Needs:

Data Need	Justification	Notes
Upstream Surface Water Transects	Characterize contaminants entering lower Willamette River from upper watershed	TSS to be collected in support of hydrodynamic sedimentation model; contaminant data also required
Suspended sediment and bedload during high flow events	Characterize contaminant movement during high flow events	To be collected in support of hydrodynamic sedimentation model
Surface sediment, subsurface sediment and biota tissue data between RM 11 and 14	Determine whether significant upstream sources that may impact the study area are present.	Limited sediment data exists in this reach. Potential sources of contamination should be evaluated to determine whether they may impact the current study area.
Subsurface sediment data between RM 9.2 and 11	Characterize vertical extent of contamination in areas of potential concern	Subsurface sediment data primarily focused in fire boat dock area
Sedflume and settling velocity data	Evaluation of sediment transport	To be collected in support of hydrodynamic sedimentation model
Additional river velocity data	Evaluation of sediment transport	To be collected in support of hydrodynamic sedimentation model
Multnomah Channel hydrodynamic data	Determine whether contaminants within ISA may be transported into Multnomah Channel	Downstream extent of contamination
Sediment data within Multnomah Channel	Determine whether contaminants within ISA may be deposited within Multnomah Channel	Downstream extent of contamination
Surface sediment, subsurface sediment and biota tissue data between RM 0 and 2	Determine whether contaminants within ISA have been transported to downstream reach	Downstream extent of contamination

Table 2
Potential Upstream Sources of Contamination
(River Mile 11 – 14)

Potential Source	COIs	River Side	River Mile	Notes
Zidell and Schnitzer	PCBs, metals	West	RM 13.8	RI/FS being performed under DEQ oversight
PGE Substation L	PCBs	East	RM 13.4	Sediment cap installed in 1993
South Water Front and Lincoln Steam Plant	Unknown	West	RM 13.2	Upland cleanup completed under DEQ oversight
City of Portland Storm Water Outfalls	Metals, PAHs, phthalates	East and West	RM 11 - 14	COIs based on sediment data collected off City outfalls within Study Area
Historic MGP	PAHs, metals, benzene, cyanide	West	RM 12	Product saturated soils identified upland
Cargill	PAHs	East	RM 11.5	Dredging activities may have eliminated some contamination
Tanner Creek	Unknown	West	RM 11.5	Tanner Creek may represent a contaminant transport pathway from historic Pearl District

Table 3
Areas of Potential Concern Identification Criteria

Contaminant	Contaminant Breakdown	Screening Chemical	Screening Criteria	Screening source
PCB	Aroclor 1221	Total PCBs (ug/kg)	0 - 34	DEQ SLV II Freshwater sediment
	Aroclor 1242		34 - 340	SLV II to SLV II x 10
	Aroclor 1248		340 - max	Exceeds SLV II x 100
	Aroclor 1254			
	Aroclor 1260			
	Aroclor 1268			
DDT	o,p DDE	Total DDT (ug/kg)	0 - 5.28	TEC
	o,p DDD		5.28 - 56	TEC to mid-range
	o,p DDT		56 - 572	Mid-range to PEC
	p,p DDE		572 - max	Exceeds PEC
	p,p DDD			
	p,p DDT			
PAH	LPAH (1)	Total PAH (ug/kg)	0 - 1610	TEC
	HPAH (2)		1610 - 22,800	TEC - PEC
			22,800 - max	Exceeds PEC
Metals	Cadmium	Individual Metals (mg/kg)	Cd > 4.98	Exceeds PEC
	Chromium		Cr . 111	Exceeds PEC
	Copper		Cu > 149	Exceeds PEC
	Lead		Pb > 128	Exceeds PEC
	Mercury		Hg > 1.06	Exceeds PEC
	Nickel		Ni > 48.6	Exceeds PEC
	Zinc		Zn > 459	Exceeds PEC
TBT	Butyltin ion	Individual Bbutyltins	190	Exceeds DEQ Level II Bioaccumulation SLV
	Dibutyltin dichloride		190	Exceeds DEQ Level II Bioaccumulation SLV
	Dibutyltin ion		190	Exceeds DEQ Level II Bioaccumulation SLV
	Monbutyltin chloride		190	Exceeds DEQ Level II Bioaccumulation SLV
	Tetrabutyltin		190	Exceeds DEQ Level II Bioaccumulation SLV
	Tributyltin		190	Exceeds DEQ Level II Bioaccumulation SLV
	Tributyltin choride		190	Exceeds DEQ Level II Bioaccumulation SLV
Phthalates	Bis(2-ethylhexyl) phthalate	Bis(2-ethylhexyl) phthalate (ug/kg)	750	Exceeds NOAA Upper Effects Level
Toxicity	Not Applicable	Not Applicable	Percent difference from control	(3)

(1) Also screened low molecular weight PAHs (LPAH) against Great Lakes PEL (1200 ug/kg)
(2) Also sceened high molecular weight PAHs (HPAH) agains Great Lakes PEC (2300 ug/kg)
(3) Sediment toxicity was screened using NOAA initial analysis of Round 2 Bioassays based on percent different from control and DEQ generated hit/no hit criteria for SedQual analyisis; 7 different hit/no hit results were considered in a line of evidence approach

Table 4
Areas of Potential Concern Summary

Area of Potential Concern	COIs	River Side	River Mile	Approximate Size (Acres)
Sultzer	PCBs, copper,	W	10.2 - 10.4	6.30
Goldendale / UPRR	PCBs, PAHs	E	9.9 -10.1	6.65
Outfall 47	PCBs (Aroclor 1221)	E	9.5 -10.0	33.80
Fireboat / GE	PCBs, zinc, phthalates	W	9.45 - 9.7	14.58
S-5 outfall	copper, zinc, toxicity (bioassay)	E	9.25 - 9.3	1.48
Gunderson / Shell	PCBs, zinc, copper, lead, TBT, DDT, PAHs, phthalates	W	8.1 - 9.4	151.96
Shipyard / Lagoon	TBT, PCBs, zinc, copper, lead, mercury, PAHs, phthalates	E	7.5 - 9.0	168.52
Willbridge	PCBs, cadmium, toxicity	W	7.4 - 7.9	32.99
Triangle Park	TBT	E	7.3 - 7.5	12.27
Outfall 48	zinc, chromium, copper. lead, nickel, PAHs	E	7.1 - 7.2	2.32
RPAC / Arkema	DDT and breakdown products, PAHs, lead, mercury nickel	W	6.3 - 7.5	54.49
Willamette Cove	PCBs, PAH, mercury, copper, zinc, chromium, nickel, TBT, DDT	E	6.3 - 6.8	26.74
Siltronic chlorinated VOCs	TCE, PAHs	W	6.4 - 6.45	0.68
Northwest Natural	PAHs (napthalene), benzene, cyanide, nickel, lead, phthalates	W	6.05 - 6.6	23.10
Crawford/ BES	copper, lead, chromium, zinc, TBT	E	5.9 - 6.2	5.03
US Moorings	TBT, zinc, chromium, PAHs	W	5.95 - 6.1	7.08
St. Johns West	lead, copper, PAHs, phthalates	W	5.65 - 5.9	4.64
Marcom	PCB, TBT, copper, zinc, lead, chromium, PAHs	E	5.5 - 5.8	8.25
Schnitzer Burgard	PCBs, TBT, zinc, lead, copper, chromium, zinc, toxicity (bioassay), phthalates	E	3.7 - 4.2	31.72
Time Premier	Toxicity (bioassay), dioxin, mercury	E	3.45 - 3.7	6.85
OSM	PCBs, chromium, zinc, lead, PAHs, toxicity	E	2.0 - 2.7	22.72
Downstream PAH's	PAHs	W	3.1 - 6.9	292.28
Downstream DDT	DDT and breakdown products, PAHs, lead, nickel, mercury	W	3.1 - 6.3	90.48
Riverwide Bioaccumulation Exceedance	PCB, DDT	NA	2 - 11	2080.00

Note: The names selected for individiual Areas of Potential Concernt are for Indentification purposes only

Table 5
Area of Potential Concern Data Gaps

Area of Potential Concern	Data Gaps								
	Nature and Extent of Off-Shore Contamination (1)					Contaminant Source Areas and Transport Pathways (2)			
Name	COIs (3)	Lateral Extent	Vertical Extent	Transition Zone Water	Surface Water (4)	Source Area	Storm-water (5)	Ground-water	Bank Erosion
Sultzer	**No** (dioxin data potentially needed due to presence of PCBs - to be determined (TBD))	**Yes (**limited RI data, may be able to use DMMP data)	**Yes** (limited subsurface data - check DMMP data)	**No** (estimate through equilibrium partitioning calculations)	**Unknown (**no sw stations nearby; may be needed based on upland work to help estimate loading)	**Yes** (potential overwater activities)	**Yes** (currently under investigation)	**Yes** (currently under investigation)	**Unkonwn**
Goldendale / UPRR	**Yes** (TPH due to lack of TPH data upstream of RM 9.2, dioxin TBD)	**Unkown** (dependent on review of historic and DMMP sediment data)	**Yes** (limited RI data; check DMMP sediment data)	**No** (estimate through equilibrium partitioning calculations)	**Yes** (surface water data may be needed to help estimate loading from UPRR outfalls)	**Yes** (potential overwater activities)	**No** (Goldendale) / **Yes** (Upland source identification on UPRR site required)	**No**	**Unkonwn**
Outfall 47	**Yes**(TPH due to lack of TPH data upstream of RM 9.2, dioxin TBD)	**No** Assuming DMMP data would be adequate	**No** (Assuming DMMP data would be adequate)	**No** (estimate through equilibrium partitioning calculations)	**No** (combine with UPRR surface water station above)	**Yes** (potential sources contributing to OF 47 not yet fully defined)	**Yes**	**No**	**No**
Fireboat / GE / Galvanizers / OFs 16 & 17	**Yes** (additional dioxin data needed due presence of PCBs)	**Yes** supplemental data for FS, (towards channel)	**Yes** (limited subsurface data downstream)	**No** (estimate through equilibrium partitioning calculations)	**No** (existing surface water sampling station)	**Yes** (Potential sources contributing to OF not yet fully defined)	**Yes**	**No**	**No**

Table 5
Area of Potential Concern Data Gaps

Area of Potential Concern	Data Gaps								
	Nature and Extent of Off-Shore Contamination (1)					Contaminant Source Areas and Transport Pathways (2)			
Name	COIs (3)	Lateral Extent	Vertical Extent	Transition Zone Water	Surface Water (4)	Source Area	Storm-water (5)	Ground-water	Bank Erosion
S-5 outfall	**Yes** (TPH due to lack of TPH data upstream of RM 9.2)	**Yes** (supplemental data towards channel for FS)	**Yes** (limited subsurface data)	**No** (estimate through equilibrium partitioning calculations)	**Unknown** (no sw stations nearby; may be needed based on upland work to help estimate loading)	**Yes** (potential sources contributing to OF S5)	**Yes**	**No**	**No**
Gunderson / Shell	**Yes** (limited VOC data off Area 1, dioxins due to PCB contamination, Mn due to downtream hits above PEC, Supplemental TPH may be required)	**Yes** (limited samples behind Shell and Area 3 docks)	**Yes** (behind Shell dock, south end of Area 3 and James River)	**Unknown** (dependent on TZW sample results off Area 1)	**Yes** (help evaluate contaminant loading in vicinty of Shell Dock and Outfall 18)	**Yes** (potential sources contributing to OF 18 and over-water activities)	**Yes** (currently under investigation) (stormwater source control action will likely be required in Areas 2 & 3)	**Yes** (currently under investigation & under source control action)	**Yes** (currently under investigation) (bank source control action will likely be required in Areas 2 & 3)
Shipyard / Lagoon	**Yes** (Supplemental TPH may be required, dioxins needed due to presence of PCBs)	**Yes** (lateral N&E fairly well defined, may need supplmental sediment data for hot spot identification)	**Yes** (vertical N&E faily well defined, may need supplemental sediment data for hot spot identification)	**No** (estimate through equilibrium partitioning calculations)	**Yes** (surface water transect needed at mouth of SI Lagoon to understand COI transport)	**Yes** (upland sources to SI Lagoon other than Shipyard and overwater activities)	**Yes** (Shipyard stormwater will be investigated) **yes** (stormwater sources to SI Lagoon other than Shipyard)	**Yes** (Shipyard GW currently under investigation) **yes** (upland GW sources to SI Lagoon other than Shipyard)	**Yes** (Shipyard bank soil currently under investigation) **yes** (bank soil other than Shipyard)

Table 5
Area of Potential Concern Data Gaps

Area of Potential Concern	Data Gaps								
	Nature and Extent of Off-Shore Contamination (1)					Contaminant Source Areas and Transport Pathways (2)			
Name	COIs (3)	Lateral Extent	Vertical Extent	Transition Zone Water	Surface Water (4)	Source Area	Storm-water (5)	Ground-water	Bank Erosion
Willbridge	**Yes** VOCs	**Yes** (supplmental sediment data for FS)	**Yes** (limited subsurface data offshore)	**Unknown** (dependent on ongoing TZW sample results)	**No** (surface water sampling station located nearby)	**Yes** (potential overwater activities)	**Yes** (currently under investigation)	**Yes** (currently under investigation)	**Yes** (currently under investigation)
Triangle Park	**No**	**Yes** (supplmental sediment data for FS)	**Yes** (limited subsurface data)	**No** (estimate through equilibrium partitioning calculations)	**No**	**Yes** (potential overwater activities)	**No**	**Yes** (currently under investigation)	**No**
Outfall 48	**No**	**Yes** (may need supplmental sediment data for FS)	**Yes** (only City surface data available near outfall; metals & PAH need further delineation)	**No** (estimate through equilibrium partitioning calculations)	**Unknown (**no sw stations nearby; may be needed based on upland work to help estimate loading)	**yes** (potential sources contributing to OF 48 not yet fully defined)	**Yes**	**No**	**No**
RPAC / Arkema	**Yes** (fingerprinting may be required for source diffrentiation)	**No (**Ri/FS**)** **Yes (**RD**)**	**No (**RI/FS**)** **Yes (**RD**)**	**Unknown** (dependent on Round 2 TZW, RPAC gw investigation and Arkema early action data needs)	**No** (2 existing stations)	**Yes** (potential overwater activities)	**Yes** (currently under investigation)	**Yes** (currently under investigation)	**Yes** (currently under investigation)
Willamette Cove	**Yes** (dioxin data needed due presence of PCB contamination)	**Yes** (supplemental data needed downstream and towards channel)	**Yes** (supplemental data needed downstream and towards channel)	**Yes** (petroleum product release area)	**No** (existing surface water sampling station)	**Yes** (potential overwater activities)	**Yes** (currently under investigation)	**Yes** (currently under investigation)	**Yes** (currently under investigation)

Table 5
Area of Potential Concern Data Gaps

Area of Potential Concern	Data Gaps								
	Nature and Extent of Off-Shore Contamination (1)					Contaminant Source Areas and Transport Pathways (2)			
Name	COIs (3)	Lateral Extent	Vertical Extent	Transition Zone Water	Surface Water (4)	Source Area	Storm-water (5)	Ground-water	Bank Erosion
Siltronic chlorinated VOCs	**No**	**No**	**No**	**No**	**No** (currently under investigation)	**Yes**	**Yes** (currently under investigation)	**Yes** (currently under investigation)	**No** (for Siltronic's HVOC release)
Northwest Natural (Gasco)	**No**	**No** (RI/FS) **Yes** RD)	**No (**RI/FS**)** **Yes (**RD**)**	**Unknown** (dependent on TZW sample results)	**yes** (onging - change method to XAD)	**No**	**Yes** (currently under investigation)	**Yes** (currently under investigation)	**Yes** (currently under investigation)
Crawford/ BES	**No**	**Yes** (distinguish sources)	**Yes** (limited subsurface data)	**No** (estimate through equilibrium partitioning calculations)	**Unknown (**no sw stations nearby; may be needed based on upland work to help estimate loading)	**Unknown** (further evaluaton of BES Lab XPA required to determine if any data gaps exist)	**Unknown** (further evaluaton of BES Lab XPA required to determine if any data gaps exist)	**Unknown** (further evaluaton of BES Lab XPA required to determine if any data gaps exist)	**Yes** (Crawford St- Beach sand removal not totally effective)
US Moorings	**Unknown** (dependent on 2B cores)	**Unknown** (dependent on 2B cores)	**Unknown** (dependent on 2B cores)	**Unknown** (dependent on 2B cores)	**No** (surface water sampling station located nearby)	(6)	(6)	(6)	(6)
St. Johns West	**No**	**Yes** (supplemental sediment data for FS; may be able to use DMMP data)	**Yes** (supplemental sediment data for FS; may be able to use DMMP data)	**No** (estimate through equilibrium partitioning calculations)	**No** (surface water sampling station located nearby)	**no** (Marine Finance property) **yes** (overwater structures)	**yes** (currently under investigation)	**No**	**No**

Table 5
Area of Potential Concern Data Gaps

Area of Potential Concern	Data Gaps								
	Nature and Extent of Off-Shore Contamination (1)					Contaminant Source Areas and Transport Pathways (2)			
Name	COIs (3)	Lateral Extent	Vertical Extent	Transition Zone Water	Surface Water (4)	Source Area	Storm-water (5)	Ground-water	Bank Erosion
Marcom	**yes** (Mn - detections above PEC observed)	**Yes** (lateral N&E fairly well defined, may need supplmental data towards channel)	**Yes** (vertical N&E fairly well defined, may need supplmental data towards channel and Cathedral Park)	**No** (estimate through equilibrium partitioning calculations)	**Yes** (understand source loading)	**No** (N Parcel) **Yes** (S Parcel - upland RI not complete for South Parcel)	**yes** (upland off-site stormwater sources & potential S Parcel sources)	**No** (N Parcel) Y**es** (S Parcel - upland RI not complete for South Parcel)	**Yes** (will need to be evaluated in both N & S Parcels)
Schnitzer Burgard	**Yes** (dioxin needed due presence of PCB contamination;PBDEs may be associated with auto fluff)	**Unknown** (dependent on 2B cores)	**Unknown** (dependent on 2B cores)	**No** (estimate through equilibrium partitioning calculations)	**No** (surface water sampling station located nearby)	**no** (Schnitzer) **yes** (upland stormwater sources)	**Yes** (potential significant migration pathway; currently under investigation)	**Yes** (GW currently under investigation)	**Yes** (currently under investigation)
Time / Premier Edible Oil	**No** (dioxin TBD)	**Yes** (supplmental sediment data needed towards channel and downstream)	**Yes** (limited subsurface data)	**Unknown** (dependent on additional upland sampling efforts)	**Yes** (off/downstream of Time Oil; dioxin)	**yes** (currently under investigation)	**Yes** (currently under investigation)	**Yes** (currently under investigation)	**Yes** (currently under investigation)
OSM/ OF 53A	**Yes** (Mn)	**Yes** (supplmental sediment data needed towards channel and downstream)	**Yes** (vertical N&E fairly well defined, may need supplmental sediment data)	**Yes** (GW contaminated with Mn and petroleum products likley entering river)	**No** (surface water sampling station located nearby)	**Yes** (potential overwater activities and sites other than OSM that may contribute to stormwater)	**Yes** (currently under investigation at OSM) **yes** (for sites other than OSM)	**Yes** (currently under investigation at OSM) **yes** (for sites other than OSM)	**Yes** (currently under investigation at OSM) **yes** (for sites other than OSM)

Table 5
Area of Potential Concern Data Gaps

Area of Potential Concern	Data Gaps								
	Nature and Extent of Off-Shore Contamination (1)					Contaminant Source Areas and Transport Pathways (2)			
Name	COIs (3)	Lateral Extent	Vertical Extent	Transition Zone Water	Surface Water (4)	Source Area	Storm-water (5)	Ground-water	Bank Erosion
Downstream PAHs	**Yes** (PAH fingerprinting to diffrentiate petrogenic and pyrogenic PAHs)	**Yes** (further identify hot spots and local sources of PAHs, define extent into the Willamette River channel and Multnomah channel	**Yes** (further define vertical extent of local hot sponts)	**Unknown** (dependent on on TZW sample results)	**No** (Numerous surface water within Area of Potential Concern)	**Yes** (source diffrentiation)	**Not Applicable**	**Not Applicable**	**Not Applicable**
Downstream DDT	**yes** (potential fingerprinting needed to distinguish certain Arkema COIs from RPAC COIs)	**Yes** (delineate downstream and offshore extent)	**Yes** (further define vertical extent of local hot sponts)	**No** (estimate through equilibrium partitioning calculations)	**No** (Numerous surface water within Area of Potential Concern)	**Not Applicable**	**Not Applicable**	**Not Applicable**	**Not Applicable**
Site-Wide PCB and DDT	**yes** (dioxin, PBDE, Mn)	**Unknown**	**Unknown**	**No** (estimate through equilibrium partitioning calculations)	**No** (Numerous surface water within Area of Potential Concern)	**Yes**	**Yes**	**Yes**	**Yes**

Footnotes:

(1) Nature and extent of offshore contamination are generally considered in-water data gaps to meet project schedule
(2) Evaluation of contaminant source areas and transport pathways is generally considered an upland data gap.
(3) Dioxin is considered a potential COI at all locations.
(4) Data gaps assume ongoing data collection at existing surface water stations
(5) "Stormwater" includes runoff directed to conveyance systems & overland runoff (ie, sheet flow)
(6) Potential upland source area(s) not in DEQ's Cleanup Program

Table 6
Changes to the Assessment Endpoint Table

Receptor of Concern	Assessment Endpoint	Measures of Effect and Exposure	Changes to the table	Justification/Notes	Data needs (numbers correlate to the Data Needs Table)
Benthic					
The benthic community	Survival, growth and reproduction	Sediment toxicity testing to assess effects (direct toxicity and/or a predictive approach will be evaluated).	Modify the Measures of Effect and Exposure to include: 1) Compare tissue-based TRVs against field collected benthic tissue data (e.g., clams, mussels and multi-plate tissue) and results from laboratory bioaccumulation testing; and 2) add assessment of risk from groundwater discharge areas using existing bioassay tests, comparison of transition zone water to AWQC and either collecting tissue from groundwater discharge areas or doing in-situ toxicit testing.	(1) The two tests being run (10 and 28 day tests) do not represent bioaccumulation. (2) Need a method to assess risk to benthic community from groundwater discharge.	1, 2, 4, 5
Shellfish (bivalves)	Survival, growth and reproduction	Tissue-based TRVs (provided sufficient clam tissue can be obtained) and benthic bioassay toxicity testing. For TBT, derive a site specific biota-sediment accumulation factor or use screening value based on sediment concentrations[1].	No change.		1, 4, 5
Crayfish	Survival, growth and reproduction	Tissue based TRV approach.	No change.		1, 4
Fish					
Invertivore					
Juvenile Chinook Salmon[2]	Survival and growth	A combination of dietary TRV and tissue based TRV approach. For metabolized COPCs, determine potential exposure through diet, tissue, and/or biomarker analysis and assess potential effects on survival and growth. Compare water concentrations to AWQC criteria and literature-based values for protection of early life stages of salmonids.	Modify the Measures of Effect and Exposure to include TRVs that include reproductive effects (as a surrogate for growth).	Reproductive effects are should be used a surrogate for growth because a signifcant amount of reproductive data is avaialable.	7
Adult Chinook Salmon[2]	Survival, growth and reproduction	Adult Chinook salmon will be assessed for olfactory function of returning, pre-spawning adults. Surface water data will be evaluated to determine if contaminant concentrations may cause changes to olfactory function that may affect swimming, homing behavior and ultimately reproduction.	Adding adult Chinook salmon to Assessment Endpoint Table.	Adult Chinook represents a unique exposure-receptor pathway, and is tied directly to salmon survival and reproduction.	
Peamouth	Survival, growth and reproduction	A combination of dietary and tissue based TRV approach. Compare water concentrations to literature-based or AWQC criteria for protection of early life stages.	No change.	Note: Reexamine peamouth and juvenile Chinook diets to determine how similar they are, and decide whether peamouth is an adequate representative of juvenile Chinook.	7, 8
Sculpin[2]	Survival, growth and reproduction	A combination of dietary and tissue based TRV approach. For metabolized COIs, determine potential exposure through diet and/or biomarker analysis and assess potential effects on survival, growth and reproduction. Compare water concentrations to literature-based or AWQC criteria for protection of early life stages.	No change.		4, 6, 7, 8, 10

Table 6
Changes to the Assessment Endpoint Table

Receptor of Concern	Assessment Endpoint	Measures of Effect and Exposure	Changes to the table	Justification/Notes	Data needs (numbers correlate to the Data Needs Table)
Omnivore/Herbivore					
Carp (Surrogate Fish Tissue)[3,4]	Survival, growth and reproduction	Tissue-based TRV approach for dioxin-likecontaminants using literature values and incorporating toxic equivalent (TEQs) based on the World Health Organization toxic equivalent factors (TEFs). Risk from other compounds assessed in uncertainty analysis.	No change.		
Largescale Sucker[2,3,5]	Survival, growth and reproduction	A combination of dietary and tissue based TRV approaches. For metabolized COIs, determine potential exposure through diet, and/or biomarker analysis and assess potential effects on survival, growth, and reproduction. Compare water concentrations to literature-based or AWQC criteria for protection of early life stages. Incorporate sediment ingestion as part of the dietary TRV. Note prevalence of external lesions or tumors.	No change.		7, 8, 9, 11
White Sturgeon	Survival, growth and reproduction	A combination of dietary and tissue based TRV approaches. Compare water concentrations to literature-based or AWQC criteria for protection of early life stages. Modeling and/or additional data collection will be required if current data is inadequete to assess exposure and effects. [7]	No change.	Note: Assume 100% site fidelity for all sturgeon assessment endpoints.	7, 8, 9, 11, 12, 13
Smallmouth Bass	Survival, growth and reproduction	A combination of dietary and tissue based TRV approaches. Compare water concentrations to literature-based or AWQC criteria for protection of early life stages.	No change.		7, 8, 9
Piscivores					
Northern Pikeminnow	Survival, growth and reproduction	A combination of dietary and tissue based TRV approaches. Compare water concentrations to literature-based or AWQC criteria for protection of early life stages.	No change.		7, 8, 9, 11
Detritivores					
Pacific Lamprey Amocoetes	Survival and growth	Tissue residue concentrations compared to relevant TRV or surrogate. In absence of tissue data, modeling to determine dietary and tissue concentrations. Compare water concentrations to literature-based or AWQC criteria for protection of early life stages.	Refinements to the approach for assessing risks to Pacific Lamprey amocoetes is required.	Pacific Lampry amocoetes are unique due to their special species status, high lipid content and life history.	Direction on assessing riskto Lamprey and data needs coming soon

Table 6
Changes to the Assessment Endpoint Table

Receptor of Concern	Assessment Endpoint	Measures of Effect and Exposure	Changes to the table	Justification/Notes	Data needs (numbers correlate to the Data Needs Table)
Wildlife					
Bald Eagle	Survival, growth and reproduction	Dietary-based approach incorporating food chain transfer of contaminants from appropriate fish species (assuming all exposure comes from prey fish). Assess dioxin-like contaminants using a TEQ approach based on appropriate surrogate fish tissue data. Use TRVs based on the most sensitive life stages, which include egg or embryo-based TRVs for DDT and metabolites, PCBs, and dioxin-like compounds. Egg concentrations will be determined by egg analysis or by food chain modeling.	No change.	Note: Bald eagle can be represented by osprey, assuming individual level protection and 100% site use (no migration factor). Need to estimate contaminant concentrations in Bald eagle eggs to validate the Food Web Model and assess risk to eagles.	14
Hooded Merganser	Survival, growth and reproduction	Dietary based TRV approach. Dietary based analysis using sculpin and/or invertebrate tissue data to represent feeding guild. In the absence of appropriate fish and invertebrate tissue concentrations, modeled concentrations will be used. For dioxin like contaminants (carp or appropriate prey species), use a TEQ-based approach to assess reproductive effects.	No change.	Note: Two ingestion scenarious should be considered - 100% invertebrates and 100% fish - for a conservative scenario.	1, 2, 4, 5, 6
Osprey	Survival, growth and reproduction	Dietary-based approach incorporating food chain transfer of contaminants from appropriate fish species (primarily pikeminnow and sucker). Assess dioxinlike contaminants using a TEQ approach based on appropriate surrogate fish tissue data. Use TRVs based on the most sensitive life stages, which include egg or embryo-based TRVs for DDT and metabolites, PCBs, and dioxin-like compounds. Egg concentrations will be determined by egg analysis or by food chain modeling.	No change.	Note: Need to understand contaminant concentrations in osprey eggs to validate the Food Web Model and assess risk to osprey.	14
Spotted Sandpiper[3]	Survival, growth and reproduction	Dietary based TRV approach. Sediment concentrations determined from site specific evaluation. In the absence of appropriate invertebrate tissue concentrations, use modeled invertebrate tissue concentrations.	No change.		1, 2, 4, 5, 6, 15
Mink [6]	Survival, growth and reproduction	Dietary based TRV approach, considering both relevant fish species concentrations and invertebrate (crayfish) components of the diet. For dioxin-like contaminants (carp or appropriate prey species), use a TEQ-based approach to assess reproductive effects.	No change.	Otter has a different diet than mink (feeds on carp). Need to ensure that two ranges of diet are assessed - one for mink and one for otter.	1, 2, 4, 5, 6, 15
Amphibians	Survival, growth and reproduction	Water concentrations compared to literature-based values or AWQC to protect sensitive life stage.	No change.	Note: Use amphibian and bird endpoints to provide protection for reptiles.	3, 15

Table 6
Changes to the Assessment Endpoint Table

Receptor of Concern	Assessment Endpoint	Measures of Effect and Exposure	Changes to the table	Justification/Notes	Data needs (numbers correlate to the Data Needs Table)
Plants					
Aquatic Plants	Survival, growth and reproduction	Comparison of emergent aquatic plant exposure based on concentrations of chemicals in sediment and relevant toxicological data.	No change.		3, 15

Footnotes:

[1] For TBT, suggested screening value of 6,000 ng/g OC (based on 2 % OC), which represents a dry wt concencentration of 120 ng/g.

[2] Considered representative of fish exposure to PAHs. Analysis should include an analysis of whether these compounds are found in the diet of the fish receptors, as well as if found in tissue analysis.

[3] Considered representative of sediment ingestion.

[4] Carp is not a receptor of concern for the ecological risk assessment.; whole-body fish tissue (I.e., carp) was analyzed for dioxin-like chemicals, including PCB congener analysis, and is a surrogate for other fish species for these chemicals.

[5] Represents a resident broadcast spawner. Therefore, exposure to sensitive early life stages and eggs will be assessed to all contaminants, including PAHs and dioxin like compounds.

[6] Mink was selected to also represent river otter. Therefore, the dietary requirements of the river otter, which include a fish diet, must be assessed.

[7] Possible approaches for sturgeon will be developed through the ecological risk assessment TM process and the approach for the site will be selected following discussions between the LWG, EPA and its partners.

Table 7
Ecological Risk Assessment Data Needs

Data Need	Justification	Data use	Potential Methologies	Comments
1. Tissue concentrations from infaunal invertebrates (living in soft sediment, being large enough to displace sedimentary grains) and epibenthic invertebrates (may be freely moving on sediment surface permanently attached to a surface or structure).	Multiplate samples may not represent the biomass or diversity of the invertebrates consumed by other receptors, and therefore may bias or increase uncertainty in the Food Web Model and Dietary Approach. Studies indicate that crayfish may not be good accumulators of contaminants, and therefore may not represent other epibenthic species. Additional data on invertebrates are needed to better represent site-specific exposure.	Tissue concentrations will be used for contaminant pathway analyses in the Food Web Model and Dietary Approach, for endpoint analyses for epibenthic invertebrates themselves, and could improve estimates of site-specific exposure.	Laboratory and or in-situ bioaccumulation testing	This data need is contingent on whether adequate data are obtained on clams and *Lumbriculus* in the late-2005/early-2006 sampling effort and proposed Lumbriculus and *Corbicula* lab tests.
2. Tissue concentrations for invertebrates exposed to surface water	These data are needed to represent surface water exposure to invertebrates, both on structures and in the water column.	Will be used in the Food Web Model and Dietary Approach.	Deploy more multiplates than in Round 2 over a larger area; zooplankton tows	Review existing multiplate data when analysis is complete to inform subsequent sampling (sufficient tissue was not obtained in the first sampling effort to represent individual sites or faunal diversity). Zooplankton tows are also needed with the ability to separate zooplankton from phytoplankton or detritus.
3. Collect periphyton and phytoplankton (in-water plants) for tissue contaminant analysis.	These data are needed to provide dietary concentration information for receptors of concern and for use in the Food Web Model.	Will be used in the Food Web Model and Dietary Approach.	Net and tow collection, potentially other methods available	Should be combined with zooplankton collection. Identify to appropriate level of taxonomic level. Contingent on evaluation of multi-plate and benthic tissue sampling results.

Table 7
Ecological Risk Assessment Data Needs

Data Need	Justification	Data use	Potential Methologies	Comments
4. Biota tissue to develop localized estimates of exposure for source identification, assessing localized risk and developing BSAFs.	Composite sampling of wider ranging species, and/or combining samples from diverse locations within the same composite does not provide sufficient spatial resolution for site specific evaluation.	Will be used in site specific ERAs, in the Food Web Model and Dietary Approach, and for source identification.	Caged and field collected clams, mussels, sculpin, possibly crayfish (crayfish accumulation is variable, but they are an important pathway for fish and birds), Semi-permeable membrane devices (SPMDs), bioaccumulation testing	
5. Need to collect clams and larger, longer-lived mussels, and need to identify the species of mussels found in the ISA	These data are needed to better characterize dietary uptake for invertivores (larger mussels for mink, otter and sturgeon) and to develop BSAFs, especially at site specific locations. Existing sample size of clams (n = 3) is inadequate.	Will be used in the Food Web Model, to assess risk to invertivores and shellfish, and to derive BSAFs.	Co-located benthic sledge tows and sediment grabs	Fall 2005 benthic tissue sampling is expected to fill this data gap.
6. Colocated samples for sculpin and sediment	Additional sculpin tissue is needed to assess exposure to transition zone water, evaluate temporal (seasonal and interannual) variability, and assess localized risk at certain sites. In addition, adequate spatial coverage does not exist for wildlife feeding areas in relation to sediment areas of concern.	Will use in the Food Web Model, in the Dietary Approach for wildlife receptors, for source identification, to establish a more reliable BSAF, and as part of a strategy to monitor temporal trends in contaminant levels.	Need to stratify sampling across a range of contaminant levels to further the develop relationship between sediment and sculpin concentrations.	See Data Gaps 4 and 5 above.
7. Additional lines needed to assess PAH exposure and risk to all fish	Most PAHs are metabolized in fish, and for those that are not metabolized, TRVs are not available to assess (and the detection limits previously used were not adequate to detect PAHs in tissue). Concentrations in fish prey items may not represent what the fish is actually exposed to, resulting in high uncertainty in using the Dietary Approach.	Will use additional lines of evidence to evaluate resident fish exposure to PAHs, understand relationship between concentrations in sediment and water, and identify deleterious effects.	Additional lines of evidence include analysis of stomach contents for unmetabolized PAHs and evaluation of liver and skin lesions.	Analysis needs to be conducted on individual fish, and could be coordinated with fish lesion data collection and/or data collection to understand variability in individual fish concentrations (see below).

Table 7
Ecological Risk Assessment Data Needs

Data Need	Justification	Data use	Potential Methologies	Comments
8. Quantify fish liver and skin lesions	Need to understand relationship between sediment concentration and incidence of occurance of liver or skin lesions in fish.	Will use as a line of evidence risk associated with PAH exposure.	Conduct a fish health assessment on individual fish.	Existing information was collected incorrectly or not at all. Data collection should be combined with other sampling efforts on individual fish.
9. Need to understand variability in individual fish concentrations	Existing composite samples are valuable for assessing contaminant transfer to upper trophic species, but composites provide limited information for assessing risk to individual fish themselves. Population and individual risk may be misrepresented by looking at mean composite versus individual concentrations.	Will use to reduce uncertainty in the Food Web Model and to better represent risk to fish populations and individuals of special status species. May also address some human health data needs.	Collect specific individual fish species (northern pikeminnow, smallmouth bass, black crappie, largescale sucker and sculpin) for chemcial analysis.	Individual fish sampling will support PAH lines of evidence and fish health assessment data needs.
10. Need to better characterize the range of variability in the ISA system	No data currently exists to understand how tissue or water contaminant concentrations change during different times of year. Contaminant concentrations likely vary greatly from summer to winter months. For example, data shows that periods of high flow can increase sediment resuspension and bioavailability, and may increase storm water discharges and bioaccumulatives in the river.	Will use to refine and improve the Food Web Model and to assess risk over time	Caged clams or mussels, SPMDs, surface water collection, sculpin samples	Seasonal surface water data and BCFs could work to predict seasonal changes in tissue concentrations, but tissue data would provide better representatin.
11. Site-specific data on potential risk to early life stages for fish	Need site specific concentrations in early life stages such as in eggs and developing embryos.	Assess reproductive effects of contaminant levels for which egg TRVs are available; compare to egg TRVs.	Collect resident fish eggs for analysis, or analyze fish eggs collected on multiplates, to compare to egg TRVs; may be possible to compare egg TRVs to surface water concentrations	

Table 7
Ecological Risk Assessment Data Needs

Data Need	Justification	Data use	Potential Methologies	Comments
12. Pre-breeding sturgeon whole body tissue	LWG assumes 100% presence and residence time for juveniles, but the largescale sucker and pikeminnow surrogates may not be appropriate. Currently, no whole body juvenile sturgeon data exist for the ISA; ISA-specific field collected tissue is needed to determine toxicity and bioaccumulation, and to inform the Food Web Model.	Will use for assessing risk to sturgeon	individual whole body collection for the size of sturgeon that are known to reside in the ISA (juveniles)	
13. Estimates of reproductive sturgeon tissue concentrations	Long lived fish can accumulate higher levels of contaminants, and risk estimates for longer lived sturgeon are needed.	Will use for assessing risk to sturgeon	Modeling of tissue concentrations from pre-breeding tissue	
14. Need to analyze osprey eggs to understand contaminant concentrations	These data are needed to validate the Food Web Model and reduce uncertainty in assessing osprey risk using a sensitive reproductive endpoint.	Will use to validate the FWM and assess risk to osprey	Analysis of previously collected osprey eggs.	Osprey egg samples have been collected from the ISA by USGS. Opportunity to obtain and analyze data.
15. Evaluate and/or collect riparian soil and sediment data between the high water mark and the ordinary high water mark.	The bank system has not been characterized as part of the in-water RI/FS. This characterization needs to extend up to the Ordinary High Water Mark. Data are needed to assess risk to species that use the bank area as part of the aquatic system, including sandpiper/killdeer, mink/otter, amphibians, aquatic/emergent plants, invertebrates and fish.	Will use to assess risk to in-water receptors	For aquatic/emergent plants, the LWG should assume that the plants are throughout the ISA, and focus data collection on any habitat areas that could support the plants.	A major gap currently exists in the LWG's efforts between Ordinary High Water Mark and the Low Water Mark.

Table 8
Outstanding Deliverables

Document(s)	**Original Due Date**	**Resolution**
Groundwater Pathway Assessment SAP	10/14/2005	Submit revised SAP that addresses EPA comments by February 1, 2006. TZW Assessment process should be included in Comprehensive ERA TM and HHRA vehicle
Step 2 Natural Attenuation Report	11/3/2005	Submit by February 1, 2006. Use as vehicle for refining data gaps on both site-wide and Area of Potential Concern basis. Address data gaps in Round 3 FSP.
Comprehensive ERA TM	Linked to PRE Approval	Revise per EPA direction on ERA. Resubmit along with ERA FSP by May 1, 2006
Approach to Determining Background for the Portland Harbor Superfund Site TM	11/3/2005	Submit by February 1, 2006. Use to develop background and ambient conditions component of site-wide CSM FSP.
Process for Delineating Extent of Contamination Upstream and Downstream of the ISA	Linked to Round 2 Site Summary Report	Include in Comprehensive Round 2 Site Characterization Summary and Data Gaps Analysis Report.
COPC Selection Interim Deliverable	1/23/2005	Submit according to current schedule. Use as vehicle for refining HHRA data gaps on both site-wide and Area of Potential Concern basis.
Revised Interim Deliverable for HHRA – EPC Calculation Approach and Exposure Factor Summary	Linked to meeting to resolve comments	EPA will provide direction on how to address EPA's previously submitted comments.
Round 2 Benthic Assessment Interpretation Report	11/1/2005	Submit by February 1, 2006. Use as vehicle for identifying additional bioassay sampling locations.
Literature Survey of Treatability Studies	9/9/2005	Submit by February 1, 2006. Use as vehicle for identifying treatability study sampling locations.
Facility Siting Re-Screen Report	TBD	TBD
Revised Food Web Model Report	2/6/2006	Submit by February 6, 2006 (contingent on receipt of EPA comments). Use as vehicle for finalizing food web model data needs.
Round 2 Comprehensive Site Summary Report	5/1/2005	Submit by May 1, 2005. Include Round 3 FSP for completing characterization phase of Portland Harbor RI/FS

Table 9
Summary of Round 3 In-Water Data Gaps

Data Use	Media to be Sampled or Test						
	Surface sediment	**Subsurface sediment**	**Surface Water**	**Transition Zone Water**	**Fish and Shellfish Tissue**	**Invertebrate Tissue**	**Toxicity and/or bioaccumulation**
Upstream	RM 11-14 Upstream of RM 14 Upstream of Willamette Falls	RM 9.2 -11	Transects upstream of River Mile 14 (chemistry)	Not required at this time	RM 11 – 14 Upstream of 14	Not required at this time	Not required at this time
Downstream	RM 0-2 Depositional areas within Multnomah Channel	RM 0 -2	Multnomah Channel	Not required at this time	RM 0 – 2	Not required at this time	Not required at this time
Areas of Potential Concern	To be determined on site specific basis	To be determined on site specific basis	In limited areas (See Table 5)	Based on review of Round 2 TZW sampling	See human health risk assessment and ecological risk assessment data needs below.	See human health risk assessment and ecological risk assessment data needs below.	See human health risk assessment and ecological risk assessment data needs below.
Human Health Risk Assessment	Not required at this time	Not required at this time	SPMDs if necessary to estimate tissue uptake.	Based on review of Round 2 TZW sampling	Small mouth bass to evaluate localized risk. Upstream sampling of relevant fish species.	Additional invertebrate tissue based on review of Round 2 tissue sampling.	Not applicable

Data Use	Media to be Sampled or Test						
	Surface sediment	**Subsurface sediment**	**Surface Water**	**Transition Zone Water**	**Fish and Shellfish Tissue**	**Invertebrate Tissue**	**Toxicity and/or bioaccumulation**
Ecological Risk Assessment	Riparian areas. Co-located samples for BSAF development.	Not required at this time	SPMDs if necessary to estimate tissue uptake.	Based on review of Round 2 TZW sampling	Sculpin in areas of localized sediment contamination. Analysis of stomach contents and fish eggs. Evaluation of skin and liver lesions.	Additional invertebrate tissue based on review of Round 2 tissue sampling.	Institu toxicity and bioaccumulation testing in areas of groundwater discharge
Hydrodynamic Model, Contaminant Fate and Transport Model, and Recontamination Potential	Sedflume and other physical measurements.	Sedflume and other physical measurements.	Measurements of flow and TSS at upstream, Multnomah Channel and at selected locations within study area.	Flux measurements to support loading estimates	Not applicable	Not applicable	Not applicable
Food Web Model	Not required at this time	Not required at this time	Temperature, TSS, and flow estimates from RM 12.8. Chemistry data to support loading estimates.	Flux measurements to support loading estimates	Individual analysis of northern pikeminnow, smallmouth bass, black crappie, largescale sucker. Composites samples for sculpin.	Periphyton Phytoplankton Zooplankton	Not required at this time

Note: This table does not include upland data gaps.

TAB 4

OUTSTANDING PORTLAND HARBOR RI/FS ISSUES
STATUS AS OF 4/15/2009

	Issue	EPA Comment Reference to Issue[2]	Resolution Status	Resolution Process	3/17/09 EPA RESPONSE (Blanks indicate EPA agrees with Resolution Process)	4/15/09 LWG RESPONSE TO EPA
RESOLVED ISSUES						
1	Uses of "Background" Values	March 20, 2008 EPA Comment Letter on R2 Report Section 10: Section 10.2—Background Evaluation, page 13	Resolved	The following are the general uses of "background" in the RI/FS: 1. PRG development 2. Risk characterization 3. Development of Remediation Goals and AOPCs (hill topping replacement values) 4. Criteria for assessing long-term monitoring 5. Evaluation of potential capping material 6. Possibly recontamination evaluation (it was discussed that this may not be properly defined as a background issue). Regarding use of background in risk characterization: On 5/14/08, LWG and EPA confirmed that background risks would be compared to site risks per OSWER Guidance.		
2	Use of Upstream Tissue Data	January 15, 2008 EPA Comments 10 (D), 304	Resolved	Language from 4/30/08 RI/RA Issue Resolution Table: EPA agrees that upstream fish tissue data should not be used in background assessments or risk assessment but could be presented in the RI Report for "informational purposes".		
3	Use of Anthropogenic Background	March 20, 2008 EPA Comment Letter on R2 Report Section 10: Section 10.2—Background Evaluation, page 13	Resolved	The LWG will develop background values for anthropogenic chemicals in addition to naturally-occurring chemicals for use in risk characterization and development of remediation goals.		
4	Transition Zone Water (TZW) ecological risk assessment	January 15, 2008 EPA Comments 324, 332, 382, 422; p. 39 of EPA's 2/15/08 ecological problem formulation	Resolved	The LWG and EPA managers and BERA leads have verbally agreed that the LWG will screen TZW concentrations against ecoSLs, then talk about the pore water ventilation fraction in the uncertainty section.	Issue number 4 - The language presented in the table does not match EPA's understanding. Consistent with the problem formulation, EPA requires evaluation of TZW relative to water TRVs in the BERA. This is more than a screening step as described here. Evaluation of TZW relative to water TRVs is considered a line of evidence for the BERA for which a hazard quotient should be calculated. EPA agrees that the pore water ventilation fraction may be addressed in the uncertainty section.	The LWG will compare shallow TZW concentrations to surface water TRVs and identify exceedances in the BERA. Pore water ventilation fraction will be addressed in the uncertainty section.
5	Presentation of Uncertainty Analyses	January 15, 2008 EPA comments include 3, 287, 288, 289, and 291	Resolved	Language from 4/30/08 RI/RA Issue Resolution Table: Uncertainty and assumptions used will be discussed in a factual manner throughout the BERA and HHRA consistent with EPA RAGS A guidance. The reports will be organized to address uncertainties at the end of a report section rather than in an uncertainty section at the end of the report. For example, the uncertainty in the effects assessment will be presented at the end of effects assessment section. Judgmental and qualifying language will not be used in the uncertainty discussions.		
6	Evaluation of a future erosion scenario in the BERA (benthic risk)	January 15, 2008 EPA Comment 259	Resolved	The LWG and EPA managers and BERA leads verbally agreed that an erosion event scenario will be included in the BERA, looking only at short-term duration exposures, especially direct toxicity risk to benthic invertebrates. The LWG and EPA managers and BERA leads also verbally agreed that PRGs will be compared to concentrations in buried sediments in the FS, as needed to evaluate potential remedies. On April 30, EPA and LWG agreed that if modeled post-erosion surface sediment concentrations are not significantly different from current concentrations then evaluation of the future erosion scenario may not be required for the BERA.		

OUTSTANDING PORTLAND HARBOR RI/FS ISSUES
STATUS AS OF 4/15/2009

	Issue	EPA Comment Reference to Issue[2]	Resolution Status	Resolution Process	3/17/09 EPA RESPONSE (Blanks indicate EPA agrees with Resolution Process)	4/15/09 LWG RESPONSE TO EPA
7	Initial and refined eco risk screening steps	January 15, 2008 EPA Comment 368 and February 15, 2008 BERA Problem Formulation	Resolved*	The LWG and EPA managers and BERA leads verbally agreed that the LWG will implement the initial and refined screening steps with modifications that were documented in a flow diagram provided to EPA's BERA lead on 4/14/08. On 5/14/08, EPA and LWG agreed that EPA would modify the flowchart and provide to LWG. Since the LWG never received the revised flowchart from EPA, the LWG has proceeded with developing the BERA using the changes provided to EPA's BERA lead on 4/14/08.	Issue number 7 - The LWG should confirm that the refined screen for the evaluation of effects on the benthic community will be based on a point by point comparison and not the 95% UCL of the site-wide average. This is consistent with the problem formulation for the ecological risk assessment. Any estimation of exposure point concentrations (EPCs) in the refined screen must match the scale of the receptor.	The LWG is using the maximum detected concentration in the refined screen The refined screening calculation is done only on the maximum detected concentration and not repeated for every data point. This is consistent with the problem formulation and appropriate for COPC identification. The analysis of COPCs is done point-by-point in the benthic BERA.
9	Evaluation of surface water as a drinking water source	January 15, 2008 EPA Comments 247, 248 (D), 249, 251 (D), and 253 (D)	Resolved	Language from 4/30/08 RI/RA Issue Resolution Table: The LWG will perform the work directed by these comments. EPA agrees that the LWG and its members have preserved the right to object to future identification of MCLs as ARARs for Portland Harbor surface water or to remedy decisions based upon surface water drinking water exposures. On 4/30/08, EPA and LWG agreed that only the vertically integrated and transect samples will be included in the dataset for this evaluation. Maximum detected concentrations will be screened against MCLs and Region 6 screening levels. For chemicals that screen in, EPCs will be calculated for individual transects and individual vertically integrated sample locations. Temporal averages will be included in the EPCs. Site-wide EPCs will also be calculated. Total data will be used. XAD column and filter data will be summed. RME and CT EPCs will be calculated using the same approach as biota (e.g., 5 or more samples are needed to calculate a 95% UCL). Note: EPA and LWG HHRA leads agreed to use the EPA Regional Screening Levels, which replaced the Region 6 screening levels.		

OUTSTANDING PORTLAND HARBOR RI/FS ISSUES
STATUS AS OF 4/15/2009

	Issue	EPA Comment Reference to Issue[2]	Resolution Status	Resolution Process	3/17/09 EPA RESPONSE (Blanks indicate EPA agrees with Resolution Process)	4/15/09 LWG RESPONSE TO EPA
10	Evaluation of surface water for potential bioaccumulation	January 15, 2008 EPA Comments 247, 248 (D), 249, 253 (D), 310, 313 (D), and 315	Resolved	Language from 4/30/08 RI/RA Issue Resolution Table: The LWG will screen surface water data against WQC based on an ingestion rate of 17.5 g/day and 175 g/day. Surface water data should be evaluated in conjunction with co-located biota data in the baseline risk assessment. The LWG and EPA will continue to discuss the role of AWQCs in PRG development or as ARARs, and EPA agrees that the LWG and its members retain their ability to object to future use of AWQCs for either of these purposes. LWG recognizes that additional technical resolution is required to fully resolve this issue but has not identified any other elements that warrant dispute. On 4/30/08, EPA and LWG agreed that all surface water will be screened against WQC based on fish ingestion rates of 17.5 g/day and 175 g/day. The maximum detected concentration will be used in the screen. For those chemicals that screen in, the 95% UCL for the site-wide, temporal average also will be calculated. The 95% UCL also will be screened against WQC based on fish ingestion rates of 17.5 g/day and 175 g/day. Chemicals that screen in for either analysis will be compared with the tissue chemicals of concern (COCs) at the end of the HHRA. The tissue COCs will be considered the primary line of evidence (LOE). Chemicals not identified as COCs based on the tissue LOE will be evaluated on a chemical specific basis to determine whether the chemical should be identified as a COC. Co-located surface water and tissue data will be compared in the RI.		
11	Evaluation of TZW as a source to surface water used for drinking water	January 15, 2008 EPA Comments 253 (D) and 32	Resolved	Language from 4/30/08 RI/RA Issue Resolution Table: The LWG will present this comparison in Section 6 as required by EPA. The LWG will also estimate the average surface water concentrations associated with transition zone water discharges through loading calculations. The estimated surface water concentrations will be compared with MCLs and Region 6 Tap Water PRGs. EPA agrees that the LWG and its members have preserved their ability to object to addressing this risk pathway in any manner in the evaluation of remedial alternatives. Note: EPA and LWG HHRA leads agreed to use the EPA Regional Screening Levels, which replaced the Region 6 screening levels.	Issue number 11 - Based on the language presented in the table, it is unclear whether the LWG will be screening TZW against EPA Region 6 tap water PRGs (Regional Screening Levels) and MCLs. The LWG should confirm that TZW should be screened against tap water PRGs and MCLs.	TZW will be screened against the EPA Regional Screening Levels for tap water and MCLs.
12	Evaluation of TZW as a source to biota	January 15, 2008 EPA Comments 253 (D), 321, 322, 323, and 324 (D)	Resolved	Language from 4/30/08 RI/RA Issue Resolution Table: EPA agrees the evaluation of TZW as a source of contaminants in biota is no longer required in the HHRA. The HHRA will rely primarily on clam and crayfish tissue data for the purpose of evaluating this exposure pathway. EPA may in the future require the presentation of TZW data relative to human health fish consumption AWQC for the purpose of evaluating the contribution of contaminated groundwater to biota tissue.	Issue number 12 - The language presented in the table does not match EPA's understanding. EPA did not agree that the evaluation of TZW as a source of contaminants in biota is no longer required. EPA agreed to rely primarily on tissue data for the evaluation of human health risks in the HHRA. However, EPA also requires the evaluation of TZW relative to fish consumption AWQC as a line of evidence in the HHRA and for the purpose of evaluating the contribution of TZW to biota tissue.	An evaluation of co-located TZW, sediment, and shellfish (i.e., clams and crayfish) tissue data relative to fish consumption AWQC will be included in the HHRA.
13	Evaluation of subsurface sediment in HHRA	January 15, 2008 EPA Comment 259	Resolved	On 4/30/08, EPA and LWG agreed that subsurface sediment will not be evaluated in the HHRA due to the short term nature of erosion events.		
14	Nature and Extent Section Detail	January 15, 2008 EPA Comment EPA Cover Letter page 5 and Comment No. 1 (General Comment)	Resolved	EPA and LWG agree in general that the Nature and Extent section of the RI Report should be streamlined and focus on maps, charts, and tables.		

OUTSTANDING PORTLAND HARBOR RI/FS ISSUES
STATUS AS OF 4/15/2009

	Issue	EPA Comment Reference to Issue[8]	Resolution Status	Resolution Process	3/17/09 EPA RESPONSE (Blanks indicate EPA agrees with Resolution Process)	4/15/09 LWG RESPONSE TO EPA
15	SLV or site specific PRG screens for mapped sediment and tissue data presentations for RI Nature and Extent.	January 15, 2008 EPA Comment EPA Cover Letter page 4, Comments 181, 186	Resolved	Issue resolved for Draft RI report. The use of site-specific benchmarks in data presentations may be revisited for the final RI report.		
17	Atmospheric Deposition	January 15, 2008 EPA Comments 47 (D), 102, 241 (D)	Resolved	The LWG will do a literature-based evaluation of the effects of "background" atmospheric deposition on stormwater and upstream inputs, but no new data will be collected. This qualitative evaluation will focus on local data to the extent possible.		
18	Loading assessment for Permitted Discharges	January 15, 2008 EPA Comments 224, 226	Resolved	The LWG will develop permitted discharge loading estimates based on individual NPDES permits and 1500 and 1300 J permits. The LWG also will collect the corresponding permit applications to look for any additional information on chemicals in the discharge.		
19	Anthropogenic Sediment Physical Transport Processes	Issue discussed in meetings but not specifically raised in EPA January 15, 2008 Comment Letter	Resolved	The LWG will include a qualitative/areal discussion in the fate and transport section of maintenance dredging and prop wash potential in known areas of concern for such factors, such as berths and docks. Sediment quality in subsurface horizons will be evaluated in these areas as potential exposed surfaces (analogous to the erosion area analysis to be based on the EFDC model output).		
20	Consideration of background metals in TZW (eco risk characterization)	January 15, 2008 EPA Comments 243, 382 (D), 385 (D)	Resolved	Metals in TZW will not be screened out of the BERA on the basis of background. The LWG will include additional discussion of geochemical controls on metals in pore water in the risk characterization section of the BERA. Relevant literature information on naturally occurring levels of As, Ba, and Mn in low-redox sediment pore water will also be presented. This discussion will acknowledge the limitations of the available pore water and upland groundwater data set and the resulting uncertainties in determining the source of these metals in a manner consistent with other parts of the BERA of comparable importance from an ecological risk perspective.		
21	Use of unfiltered TZW results in risk assessments	January 15, 2008 EPA Comments 265, 319 (D), 325 (D), 354, 382 (D), and 469	Resolved	EPA agreed during the 4/23/08 meeting on BERA Problem Formulation that total metals concentrations will not be screened against dissolved metals criteria.		
22	Study Area Boundary	January 15, 2008 EPA Comments 5, 65, 184, 186, 187, and 189	Resolved	Language from 4/30/08 RI/RA Issue Resolution Table: EPA and the LWG agree to expand the Study Area to River Mile (RM) 11.8 and to consider downstream extension of the Study Area to RM 1 and into Multnomah Channel pending assessment of the R3B sediment data and other appropriate data. On 6/11/08 EPA and LWG agreed that the site-wide risk scenarios would be developed for the Study Area from RM 2 to RM 11.8 and that separate EPCs and baseline risk evaluations would be prepared for the areas between RM1 and RM2, upper Multnomah Channel, and RM 11.8 to RM 12.2.	Issue number 22: The LWG should clarify which data falls into which data set (e.g., site wide vs. RM 1 - 2). A table listing samples to be included in the RM 1 - 2, upper Multnomah Channel and RM 11.8 - 12.2 data sets should be provided.	This table will be provided in the RI.
23	Evaluation of riparian soils – terrestrial receptors	January 15, 2008 EPA Comment 190	Resolved	Language from 4/30/08 RI/RA Issue Resolution Table: EPA confirms that assessing risk to upland terrestrial receptors refers to the DEQ process, not the work of the LWG.		
24	Tap water PRGs as potential ARARs	March 20, 2008 EPA comments on Sec. 10, p. 4, last bullet	Resolved	Language from 4/30/08 RI/RA Issue Resolution Table: PRGs can come from multiple sources, even non promulgated guidance, Region 6 Tap water PRGs are not ARARs. Regional Screening Level values are also not ARARs.		
25	Background Estimation - Statistical Methods	January 15, 2008 EPA Comments 191 (D), 192 (D)	Resolved	On 9/19/08 EPA provided additional comments on the development of background values for bedded sediment. The LWG agrees that it wil**hot** transform non-normal data to normal distributions before performing outlier tests.		

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	Issue	EPA Comment Reference to Issue	Resolution Status	Resolution Process	3/17/09 EPA RESPONSE (Blanks indicate EPA agrees with Resolution Process)	4/15/09 LWG RESPONSE TO EPA
26	Background Data Set	January 15, 2008 EPA Comment 213 (D)	Resolved	On 9/19/08 EPA provided comments on the development of background values for bedded sediment. The LWG will develop background values in accordance with the comments provided by EPA on 9/19/08. The LWG will also develop, and present in the RI Report, a second set of background sediment values developed without excluding certain statistical outliers from the dataset, unless EPA provides credible evidence that the outliers are indeed affected by specific CERCLA-like source(s).	Issue number 26: The LWG state that background concentrations will be estimated as directed by EPA on 9/19/2009. However, the table also states that a second set of background values will be developed without exclusion of statistical outliers unless EPA provides credible evidence that the outliers are affected by specific CERCLA like sources(s). The LWG should clarify how this second set of background values will be presented and what is meant by "EPA provides credible evidence." Please note that EPA and DEQ agreed to investigate potential sources in the vicinity of statistical outlier clusters.,	In the cases of the two chemical groups — total PCB Aroclors and total DDx — for which EPA and LWG reached different conclusions on the disposition of potential outliers in specific locations, the draft RI will present background estimates both with (LWG case) and without (EPA case) these potential outliers retained in the data set. The estimates presented for the two cases will be clearly identified in the RI Report as "EPA Case" and "LWG Case". By "credible evidence," the LWG means simply that if EPA and DEQ's efforts to investigate potential sources yield information indicating the likelihood of CERCLA-like, point sources of total PCBs or DDx in the vicinity of the potential outliers in question, then the LWG would agree that it is appropriate to exclude these data from the background evaluation.
29	Tissue TRV methodology	February 15, 2008 BERA Problem Formulation states that "EPA is in the process of reviewing the TRVs used in the Round 2 Report, and will subsequently provide direction for TRVs to be used in the BERA."	Resolved*	On 8/5/08 EPA provided a revised tissue TRV methodology addressing LWG comments. Although the LWG still has some concerns regarding the methodology, the LWGagreed that EPA should proceed with developing the tissue TRVs and commented on specific TRV as they were developed.	Issue number 29: TRVs are resolved per LWG letter dated March 5, 2009.	
30	Other TRVs	February 15, 2008 BERA Problem Formulation states that "EPA is in the process of reviewing the TRVs used in the Round 2 Report, and will subsequently provide direction for TRVs to be used in the BERA."	Resolved	The LWG provided revised benthic tissue TRV tables for Cd, Cu and DDD to Burt Shephard on 11/26/2008 and a revised Benthic TRV table for PCBs was provided to Burt on 12/1/2008; EPA has not yet responded to these revised tables. Fish tissue-residue TRV reconciliation tables were submitted to EPA on 11/20/2008, EPA responded to the reconciliation tables on 12/22/2008. EPA and LWG disagree on inclusion of certain sac-fry studies where eggs were collected from the Great Lakes in the 1970s and the inclusion of certain behavioral studies that the LWG believes are not appropriately related to survival, growth, or reproduction. LWG and EPA met 1/9/09 to discuss outstanding differences on fish tissue TRVs. As action items from the 1/9/09 meeting the LWG agreed to summarize its reevaluation of behavioral studies and our arguments for excluding the 1970's Great Lakes sac fry studies (Berlin et al. (1981) and Broyles & Noveck (1979)). The results of that work were provided to EPA on 1/14/09, followed by an e-mail communication from J. Toll to B. Shephard on 1/21/09 and a phone call from J.Toll to E. Blischke on 1/22/09. EPA directed the LWG on the resolution of the behavioral endpoint and 1970s Great Lakes sac fry issues on 1/23/09. LWG responded to EPA's directive in a letter dated February 6, 2009.		
31	Use of the FPM to set SQVs	Verbal proposal from Burt Shephard to John Toll on April 30, 2008	Resolved*	LWG agreed to attempt to use DEQ's recently available updated version of the FPM to develop benthic PRGs assuming that the updated model is reliable and functional. EPA's BERA lead has defined FPM SQVs as "sediment concentrations that minimize false positive and false negative error rates" in the FPM. The LWG's BERA lead agrees with this definition, but stresses that best professional judgment (BPJ) is required to determine the "sediment concentrations that minimize false positive and false negative error rates" because the FPM is multivariate. The EPA and LWG BERA leads have agreed to this pending review of the new version of the FPM to understand how it handles the BPJ step.	Issue number 31: Use of FPM to set SQVs: There are number of questions about application of the FPM which are not completely resolved. These include which COIs are to be modeled, acceptability parameters and how best professional judgement will be applied. It may be useful to schedule a check-in on the application of the predictive models to facilitate agency review of the Portland Harbor RI and BRA.	The LWG is eager to share it's work on the FPM, and other aspects of benthic toxicity modeling, with the agency team. We understand the complexity of the benthic modeling issues and the need for dialogue to facilitate adequate and timely EPA technical review. Benthic interpretation discussions between the LWG and EPA went on until late November, 2008. Since that time the LWG has been working diligently to build the models and is working very hard to finish the first internal review draft of the benthic BERA in April. The next opportunity for a check-in will be when the LWG has completed it's review of the benthic BERA. The scheduled completion date for the LWG's review is mid July 2009.

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	Issue	EPA Comment Reference to Issue[8]	Resolution Status	Resolution Process	3/17/09 EPA RESPONSE (Blanks indicate EPA agrees with Resolution Process)	4/15/09 LWG RESPONSE TO EPA
32	Use of negative control comparisons and the biomass endpoint	December 2007 Hyalella growth meeting with agency team and national experts	Resolved	LWG and EPA agree to follow the approaches for a reference envelope and the Hyalella growth endpoint as provided by MacDonald and Landrum in their September 2008 "Evaluation of the Approach for Assessing Risks to the Benthic Invertebrate Community at the Portland Harbor Superfund Site" with some modifications to the reference station selection criteria as documented in the LWG's 11/14/08 Memo on Criteria for Identifying Reference Sediment Samples (see 11/21/08 email approval of the memo by E. Blischke).		
33	Criteria for interpreting bioassay data	February 15, 2008 BERA Problem Formulation proposed 10-20-30% criteria	Resolved	LWG and EPA agree to follow the approach for interpreting bioassay data that is provided by MacDonald and Landrum in their September 2008 "Evaluation of the Approach for Assessing Risks to the Benthic Invertebrate Community at the Portland Harbor Superfund Site" (i.e., interpret each of the four bioassay endpoints separately, use the reference envelope and narrative intent to define high and low level hit thresholds).		
34	Evaluation of Pacific Lamprey at the individual level	2/15/08 EPA Problem Formulation for the BERA page 26 fn. 2	Resolved	Following EPA's 5/19/2008 direction to evaluate Pacific Lamprey at the organism level, the LWG and EPA agreed to evaluate Pacific Lamprey at the organism level following the approach outlined in EPA's 7/1/08 letter and attachment.		

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	Issue	EPA Comment Reference to Issue[2]	Resolution Status	Resolution Process	3/17/09 EPA RESPONSE (Blanks indicate EPA agrees with Resolution Process)	4/15/09 LWG RESPONSE TO EPA
35	BERA revised problem formulation	2/15/08 EPA Problem Formulation for the BERA	Resolved	On 5/14/08, EPA and LWG agreed that the LWG will draft the revised problem formulation (using redline/strikeout tracking). Language from 4/30/08 RI/RA Issue Resolution Table: The LWG will perform the work directed in the revised BERA problem formulation as agreed to by EPA and the LWG (to be prepared in early summer 2008) and will also provide additional analysis and evaluation as appropriate for a baseline risk assessment.		
36	"Forward" (dose) versus "backward" (ATC) exposure calculations	February 15, 2008 Problem Formulation called for the LWG to use ATC for some receptors, forward risk calculations for others.	Resolved	On 5/14/08, EPA and LWG agreed that the LWG will use "backward" exposure calculations for dose-based risk assessment for all wildlife receptors. On 5/21/08 the LWG provided EPA with a written demonstration of how the "backward" ATC approach would be used for receptors with a significant sediment ingestion rate.		
37	Evaluation of biota consumption in the HHRA	January 15, 2008 EPA Comments 247, 248 (D), 249, and 252 (D)	Resolved	On 5/14/08, EPA and LWG agreed that the LWG will calculate bass EPCs using 1-mile segments combining both sides of the river. The location of the bass exposure segments will be determined cooperatively by the LWG and EPA. A discussion of variations in bass tissue concentrations on opposite sides of the river within a given segment will be included in the uncertainty section of the HHRA. In calculating the EPCs, 95 percent upper confidence limits on the mean (95% UCLs) will be calculated for datasets with 5 or more samples using the latest version of Pro UCL. Non-detects (NDs) will be incorporated per the latest Pro UCL guidance (i.e., using the full detection limit with a non-detect flag). The 95% UCL will be used as the RME EPC. EPCs that are calculated using fewer than 10 samples will be identified and discussed in the uncertainty section. Where fewer than 5 samples are available or if Pro UCL is unable to calculate a 95% UCL, the maximum concentration for the dataset will be used as the RME EPC. The arithmetic average, regardless of dataset size, will be used as the CT EPC. Language from 4/30/08 RI/RA Issue Resolution Table: EPA and the LWG agree to include this scenario in the HHRA using 1-mile segments for calculating EPCs pending agreement on details of the assessment. As with other ecological and human health risk scenarios, LWG understands this agreement does not waive our right to dispute how the risk assessment is used to evaluate remedial alternatives.		
38	Diver scenario, breast milk scenario, data use issues, and figures for the HHRA	January 15, 2008 EPA Comments 254 (D), 255, and 363 - 367	Resolved	On 5/15/08, EPA and LWG agreed that the breast milk feeding scenario would not be included in the HHRA at this time. On 9/25/08 the LWG agreed to include the diver scenario as directed by EPA on 9/15/08.	Issue number 38: EPA agreed to not include the breast feeding scenario in the draft HHRA. Pending resolution of this scenario, it will be included in the final HHRA.	Agreed
40	Lines of Evidence (LOE), PRGs, and RGs Progression	March 20, 2008 EPA Comment Letter on R2 Report Section 10: General Comments, page 1, bullets 1-5	Resolved	The LWG submitted draft definitions of these FS terms to EPA on 5/30/08. Based on ongoing discussions in meetings between EPA and LWG, the concept of refining PRGs throughout the FS process and presentation of RG in the FS appears acceptable to both the LWG and EPA.		
45	Development of AOPCs	March 20, 2008 EPA Comment Letter on R2 Report Section 10: Section 10.1.1.2—iAOPCs, pages 6 and 7; and Section 10.4—Summary of Potential Risk Areas, page 14	Resolved*	The LWG will develop a GIS mapping tool for EPA to prepare PRG screening maps separately from the LWG's FS development process. The GIS mapping tool will be demonstrated to EPA in February 2009. The LWG presented an approach for PRG and AOPC development to EPA on 9/8/08, EPA has verbally indicated that the LWG's proposed approach is generally acceptable.	Issue number 45: Development of AOPCs will proceed as planned culminating with AOPC check-in on May 27 and 28.	Agreed
46	Indicator Chemicals to be mapped in the RI Nature and Extent Section	January 15, 2008 EPA Comment 180 (D)	Resolved	LWG and EPA have agreed on the list of indicator chemicals (see 7/21/08 email from E. Blischke to LWG)		

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	Issue	EPA Comment Reference to Issue[8]	Resolution Status	Resolution Process	3/17/09 EPA RESPONSE (Blanks indicate EPA agrees with Resolution Process)	4/15/09 LWG RESPONSE TO EPA
47	Analyte List for Loading, Fate and Transport in the RI	Issue discussed in meetings but not specifically raised in EPA January 15, 2008 Comment Letter	Resolved	LWG and EPA have agreed on the list of indicator chemicals (see 7/21/08 email from E. Blischke to LWG)		
48	Site-Wide CSM Analyte List	Issue discussed in meetings but not specifically raised in EPA January 15, 2008 Comment Letter	Resolved	LWG and EPA have agreed on the list of indicator chemicals (see 7/21/08 email from E. Blischke to LWG)		
49	Subsurface Sediment Contamination – Loading to Surface Sediment	January 15, 2008 EPA Comments 222, 259	Resolved	The LWG submitted a proposed approach for estimating subsurface sediment to surface sediment loading to EPA on 6/21/08. EPA comments on the approach were provided on 8/12/08. An LWG response to EPA's comments was provided on 9/18/08; however this issue is considered resolved.		
50	Contaminant fate and transport - Chemical Degradation Rates	January 15, 2008 EPA Comment 230 (D)	Resolved	The LWG submitted a table of degradation rates to EPA on 7/24/08. EPA comments on the degradation rates were received on 9/23/08. On 9/26/08 EPA and LWG agreed to use a range of rates for PCBs and DDX ranging from nearly infinity to the medium to slow table values provided by LWG.	Issue number 50: The LWG should clarify that after the range is evaluated, the best performing degradation rate will be used.	The best performing degradation rate will be used that is consistent with other calibration parameter values, if other parameters are used.
51	Scale of Discussion/Presentation for RI Report Section 10 (CSM)	Issue discussed in meetings but not specifically raised in EPA January 15, 2008 Comment Letter	Resolved	The LWG has developed a more-detailed plan for presentation of information/observations in this section of the RI. An annotated outline of the CSM section of the RI Report was submitted to EPA for review of 11/21/08. EPA and LWG met on 12/9/2008 and again by phone on 01/20/2009 (E. Blischke and G. Revelas) to discuss EPA comments on the CSM approach and reached general agreement on the presentation format. One issue of particular concern to EPA was the presentation and discussion of upland site source information. It was agreed that a thorough consideration of upland source information presented in Section 4 of the RI (Sources) will be included in, and is key to, the CSM Section, but no attempt will be made to quantitatively rank known or potential sources of COIs.	Issue number 51: There appears to be agreement regarding the need to consider upland sources of contamination in the CSM (connect the dots). During the February 11, 2009 management meeting, it was agreed that a strict screening of upland data will not be performed but that a semi-quantitative evaluation of the magnitude of upland contamination will be presented in the RI and that a quantitative evaluation would be performed in the FS.	The RI will catalogue known or potential upland sources of COIs on a qualitative basis in Section 4 (sources) and then "connect the dots" with the in-water data in Section 10 (CSM). However, this RI evaluation will be a qualitative evaluation of the upland contamination due to the difficulties involved in screening that data or converting it into quantitative or semi-quantitative magnitude estimates. We are not aware of an agreement to conduct a quantitative evaluation in the FS. The same difficulties with doing a quantitative evaluation for the RI also exist for the FS. The LWG agrees to perform a more focused and detailed evaluation of sources on an AOPC-specific basis in the FS.
53	Use of deep TZW results in the RI and BLRA	January 15, 2008 EPA Comments 253 (D), 264, 319 (D), and 382 (D)	Resolved	On 5/14/08, EPA and LWG agreed that LWG would screen deep TZW results in the RI to assess potential TZW loading impacts to surface water and surface sediment but would not include deep TZW results in development of EPCs for the baseline risk assessments.		
54	Application of AWQC to calculated TZW concentrations in areas of the river outside plume discharge areas	Issue raised by EPA at April 16 and 17 meetings.	Resolved	On 5/14/08, EPA and LWG agreed that LWG would not need to estimate TZW concentrations in areas of the river outside plume discharge areas and compare the estimated values to AWQC.		
57	Upstream data set for surface water	Issue raised by EPA at May 1 meeting.	Resolved	At 5/29/08 meeting, the LWG and EPA agreed on the process to estimate background surface water values.	Issue number 57: The language in the table does not provide sufficient detail regarding which samples will be included in the background surface water data set. The LWG should clarify that the agreement was to use data from RM 16 and consider data from RM 11 (not including east side) in the evaluation of upstream surface water concentrations.	The LWG's understanding of the process agreed to on 5/29/08 was to evaluate RM 11 data (including RM 11 east data) in conjunction with RM 16 data on a chemical-by-chemical basis and remove RM 11 data points that are notably higher in concentrations than the other RM 11 or RM 16 values; these elevated values will be excluded from the upstream background data set.
55	Data reduction rules	Issue raised by EPA at May 1 meeting.	Resolved	On 8/12/08 EPA verbally indicated that the LWG should proceed with the RI using the data reduction rules for the RI, background, and risk assessments provided to EPA on 6/5/08.	Issue number 55: The LWG should clarify that use of 1/2 the detection limit to represent non-detect values detected at least once applies on a media specific basis.	In calculating sums for the RAs, half the detection limit will be used to represent non-detect values detected at least once on a media specific basis. In the case of biota for the HHRA, presence/absence is assessed separately for each individual species and tissue type.
56	OC-normalization	Issue raised by EPA at May 1 meeting.	Resolved	On 8/12/08 EPA verbally indicated that the LWG should proceed with the RI using the data reduction rules for the RI, background, and risk assessments provided to EPA on 6/5/08.		

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	Issue	EPA Comment Reference to Issue[8]	Resolution Status	Resolution Process	3/17/09 EPA RESPONSE (Blanks indicate EPA agrees with Resolution Process)	4/15/09 LWG RESPONSE TO EPA
58	Treatment of outliers identified by ProUCL	Issue raised by EPA at May 1 meeting.	Resolved	On 7/24/08 EPA provided comments on the LWG memo summarizing the development of background values for bedded sediment. The LWG will proceed with developing background values in accordance with the memo and EPA's comments.		
A	Inclusion of stormwater piping information in RI Report	Based on EPA clarification of EPA comment No. 106 on the R2 Report	Resolved	C. Stivers preliminary agreement with C. Humphrey to include piping data available from City GIS. City has contacted EPA to clarify that City stormwater piping information is not complete and will be difficult to compile and organize. 1/26/09 email from C. Humphrey to R. Applegate clarified that LWG would "only show current knowledge of stormline piping and sites connected (i.e., outfall drainage basins) for the large shared conveyance systems in the Harbor" and provide a map showing the various types of drainage to the river. The LWG is currently reviewing EPA's clarification request.	Issue letter A: Pipeshed information: EPA understand tha the City of Portland has provided sufficient pipeshed information for this issue to be resolved.	Agreed. This issue is resolved.
B	Stormwater Load Calculation Methods		Resolved	LWG and EPA agree to develop stormwater load estimates in accordance with the LWG's 11/16/08 Portland Harbor RI/FS Stormwater Loading Calculation Methods, and 9/2/08 Proposed Method for Calculating Basin-weighted Statistics for Stormwater Data Technical Memorandum, as modified by EPA's 11/4/08 approval letter and comments, and as clarified in LWG's 11/19/08 letter.		
C	Draft Baseline Human Health Risk Assessment Report Check-Ins	Issue raised by EPA.	Resolved	LWG and EPA agree that LWG will provide tables of exposure point concentrations, toxicity values, and exposure assumptions for informational purposes once the tables have been through LWG internal review and approval.		
D	Draft Baseline Ecological Risk Assessment Report Check-Ins	Issue raised in 12/8/2008 email from E. Blischke	Resolved	The LWG responded to EPA's request on 12/18/2008. At the 1/14/2009 Portland Harbor Managers meeting, EPA and LWG agreed that the LWG's 12/18/2008 responses to Items 4-8 were acceptable but that the LWG would provide tables of EPCs, modeled tissue concentrations, and dietary doses requested in Items 1-3 for informational purposes once the tables have been through LWG internal review and approval.		
E	Presentation of Groundwater Pathway Assessment and TZW Geochemistry Evaluation in the RI Report (Appendix C)	January 15, 2008 EPA Comments 104, 105, 195, and 211 on the R2 Report, and August 22, 2008 EPA clarification letter	Resolved*	Bill Locke and Christine Hawley held a conference call with E. Blischke and R. Fuentes of EPA on Oct. 14, 2008 in which EPA's concerns were clarified and the possibility of a new appendix to the RI report was initially discussed The LWG submitted a draft outline for the appendix to EPA on Dec. 23, 2008. EPA's comments on the outline, dated January 23, 2009, did not raise substantive concerns with the form or content of the outline, but requested that the LWG include recently collected nearshore groundwater data from Time Oil, PEO, and OSM in the analysis, as well as TZW and stratigraphy data collected after R2 at GASCO, Siltronic, and Gunderson. The LWG will comply with these requests. However, the LWG disagrees with EPA's statement in the 1/23/09 comments that the RI must address the question: "Does the presence of contaminants in porewater and/or TZW need to be addressed through source control and in-water cleanup activities"? The LWG believes the RI report is not the appropriate context for identifying upland source control cleanup needs.	Issue letter E: Evaluation of TZW in context of in-water remedy and upland source control measures. Point of compliance issues aside, this is really a question of how the FS will consider the effectiveness of source control.	We request clarification of the response. Per recent RAOs meeting discussions, it is the LWG position that the FS will evaluate the source level that are expected to cause recontamination issues, but cannot evaluate the effectiveness of potential or proposed source controls.

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	Issue	EPA Comment Reference to Issue[2]	Resolution Status	Resolution Process	3/17/09 EPA RESPONSE (Blanks indicate EPA agrees with Resolution Process)	4/15/09 LWG RESPONSE TO EPA
UNRESOLVED ISSUES						
8	Issues with applying the WOE framework (i.e., how to account for differences in relative strength of different LOEs, for example, differences in the quality of TRVs should lead to different weights on the TRV LOE for different COPCs)	February 15, 2008 BERA Problem Formulation proposed WOE framework	Unresolved*	The LWG and EPA managers and BERA leads verbally agreed that the LWG's concerns about application of the WOE framework are generally valid, and agreed to schedule a technical meeting to reach a consensus on this issue. The appropriate timing for that meeting has not yet been resolved. The extended delays in "locking down" BERA issues has put the draft BERA on the critical path for completion of the FS, so it has become essential to schedule and conduct this consensus-building process in a manner that minimizes the potential for further delays.	Issue number 8: Application of WOE: This will need to be addressed through the early RI and BRA review and FS scoping steps.	The LWG understands the need for dialogue on the WOE framework to facilitate adequate and timely EPA technical review and has agreed to a check-in on this topic. This is predominately a benthic interpretation issue. Benthic interpretation discussions between the LWG and EPA went on until late November, 2008. Since that time the LWG has been working very hard to finish the first internal review draft of the BERA in April. The next opportunity for a check-in will be when the LWG has completed its review. The LWG's review is scheduled to be completed in mid July 2009.
16	Upland Site Summary Issues	January 15, 2008 EPA Comments 122 through 175 on Section 5 Table 5.1-2	Unresolved	On 7/25/08 the LWG submitted responses to EPA comments on Table 5.1-2. EPA comments on the table received 11/4/08 requested substantial additional information and analysis be presented in the table. The LWG believes in many cases that the requested information is DEQ's responsibility and that there is not enough time in the RI to complete requested analyses. LWG submitted a response on 12/17/2008 to EPA's general comments received on 11/4/2008 and is currently evaluating EPA's specific comments. EPA provided a response on 1/21/2009 to the LWG's 12/17/2008 responses reiterating the need for the additional analysis of upland facilities.	Issue number 16: Upland Site Summary Issues: This issue is resolved per EPA email dated 3/9/2009	Agreed
27	Hilltopping Replacement Values in AOPC Development	March 20, 2008 EPA Comment Letter on R2 Report Section 10: Section 10.1.1.2.1—Site-wide Scale Method, page 7	Unresolved	LWG and EPA will further discuss specific approaches during the AOPC check-in currently planned for late May 2009.	Issue number 27: Hilltopping Replacement Values: AOPC Check-in. Use of GIS tool will allow a range of values to be considered (e.g., background, baseline, sediment trap results, upper study area bedded sediments, etc.)	Agreed
28	Harbor "Baseline" Values	Issue raised by EPA at 3/12/08 meeting	Unresolved	LWG and EPA will further discuss specific approaches during the the AOPC check-in currently planned for late May 2009.		
39	Schedule and PRGs	Second to last paragraph in March 20, 2008 EPA Comment Letter on R2 Report Section 10	Unresolved*	LWG and EPA have agreed on a list of chemicals and receptors for early PRG development (see 7/24/08 *EPA Confirmation of PRG Agreements in Principle*). The complete PRG/FS schedule is not yet finalized, however "early" PRGs are still anticipated to be submitted to EPA in March 2009.	Issue number 39: Schedule and PRGs: EPA acknowledges that the overall project schedule is still under discussion. However, EPA understands that the schedule presented in the most recent FS Milestone table remains valid.	Agreed
41	Sediment – Benthic Toxicity PRGs	March 20, 2008 EPA Comment Letter on R2 Report Section 10: Section 10.1.1.1—iPRGs, page 3, Benthic Risk bullets; Section 10.1.3.1—Ecological iPRGs, page 11	Unresolved	LWG and EPA will further discuss specific approaches during the AOPC check-in currently planned for late May 2009.	Issue number 41 - Benthic Toxicity PRGs: This will be addressed through the scheduled AOPC Check-in. Feeds into the WOE evaluation.	Agreed
42	Sediment – Fish and Shellfish SWAC Goals and Hill Top Values	March 20, 2008 EPA Comment Letter on R2 Report Section 10: Section 10.1.1.2.1—Site-wide Scale Method, page 7	Unresolved	LWG and EPA will further discuss specific approaches during the AOPC check-in currently planned for late May 2009.	Issue number 42: Fish and Shellfish SWAC goals and hilltop values: This will be addressed through the scheduled AOPC Check in.	Agreed
43	Surface Water PRGs	March 20, 2008 EPA Comment Letter on R2 Report Section 10: Section 10.1.1.1.1—Approach for Surface Water, page 4	Unresolved	No resolution except on human health incidental ingestion and ecological direct toxicity AWQC based PRGs. LWG and EPA will further discuss PRG development issues; meetings are planned for first quarter 2009.	Issue number 43: Surface Water PRGs: This will be addressed through the RAO and ARAR POC discussion.	Agreed
44	Transition Zone Water PRGs	March 20, 2008 EPA Comment Letter on R2 Report Section 10: Section 10.1.1.1.2—Approach for TZW, page 5	Unresolved	LWG and EPA will further discuss PRG development issues; meetings are planned for first quarter 2009.	Issue number 44: TZW PRGs: This will be addressed through the RAO and ARAR POC discussion.	Agreed

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STATUS AS OF 4/15/2009

	Issue	EPA Comment Reference to Issue[a]	Resolution Status	Resolution Process	3/17/09 EPA RESPONSE (Blanks indicate EPA agrees with Resolution Process)	4/15/09 LWG RESPONSE TO EPA
52	Use of AWQC as PRGs and/or ARARs for TZW	March 20, 2008 EPA Comment Letter on R2 Report Section 10: Section 10.1.1.1.2—Approach for TZW, page 5 April 16, 2008 EPA revised PRG framework table	Unresolved	LWG and EPA will further discuss this issue; meetings are planned for first quarter 2009.	Issue number 52: AWQC as PRGs and/or ARARs: This will be addressed through the RAO and ARAR POC discussion.	Agreed
59	Comparison of background distributions to site distributions for PRGs	Issue raised by LWG at May 1 meeting.	Unresolved	LWG and EPA will further discuss specific approaches during the AOPC check-in currently planned for late May 2009.	Issue number 59: Comparison of background distributions: This will be addressed through the scheduled AOPC Check-in.	Agreed

[a] - Comment number followed by (D) indicates that the EPA comment was directive.

* - Issue is resolved at the concept level but details still need to be worked out.

Note that the issue numbering has been retained from the 5/13/2008 version of the table to allow easier comparison to that previous version.

TAB 5

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10
OREGON OPERATIONS OFFICE
805 SW Broadway, Suite 500
Portland, Oregon 97205

December 23, 2009

Mr. Robert Wyatt
Northwest Natural & Chairman, Lower Willamette Group
220 Northwest Second Avenue
Portland, Oregon 97209

Re: Portland Harbor Superfund Site; Administrative Order on Consent for Remedial Investigation and Feasibility Study; Docket No. CERCLA-10-2001-0240 – Preliminary Comments on the Baseline Human Health and Ecological Risk Assessments

Dear Mr. Wyatt:

EPA has completed its initial review of the draft Baseline Ecological Risk and Human Health Risk Assessments. These documents were submitted to EPA by the Lower Willamette Group (LWG) on September 2, 2009 and September 23, 2009 respectively. These comments are targeted on elements of the baseline human health and ecological risk assessments (BHHRA and BERA) considered critical to the identification of chemicals of concern (COCs) and development of preliminary remediation goals (PRGs).

The attached comments include general comments and detailed comments regarding the identification of COCs and development of PRGs. The final section of the comments include a specific set of 10 modifications to the BHHRA and BERA that must be made prior to the development, screening and detailed evaluation of remedial action alternatives in the draft feasibility study for the Portland Harbor site. EPA expects these changes to be incorporated prior to our expected April check-in on the remedial action alternatives development and screening step.

If you have any questions regarding this matter, please contact Chip Humphrey at (503) 326-2678 or Eric Blischke (503) 326-4006. All legal inquiries should be directed to Lori Cora at (206) 553-1115.

Sincerely,

Chip Humphrey
Eric Blischke
Remedial Project Managers

cc: Greg Ulirsch, ATSDR
Rob Neely, NOAA
Ted Buerger, US Fish and Wildlife Service
Preston Sleeger, Department of Interior
Jim Anderson, DEQ
Kurt Burkholder, Oregon DOJ
David Farrer, Oregon Environmental Health Assessment Program
Rick Kepler, Oregon Department of Fish and Wildlife
Michael Karnosh, Confederated Tribes of Grand Ronde
Tom Downey, Confederated Tribes of Siletz
Audie Huber, Confederated Tribes of Umatilla
Brian Cunninghame, Confederated Tribes of Warm Springs
Erin Madden, Nez Perce Tribe
Rose Longoria, Confederated Tribes of Yakama Nation

PRELIMINARY EPA COMMENTS ON THE BASELINE HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENTS.
DECEMBER 23, 2009

EPA has completed its initial review of the draft Baseline Ecological Risk and Human Health Risk Assessments. These documents were submitted to EPA by the Lower Willamette Group (LWG) on September 2, 2009 and September 23, 2009 respectively. EPA is providing these preliminary comments to expedite the development and completion of the Portland Harbor Feasibility Study (FS). These comments are targeted on elements of the baseline human health and ecological risk assessments (BHHRA and BERA) considered critical to the identification of chemicals of concern (COCs) and development of preliminary remediation goals (PRGs). EPA expects to provide a more detailed set of comments on the BHHRA and BERA in early 2010.

Overall, most of the procedures followed in the BHHRA and BERA are consistent with and followed the procedures agreed upon by EPA and the LWG for completing the baseline risk assessments. There are also a number of instances where procedures in the BERA go beyond or are in addition to the procedures agreed upon or directed for use in the BERA. While additional risk assessment procedures and analyses are appropriate, indeed are encouraged, what is inappropriate according to EPA guidance and policy for both BHHRA and BERA is the making of risk management decisions within risk assessments.

The risk assessments tend to minimize the risks to human health and the environment. For human health, the BHHRA improperly overstates the conservative nature of the human health risk assessment, overstates the uncertainties in the HHRA, and pre-maturely identifies "risk drivers" as a subset of the COCs. The BERA eliminates lines of evidence, such as comparison of bulk sediment chemical concentrations to published sediment quality guidelines that were directed by EPA to be used in the BERA. The BERA also prematurely makes risk management decisions by eliminating COCs and lines of evidence (LOEs) in the risk characterization sections of the BERA. The following general comments are intended to provide the LWG an overview of EPA's concerns regarding the BHRRA and BERA:

General Comments:

<u>Inappropriate Risk Management Decisions in the BERA</u>

Numerous instances exist where identified unacceptable risks are dropped out of the BERA prior to completion of the risk characterization sections of the BERA. EPA requires quantification and tabulation of all identified unacceptable risks in the risk characterization sections of the document. This includes unacceptable risks of any magnitude for all chemicals, receptor groups and exposure pathways, including unacceptable risks found only in localized areas of the site. To not carry such risks through the end of the risk characterization provides an incomplete description of unacceptable risks and limits the identification of COCs and the development of PRGs to be carried forward into the draft FS. The decisions to drop certain unacceptable risks from the risk characterization are risk management decisions that are inappropriate to be included in the draft BERA. EPA requires the BERA to identify, quantify and tabulate all

unacceptable risks in the risk characterization conclusions, not just those that the LWG believes are sufficiently reliable to form the basis of site remediation.

The first bullet on page ES-2 is the first of many instances in the draft BERA where inappropriate risk management decisions are described and made in the BERA. The statement that "the majority of COCs identified in the draft BERA were determined to pose no unacceptable risks to ecological populations or communities" is incorrect. As stated above, all identified COCs with a hazard quotient (HQ) $\geq$ 1.0 potentially pose unacceptable risks to ecological receptors. Whether these risks rise to a level requiring remediation is a risk management decision to be made by EPA. The primary goal of the BERA is to describe all unacceptable risks and their associated uncertainties, not to make judgments regarding the acceptability of identified risks.

The 7th bullet on page ES-2 is another example of an inappropriate risk management decision in the BERA. While EPA in this instance agrees with the LWG that mercury contamination is a greater Willamette River issue requiring watershed-scale risk management, this conclusion is a risk management decision, not a risk assessment conclusion, and is inappropriate to discuss in the BERA. The risk assessment conclusions for mercury in the BERA should be limited to the unacceptable risks presented in, for example, Tables 11-1 and 11-2.

All chemicals that exceed unacceptable risk should be carried forward into the draft Feasibility Study (FS). Information regarding the magnitude of the risk, the distribution of the risk and the strength of the measurement endpoint may be incorporated into the draft FS for the purpose of focusing remedial action decisions. However, it is important that the draft FS develop remedial action alternatives that meet the remedial action objectives for all chemicals that present an unacceptable risk to human health or the environment.

Evaluation of Localized Risk in the BERA

The risk characterization and conclusions should not be based on the spatial distribution or frequency of HQ $\geq$ 1.0. The COC list in the BERA is to be based solely on the magnitude of risk. It is entirely appropriate for the BERA to describe the identified ecological risks in terms of the spatial pattern and limitations of identified risks, as well as to describe whether COCs represent site-wide risks to multiple receptors, represent risks to only one receptor or represent risks in a limited area or section of the site, or something in between these extremes. This information may be used by EPA to identify a subset of the entire COC list that will require development of PRGs. However, it is not acceptable for the BERA to eliminate chemicals from the final COC list for the BERA for which the magnitude of risk is small (i.e. a hazard quotient only slightly greater than one), or which pose unacceptable risks in only a limited area of the site.

The difference between identification of unacceptable risks in the BERA, and how those unacceptable risks may be used by EPA risk managers in making response or remedial decisions is given in an EPA Office of Solid Waste and Emergency Response (OSWER) directive. OSWER Directive 9285.7-28 P (Issuance of Final Guidance: Ecological Risk Assessment and Risk Management Principles for Superfund Sites, October 7, 1999) is explicit in its Principle number 4 regarding characterization of site risks, and is repeated here to make clear to LWG

what EPA requires for a risk assessment. "When evaluating ecological risks and the potential for response alternatives to achieve acceptable levels of protection, Superfund risk managers should characterize site risks in terms of: 1) magnitude; i.e., the degree of the observed or predicted responses of receptors to the range of contaminant levels, 2) severity: i.e., how many and to what extent the receptors may be affected, 3) distribution; i.e., areal extent and duration over which the effects may occur, and 4) the potential for recovery of the affected receptors. It is important to recognize, however, that a small area of effect is not necessarily associated with low risk; the ecological function of that area may be more important than its size."

The failure to carry through to the completion of the BERA all chemicals identified as posing unacceptable risks to one or more ecological receptors, all lines of evidence directed to be used in the BERA by EPA and compounded by the subsequent development of PRGs for only a subset of chemicals posing unacceptable ecological risks in a document separate from the BERA, demonstrates the shortcomings of the BERA to provide the information needed by EPA risk managers to make remedial decisions at the Portland Harbor site. EPA should not have to review the details of a BERA with 18 attachments to identify those chemicals identified somewhere in the BERA as posing unacceptable risks. They should all be identified in both the executive summary and conclusion sections of the BERA. The penultimate BERA conclusion that only five chemicals (PCBs, dioxins/furans, mercury, PAHs, DDx compounds) are COCs is not consistent with LWG's own determinations throughout the BERA, and is unacceptable to EPA.

Statements Regarding Population Level Effects

The BERA makes numerous statements regarding the risks associated with population level effects (e.g., page 3 of the executive summary and text boxes on pages 253, 292 and 510 of the main BERA text). EPA acknowledges that remedial action alternatives are generally based on population or community level effects as stated in OSWER Directive 9285.7-28P (Issuance of Final Guidance: Ecological Risk Assessment and Risk Management Principles for Superfund Sites, October 7, 2009): "Superfund remedial actions generally should not be designed to protect organisms on an individual basis (the exception being designated protected status resources, such as listed or candidate threatened and endangered species or treaty-protected species that could be exposed to site releases), but to protect local populations and communities of biota." However, the OSWER Directive goes on to state: "Levels that are expected to protect local populations and communities can be estimated by extrapolating from effects on individuals and groups of individuals using a lines-of evidence approach." EPA believes that the approach used to consider population level effects based on measurement endpoints in the BERA are appropriate and consistent with EPA guidance.

Inappropriate Statements Regarding Fish Ingestion Rates

The BHHRA makes numerous statements throughout the document that question the fish consumption rates used to evaluate the risks to human health. For example, the three main rates are referred to as high (17.5 g/day), higher (73 g/day), and highest (142 g/day). EPA disagrees with this characterization. The EPA rate of 17.5 g/day (two 8-oz meals per month) is based on the 90th percentile of the general population, which includes non-consumers of fish. The 90th

percentile for fish consumers is much higher (200 g/day). EPA uses the 17.5 g/day rate to approximate a fish-consuming population that does not include tribal or subsistence fishers. It is not an unreasonable rate, and should not be referred to as a "high" ingestion rate, but rather as a "low" ingestion rate.

The rate of 142 g/day used as the highest rate for non-tribal fishers in this risk assessment is the 99th percentile for consumers and non-consumers from the same USDA study; the consumption rate for consumers only from this study is 506 g/day. The ingestion rate of 142 g/day was used by EPA in developing its Ambient Water Quality Criteria for consumers who obtain much of their daily protein from fish; therefore, it is appropriate to use this value as a "high" ingestion rate for this risk assessment. It should be kept in mind that the rate of 142 g/day does not truly describe subsistence consumption as a "subsistence" fish consumer would obtain almost all of their protein from fish. The more appropriate rate for subsistence fishers may be closer to the 506 g/day value which is the 99th percentile value for consumers only in the USDA study. This is supported by the fish consumption study of the Suquamish Tribe in Puget Sound whose 90% biota consumption rate is over 500 g/day. The consumption rate of 142 g/person/day was used to represent high frequency non-tribal fishers in this risk assessment. For subsistence fish consumers, who could represent an important population in PH, using 506 g/day as an approximate subsistence value, only about 28% (142 g/day divided by 506 g/day) of total fish consumption would have to come from the LWR in order for a consumption rate of 142 g/person/day and the upper range risks estimated in the HHRA to apply.

For the third non-tribal adult fish consumption rate used in this risk assessment, 73 g/day, data from the Columbia Slough Study was used. The possible uncertainties in this study and in the consumption rates derived from it rate are appropriately discussed in the BHHRA. The BHHRA discussion and the data from the USDA study support use of a fish consumption value of 74 g/day as "medium" consumption rate, not a "higher" consumption rate.

The arguments concerning uncertainties in fish ingestion rates provided in the HHRA are not compelling. Further, EPA believes that the body of information available regarding fish consumption rates both nationally and locally makes it clear that the fish ingestion rates used in the BHHRA appropriately address a range of exposures that might occur for consumers of locally caught fish. Text throughout the document should be revised to indicate the nature of these risk estimates, as indicated above, and appropriate text substituted to acknowledge the need to protect high consuming fish populations and discuss fish ingestion rates in that context.

Shellfish consumption

Although the extent of shellfish consumption in the lower Willamette River is not known, certain information regarding the consumption of shellfish in the lower Willamette River is available. The Oregon Office of Environmental Public Health, Department of Health Services (DHS) had previously received information from ODFW indicating that an average of 4300 lbs of crayfish were commercially harvested from the portion of the Willamette River within Multnomah County each of the 5 years from 1997-2001. Most of this catch was sold to the Pacific Seafood Company of Oregon. DHS also has information from local commercial crayfish harvesters indicating that Europe is a major portion of their market. Furthermore, as part of the McCormick

and Baxter assessment in 1991, Ken Kauffman at DHS talked with the wife of a licensed commercial crayfish harvester who served (at that time) as the secretary-treasurer of the Oregon Crayfish Association. She indicated that the area around McCormick and Baxter was a very productive Cray fishery and that she and her husband had harvested there prior to the advisory on many occasions.

In addition to this historical commercial crayfish harvesting information in the Lower Willamette, DHS also occasionally receives calls from citizens interested in harvesting crayfish from local waters who are interested in fish advisory information. Between 2001 and 2007, DHS fielded 8 calls from citizens who reported catching and eating crayfish from Portland-area waters (only one was specifically from the Study Area). DHS has no way of knowing what percent of individuals who catch and eat crayfish contact their office first to ask for fish advisory information. They estimate, however, that for each person who contacts them regarding the safety of consuming crayfish from the Lower Willamette, there are many more that catch and consume the animals without contacting their office.

Further, the fact that collection of Corbicula is illegal is relevant but not particularly important for the pathway in general. There are indications that Corbicula are being collected and consumed (e.g., from the Linnton Community Center's discussion with transients). It is reasonable to assume that bivalve consumption is a current and potential future exposure pathway and that future biomass would increase. Therefore, the low clam mass (e.g., see page 123 in the BHHRA) that may limit current bivalve consumption does not apply to future exposure.

Risk Characterization for Non-Cancer Effects

In the draft BHHRA, the calculation of a chronic hazard index (HI) for each exposure pathway is not presented in the risk characterization tables (i.e., in the Section 5 tables in the draft HHRA). EPA's Risk Assessment Guidance (Risk Assessment Guidance for Superfund Volume I, Human Health Evaluation Manual (Part A) provides the following guidance on the evaluation of noncarcinogenic effects:

Noncarcinogenic effects, chronic exposures – For each chronic exposure pathway calculate a separate chronic hazard index (HI) from the ratios of the chronic daily intake (CDI) to the chronic reference dose (RfD) (i.e., the HQ) for individual chemicals as described in the box below.

Chronic Hazard Index = CDI_1 /RfD1 + CDI2 /RfD2 + ... + CDIii /RfDii
where:
CDI = chronic daily intake for the ii th toxicant in mg/kg-day, and

RfD = chronic reference dose for the ii th toxicant in mg/kg-day.

If the HI is greater than unity as a consequence of summing several hazard quotients of similar value, it would be appropriate to segregate the compounds by effect and by mechanism of action and to derive separate hazard indices for each group.

Per EPA risk assessment guidance, the chronic HI for each exposure pathway should be added to these Risk Characterization tables in the final HHRA. In addition, only those exposure pathways which have a chronic HI greater than 1 should be included in tables that show the calculation of the End-Point Specific HIs. Unnecessary tables totaling hundreds of pages that are now included in the draft HHRA can and should be eliminated when this is done.

Inappropriate Statements Regarding Compounding Conservatism and the Range of Uncertainties

There are numerous statements in the draft HHRA regarding the compounding of conservative risk assumptions which resulted in the LWG concluding that the final risk characterization results are unreasonable. This issue is also highlighted in the LWGs October 8, 2009 letter. EPA disagrees with this characterization. The approach used in this HHRA follows standard EPA guidance on risk assessments and is similar to risk assessment approaches used on other Superfund sites. Overall, EPA believes the risk assessment for Portland Harbor is consistent with the application of reasonable maximum exposure assumptions and is not overly conservative.

EPA also has concerns with the language and ranges used in discussing uncertainties in the BHHRA. For example, in the presentation of uncertainty, the range of variation in hazard index values is greatly overstated. This is because each toxic endpoint in an exposure scenario is considered independently. Instead, each scenario should be evaluated based on the chemical(s)/endpoint combination resulting in the greatest hazard index. For example, in Table 5-186, the HI range for tribal fisher direct exposure to in-water sediment across all half-mile segments is listed as 0.00000008 to 1. This range is developed using the very lowest chemical/endpoint combination (naphthalene causing whole body effects) to the highest chemical/endpoint combination (arsenic causing skin effects). The lowest HI for a scenario is irrelevant for decision making; decisions are based on the highest calculated HI at each location. The correct range for tribal fisher sediment exposure should be developed using the highest chemical/endpoint combination at each location (Table 5-36). This range is 0.002 (arsenic, skin effects) to 1 (dioxin TEQ, reproductive effects). In this example, the HI range in Table 5-186 is overstated by a factor of 25,000. This overstatement of HI uncertainty is typical of many other scenarios. However, if as described above, end-point specific HIs are calculated according to EPA guidance for only for those exposure pathways with a chronic HI greater than 1, all of the end-point specific HIs presented in Table 5-36 would be deleted from the BHHRA (an elimination of 49 pages for this one receptor/exposure media/exposure route) as none of the exposure pathways have an HI greater than 1. This conclusion can be found on page 78 of the draft BHHRA where it states, *"The tribal fisher scenario for in-water sediment results in no HIs greater than 1."* The correct evaluation will need to be performed before the agencies have an appropriate view of uncertainty associated with non-cancer risks.

One of the major uncertainties that was not discussed in the draft HHRA is that relating to the calculation of end-point specific HIs. In deriving these endpoint specific HIs, only one health endpoint is used for each chemical, even though most chemical have a myriad of health effects as exposures increase. By considering these effects individually, certain noncarcinogenic risks may be under estimated. For example, a majority of the non-cancer impacts from the site for

many biota are from PCBs and total TEQ. The end-point used for deriving the RfD for PCBs is immunotoxicity (based upon immunological effects seen in a monkey study at a dose of 0.005 mg/kg/day and a 300 fold Uncertainty Factor) and the end-point used for deriving the RfD for dioxin/furan TEQ and PCB TEQs is reproduction. However, if the reproductive endpoint for PCBs based upon the LOAEL of 0.02 mg/kg/day is used with the same Uncertainty Factor as the immunological endpoint to derive an RfD for a reproduction end-point for PCBs, the RfD for reproductive effects will be 4 times the RfD for immunological effects. For the chemicals that have the largest non-cancer contribution in the HHRA, the Uncertainty Section should discuss the possibility of under predicting non-cancer health impacts by using only one endpoint per chemical.

Inappropriate Comparison to Regional Risk Levels

There are several inappropriate discussions relating to background and "regional" risk levels, especially for biota. EPA and the LWG agreed that the biota data collected upstream of the Portland Harbor site by the LWG would not be used in the BHHRA. Therefore, there is no background data set for biota for Portland Harbor that can be used and/or evaluated in the BHHRA. Therefore, any reference to "background" in relation to biota in the BHHRA should be deleted. EPA acknowledges our agreement to use upstream tissue data for information purposes in the remedial investigation report.

Comparisons are also made to risks from biota consumption in other "regional" risk studies (e.g., the EPA *Columbia River Basin Fish Contaminant Survey*, and the ODEQ mid-Willamette Basin study). Comparison to these studies, which were initiated because of known or suspected concern with contamination in the particular areas in which they were done, should not be included in the BHHRA. EPA's risk assessment guidance is clear that for a BHHRA, risks from contaminants at the site are to be characterized. Following this risk characterization, comparisons to background risk can be discussed in the risk assessment if such data are available (they are not for Portland Harbor). Comparisons to risks from other contaminant surveys are irrelevant and have no purpose in the BHHRA as they provide no useful information on the Portland Harbor Site risks or background risks.

Inappropriate Evaluations of Surface Water and Transition Zone Water

In EPA's more detailed comments on the BHHRA which will follow in early 2010, comments will be provided on the changes needed on the data selected and methods used to evaluate surface water and groundwater. For example, although EPA agreed that "integrated data" could be used to select COPCs and develop exposure point concentrations for surface water as a drinking water source, it was assumed that surface water data from throughout the Portland Harbor site would be used and that this data would be integrated as appropriate (e.g., near bottom and near surface samples would be combined in an area). Instead only surface water data from the river transects, Willamette Cove, Cathedral Park and the Shipyard were used. However, water could be withdrawn from the river at any point for use as drinking water. Another example is the screening of TZW for the biota consumption exposure pathway. To perform this screening, only shallow TZW data within a 100-foot radius of a shellfish sampling station were used and, within this subset of TZW data, only chemicals in biota that that were above 10^{-6} or an HI of 1 for consumption of shellfish were selected. This results in the screening of an

unacceptably small subset of TZW data and does not allow for an evaluation of TZW contaminants that are of concern for bioaccumulation.

Inappropriate Discussions of "Risk Drivers"

Section 8.2, Risk Drivers, should be deleted from the BHHRA. The role of the BHHRA is to identify Contaminants of Concern (COCs) based upon the risk calculated from the RME. For the Portland Harbor BHRRA, COCs are defined both by:

- EPA's target risk range of 10^{-6} to 10^{-4} and point of departure of 10^{-6} for cancer and a Hazard Index (HI) of 1 for non-cancer effects, and;

- ODEQ's acceptable risk levels of less than or equal to 1 x 10^{-6} for individual carcinogens and less than or equal to 1 X 10^{-5} for cumulative excess cancer risks for multiple carcinogens; and a HI of less than or equal to 1 for non-cancer effects.

It is not the role of the BHHRA to focus on a subset of the COCs based upon the "considerations" listed on pages 142 and 143. These "considerations" include such things as the relative percentage of each chemical's contribution to the total human health risk, uncertainties associated with exposures, frequency of detection (localized and study-area wide), comparisons of Portland Harbor site risk to risks in "regional" studies, and the magnitude of risk exceedance above 10^{-4} to 10^{-6}. These "considerations" are risk management issues and should be dealt with outside of the BHHRA (e.g., in the FS). Therefore, Section 8.2 should be deleted and Section 9, conclusions, should summarize the COCs and exposure scenarios as defined by the two bullets above.

Infant Exposure to Human Milk

EPA and the LWG agreed that the human milk pathway for infants (i.e., previously referred to as "breastfeeding") would not be included in the draft HHRA, but would be included in the final HHRA. EPA has been collaborating with ODEQ, OR DHS, ATSDR, and two university researchers to ensure that the method to be used for the risk characterization for this pathway is appropriate and defensible. This collaboration compared two physiologically-based pharmacokinetic (PBPK) models for infant exposure to human milk (the Haddad model, an 8-compartment physiologically-based pharmacokinetic (PBPK) model that has been validated by comparing estimated milk concentrations against concentrations measured in a Canadian Inuit population, and the Yang model, a 3-compartment PBPK model) to an EPA model which is a single compartment, first-order kinetic model described in EPA's *Human Health Risk Assessment Protocol for Hazard Waste Combustion Facilities*[i] (Combustion Guidance). The result of this comparison has shown that the EPA model is accurate and protective and should be used for the risk characterization for infant exposure to human milk in the Portland Harbor BHHRA as well as in other risk assessments done in Region 10. EPA will be providing this methodology, including the appropriate parameters to be used, to the LWG by the end of February. The risk characterization results from this pathway will impact the non-cancer evaluations primarily for PCBs for both biota consumption and other pathways. This should also

be reflected in the CSM for the site such that in Figure 3.1 all of the receptors should be shown as potentially complete for infant exposure to human milk)

PRG and COC specific Comments:

BERA Comments

Elimination of the Logistic Regression Model as a Line of Evidence

EPA does not agree with the elimination of the Logistic Regression Model as a line of evidence for evaluating benthic risk. However, EPA is still in the process of reviewing the benthic risk evaluation received on November 13, 2009.

Elimination of transition zone water as a Line of Evidence

The draft BERA states that "TZW was evaluated but was not used to identify COCs and is therefore not discussed further in the conclusions." This is an inappropriate elimination of a valuable line of evidence (LOE) deviates from the procedures outlined in the February 15, 2008 BERA problem formulation. Table 6-28 identifies 63 chemicals (15 metals, 16 PAHs, 3 SVOCs, 6 insecticides, 16 VOCs, 5 petroleum fractions, cyanide and perchlorate) that exceed TZW TRVs in one or more samples at one or more of the 10 facilities where TZW samples are available. All 63 of these chemicals must be identified as posing unacceptable ecological risks in the risk characterization for TZW. They form a possible basis for making remedial decisions both in the in-water and upland (source control) portions of the Portland Harbor site.

Elimination of generic SQGs as a line of evidence for evaluating benthic risk from the BERA

The draft BERA states that "None of the generic SQGs could reliably predict toxicity in Portland Harbor sediments (Attachment 7); therefore, the generic SQGs were not used in risk characterization for the BERA." There is not basis in the February 15, 2008 BERA problem formulation for the elimination any TRVs in any line of evidence based on an assessment of TRV reliability. Further, published reliability criteria for generic SQGs such as probable effect concentrations (PECs, MacDonald et al. 2000) largely meet LWG's proposed reliability criteria, meaning the PECs, at least, should have been used in risk characterization of bulk sediment chemistry given LWG's own reliability criteria.

Level 2 Risks to the Benthic Community

The BERA determined that only Level 3 effects (empirical toxicity tests and site specific sediment quality guidelines developed through benthic toxicity predictive models) represent a risk to the benthic community. EPA believes that Level 2 effects (empirical or predicted) represent a risk to the benthic community and should be used for PRG development.

Elimination of certain chemicals as COCs

Table 11-2 of the BERA identified a number of chemicals as not posing unacceptable risk. In particular, certain measurement endpoints have been inappropriately identified as not presenting unacceptable risk. These include the assessment of surface water exposures, the assessment of localized risks to sandpiper based on a comparison to dietary TRVs, the assessment of risks to bald eagle based on comparison to estimated bird egg TRVs, the assessment of risk to the benthic community through a comparison to sediment quality guidelines, the assessment of dietary exposures to fish and wildlife through a comparison to dietary dose TRVs, the assessment of risk to fish and invertebrates based on a comparison to tissue residue TRVs, and the assessment of benthic risk through consideration of both level 2 and level 3 effects.

In some cases, the omissions eliminate some key COC-Receptor Group pairs such as the potential risks to osprey and eagles from 4,4'-DDE based on modeled egg tissue concentrations and the failure to consider localized risks associated with specific sources (e.g., potential risks to the benthic community from tributyl tin based on predicted tissue concentrations in Swan Island Lagoon, potential risks to fish from PAHs based on surface water exceedances in the vicinity of RM 6 and potential risks to shorebirds from pesticides at beaches B-16 and B-22).

As stated in the general comments above, determination that certain chemicals did not pose an unacceptable risk to ecological receptors based on factors such low hazard quotients, the distribution of hazard quotient exceedance and the perceived strength of the measurement endpoint is inappropriate in the risk characterization portion of the BERA. As a result, all chemicals identified in Table 11-2 should be carried forward into the draft FS as COCs. Information regarding the magnitude of the risk, the distribution of the risk and the strength of the measurement endpoint may be incorporated into the draft FS for the purpose of focusing remedial action decisions. However, it is important that the draft FS develop remedial action alternatives that meet the remedial action objectives for all chemicals that present an unacceptable risk to human health or the environment.

<u>Technical errors in the calculation of risk to fish and wildlife from the ingestion of contaminated diets</u>:

There appear to be two technical errors in the calculation of risks to fish and wildlife from ingestion of contaminated diets:

1. Calculating dietary risks by adding together the two hazard quotients for risks from ingestion of contaminated prey and risks from ingestion of contaminated sediment. Total risks from all components of the diet should be calculated by summing the ingested doses from sediment and contaminated prey ingestion, then calculating a single hazard quotient combining risks from the two dietary fractions. The equation for this was given as Equation 1 on page 40 of the February 15, 2008 BERA problem formulation. It appears that the hazard quotients from the two dietary fractions were summed to obtain total risk, rather than the correct approach of summing the two ingested dose estimates, then calculating a single hazard quotient. EPA does not object to quantifying risks separately from sediment ingestion and contaminated prey ingestion, as this provides useful information. However, the total dietary risk calculations should be corrected as described earlier in this comment.

2. In the situation where only one of the two dietary fractions (either sediment or prey) has a hazard quotient > 1, the BERA shows the final HQ as only the HQ from the pathway with HQ > 1, not the sum of both HQs. This is not correct, total risk is that from the sum of ingested doses from sediment and prey. The LWG approach underestimates total dietary risks. Another problem with the BERA approach is the situation where both sediment and prey ingestion HQs are between 0.5 and 1.0, in which case the BERA drops both dietary fractions and concludes that chemical does not pose a risk. Could have a situation where prey HQ = 0.7 and sediment HQ = 0.7, for example, yielding a total HQ of 1.4 and a chemical of concern. The BERA approach would not identify such a chemical as a COC at all. Dietary ingested doses must be summed before calculating the total dietary HQ, even when both individual components of the diet (i.e. sediment and prey) have individual HQs < 1.

The water TRV for dioxin continues to be mistakenly listed as 0.0001 ug/l. The correct water TRV for dioxin is number is 0.00001 µg/l. The correct value can be found on page B-10 of the EPA water quality criterion document for dioxin which can be found at the following website:

http://www.epa.gov/waterscience/criteria/library/dioxincriteria.pdf

The same value is also provided in the summary table of all aquatic life table of the 1986 Gold Book (Quality Criteria for Water 1986).

BHHRA Comments

As discussed above, all of the COCs selected for human health, based upon both EPA and ODEQ acceptable cancer and non-cancer risk levels, should be carried through into the FS and PRGs should be developed for these COCs if possible. Before submittal of EPA's final comments on the BHHRA, EPA will fully review the COCs selected by the BHHRA (listed in Table 8-1) to ensure that we are in agreement with this list and will review the latest list of PRGs sent to EPA by the LWG on December 10, 2009.

Given that there is risk to human health from exposure to water (surface and ground) and sediment, response action is warranted at the Portland Harbor Superfund Site. Given that response action is warranted, and to the extent that "any hazardous substance, pollutant or contaminant will remain onsite" then any applicable or relevant and appropriate requirements under the circumstances of the release or threatened release of hazardous substances under federal or state law must be achieved at the completion of the remedial action. As a result, surface water and transition zone water should be evaluated against relevant human health water quality criteria (i.e., SDWA MCLs and CWA AWQCs). These chemicals should be carried forward into the Portland Harbor FS and used for the development of PRGs.

Risk Assessment Modifications to be Incorporated into the Draft Feasibility Study:

Although EPA is still in the process of reviewing the draft BHHRA and BERA for the Portland Harbor site, EPA has developed the following modifications to the risk assessment process for

the identification of COCs and development of PRGs to bee used in the draft FS for the Portland Harbor site:

1. Use the Logistic Regression Model for the development of site specific SQGs. These SQGs should be used in conjunction with generic SQGs and SQGs generated based on the logistic regression model to identify areas of sediment contamination for evaluation in the draft FS.
2. Retain the Transition Zone Water LOE as a measure of benthic risk. This information may be used in the assessment of groundwater upwelling and the evaluation of CDFs, CADs and sediment caps in the draft FS.
3. Benthic risks should be determined based on both level 2 and level 3 effects identified from the sediment toxicity tests performed at the site. This information should be used to identify areas of sediment contamination for evaluation in the draft FS.
4. All COCs with hazard quotients greater than or equal to 1 must be identified as potentially posing unacceptable risk. This information will be used to identify areas of sediment contamination for evaluation in the draft FS.
5. Generic SQGs that meet the reliability analysis requirements must be included in the assessment of benthic risk. This information will be used to identify areas of sediment contamination for evaluation in the draft FS.
6. All chemicals presented in Table 11-2 should be included as COCs. PRGs should be developed for these chemicals unless it is not possible to relate the measurement endpoint to a sediment concentration.
7. All chemicals identified as posing unacceptable risks from lines of evidence EPA directed LWG to use, but which were eliminated by inappropriate LWG risk management decisions prior to the completion of risk characterization, must also be incorporated in Table 11-2 of the BERA.
8. Table 11-2 must either amended, or split into multiple tables, so that it provides information on both which lines of evidence any given chemical poses unacceptable risks, and the magnitude of the identified risks. As currently structured, Table 11-2 provides little more than an incomplete list of chemicals identified as posing unacceptable risks to one or more receptors, and provides no information on the magnitude of risks.
9. The dietary risk evaluation must be recalculated and the COCs and PRGs adjusted accordingly for use in the draft FS.
10. Chemicals present in surface water and transition zone water evaluated above the relevant a human health water quality criteria (i.e., SDWA MCLs and CWA AWQCs) should be carried forward into the Portland Harbor FS and used for the development of PRGs.

[i] U. S. EPA. *Human Health Risk Assessment Protocol for Hazard Waste Combustion Facilities.* (EPA 530-R-05-006, September 2005.

TAB 6

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10
OREGON OPERATIONS OFFICE
805 SW Broadway, Suite 500
Portland, Oregon 97205

February 9, 2010

Mr. Robert Wyatt
Northwest Natural & Chairman, Lower Willamette Group
220 Northwest Second Avenue
Portland, Oregon 97209

Re: Portland Harbor Superfund Site; Administrative Order on Consent for Remedial Investigation and Feasibility Study; Docket No. CERCLA-10-2001-0240 – LWG Response to EPA Preliminary Comments on Baseline Human Health and Ecological Risk Assessments

Dear Mr. Wyatt:

This letter is in response to the Lower Willamette Group's (LWG) February 5, 2010 letter regarding EPA's preliminary comments on the Baseline Human Health and Ecological Risk Assessments. EPA provided these 10 directed comments on December 23, 2009 to be incorporated into the draft risk assessments for the purpose of preparing a draft Feasibility Study (FS) for the Portland Harbor Superfund site. On January 6, 2010 and again on January 20, 2010, EPA granted extensions to the original 14 day deadline for initiating dispute resolution under the terms of the Administrative Order on Consent between EPA and the LWG for performing a remedial investigation and feasibility study (RI/FS) at the Portland Harbor Site.

In the LWG's January 20, 2010 letter, the LWG objected to 8 of EPA's 10 directed comments. EPA agreed to an extension of the dispute deadline to allow time for further discussion of our differences. On February 2, 2010 and again on February 4, 2010, EPA and the LWG engaged in further discussion of the EPA directed comments. The attached table summarizes EPA's response to the LWG's understanding of the resolution of the directed comments as described in your February 5, 2010 letter.

In general, EPA agrees with the LWG's understanding of how the directed comments have been resolved with the following clarifications:

1) All chemicals with a hazard quotient greater than or equal to 1.0 based on the lines of evidence presented in the problem formulation must be identified as COCs on a site-wide and AOPC basis and carried into the FS.

2) The AOPCs as depicted in EPA's June 23, 2009 letter are approximate and may be refined based on the draft FS.

3) The draft FS must include the chemicals present in near bottom surface water samples above Region 6 tap water PRGs and/or SDWA MCLs when assessing contaminant mobility during the evaluation of remedial action alternatives in the draft FS for the Portland Harbor site, and must demonstrate that depth integrated samples in areas where near bottom samples exceed Region 6 tap water PRGs and/or SDWA MCLs will meet the threshold criteria of protectiveness and compliance with ARARs.

Please acknowledge your acceptance of the comment clarifications presented in the attached Table 1 within 10 days following receipt of this letter. If you have any questions regarding this matter, please contact Chip Humphrey at (503) 326-2678 or Eric Blischke (503) 326-4006. All legal inquiries should be directed to Lori Cora at (206) 553-1115.

Sincerely,

Chip Humphrey
Eric Blischke
Remedial Project Managers

cc: Greg Ulirsch, ATSDR
Rob Neely, NOAA
Ted Buerger, US Fish and Wildlife Service
Preston Sleeger, Department of Interior
Jim Anderson, DEQ
Kurt Burkholder, Oregon DOJ
David Farrer, Oregon Environmental Health Assessment Program
Rick Keppler, Oregon Department of Fish and Wildlife
Michael Karnosh, Confederated Tribes of Grand Ronde
Tom Downey, Confederated Tribes of Siletz
Audie Huber, Confederated Tribes of Umatilla
Brian Cunninghame, Confederated Tribes of Warm Springs
Erin Madden, Nez Perce Tribe
Rose Longoria, Confederated Tribes of Yakama Nation.

TABLE 1
Comment and Resolution Summary
EPA Preliminary Comments on the Baseline Human Health and Ecological Risk Assessments

December 23, 2009 EPA Comment	February 5, 2010 LWG Response	EPA Resolution
1. Use the Logistic Regression Model for the development of site specific SQGs. These SQGs should be used in conjunction with generic SQGs and SQGs generated based on the logistic regression model to identify areas of sediment contamination for evaluation in the draft FS.	We understand that EPA is withdrawing the comment. The LWG understands that NOAA may continue work on development of the LRM model. The scope of NOAA work currently funded by the LWG will not be modified because of this continuing work.	EPA agrees to withdraw this comment. EPA, in conjunction with NOAA, will continue to work on development of the logistic regression model (LRM) under the current funding arrangement.
2. Retain the Transition Zone Water LOE as a measure of benthic risk. This information may be used in the assessment of groundwater upwelling and the evaluation of CDFs, CADs and sediment caps in the draft FS.	We understand that Comment #2 will result only in the modification of the area designated "AOPC 8" for evaluation in the feasibility study as generally depicted on the attached Figure 1. On this basis, the LWG will not dispute the comment.	Based on information reviewed to date, only the spatial depiction of AOPC 8 will require adjustment based on this comment for evaluation in the draft FS based on the TZW LOE. However, all TZW COPCs with a hazard quotient greater than or equal to 1.0 as identified in Table 6-28 of the draft ecological risk assessment must be identified as COCs on a site-wide and AOPC basis and carried into the FS. As further analysis of the data and other information is incorporated into the FS, the AOPCs as depicted in EPA's June 23, 2009 letter may be refined based on the draft FS.

December 23, 2009 EPA Comment	February 5, 2010 LWG Response	EPA Resolution
3. Benthic risks should be determined based on both level 2 and level 3 effects identified from the sediment toxicity tests performed at the site. This information should be used to identify areas of sediment contamination for evaluation in the draft FS.	We understand that Comment #3 will result only in the modification of the area designated "AOPC 19" for evaluation in the feasibility study as generally depicted on Figure 1. On this basis, the LWG will not dispute the comment.	Based on information reviewed to date, only the spatial depiction of AOPC 19 will require adjustment based on this comment for evaluation in the draft FS based on the evaluation of empirical toxicity results. Specifically in this instance, the Hyalella biomass endpoint based on the EPA 2009 reference envelope. EPA notes that the AOPCs as depicted in EPA's June 23, 2009 letter are approximate and may be refined based on the draft FS.
4. All COCs with hazard quotients greater than or equal to 1 must be identified as potentially posing unacceptable risk. This information will be used to identify areas of sediment contamination for evaluation in the draft FS.	We understand that Comment #4 will result only in the modification of the area designated "AOPC 4" for evaluation in the feasibility study as generally depicted on Figure 1. On this basis, the LWG will not dispute the comment.	Based on information reviewed to date, only the spatial depiction of AOPCs 4 will require adjustment based on this comment for evaluation in the draft FS based on the results of the baseline ecological risk assessment. However, chemicals with a hazard quotient greater than or equal to 1.0 based on the lines of evidence presented in the problem formulation must be identified as COCs on a site-wide and AOPC basis and carried into the FS. EPA notes that the AOPCs as depicted in EPA's June 23, 2009 letter are approximate and may be refined based on the draft FS.

December 23, 2009 EPA Comment	February 5, 2010 LWG Response	EPA Resolution
5. Generic SQGs that meet the reliability analysis requirements must be included in the assessment of benthic risk. This information will be used to identify areas of sediment contamination for evaluation in the draft FS.	We understand that Comment #5 will result in no changes to the designated AOPCs for evaluation in the Feasibility Study.	Based on information reviewed to date, only the spatial depiction of AOPCs 4, 8 and 19 will require adjustment for evaluation in the draft FS based on the results of the baseline ecological risk assessment. However, chemicals with a hazard quotient greater than or equal to 1.0 based on the lines of evidence presented in the problem formulation must be identified as COCs on a site-wide and AOPC basis and carried into the FS. EPA notes that the AOPCs as depicted in EPA's June 23, 2009 letter are approximate and may be refined based on the draft FS.
6. All chemicals presented in Table 11-2 should be included as COCs. PRGs should be developed for these chemicals unless it is not possible to relate the measurement endpoint to a sediment concentration.	The LWG did not object to this comment is its January 20, 2010 letter.	No EPA response required.

December 23, 2009 EPA Comment	February 5, 2010 LWG Response	EPA Resolution
7. All chemicals identified as posing unacceptable risks from lines of evidence EPA directed LWG to use, but which were eliminated by inappropriate LWG risk management decisions prior to the completion of risk characterization, must also be incorporated in Table 11-2 of the BERA	Given that the comment addresses the contents of BERA Table 11-2, the LWG understands that EPA agrees that Comment #7 does not pertain to the FS. The LWG understands that if an HQ>1 is identified, then that chemical will be evaluated in the FS.	EPA agrees revision of Table 11-2 only pertains to revision of the draft baseline ecological risk assessment as long as all chemicals with a hazard quotient greater than or equal to 1.0 based on the lines of evidence presented in the problem formulation are identified as COCs on a site-wide and AOPC basis and carried into the FS. EPA notes that the AOPCs as depicted in EPA's June 23, 2009 letter are approximate and may be refined based on the draft FS.
8. Table 11-2 must either amended, or split into multiple tables, so that it provides information on both which lines of evidence any given chemical poses unacceptable risks, and the magnitude of the identified risks. As currently structured, Table 11-2 provides little more than an incomplete list of chemicals identified as posing unacceptable risks to one or more receptors, and provides no information on the magnitude of risks.	Given that the comment addresses the contents of BERA Table 11-2, the LWG understands that EPA agrees that Comment #8 does not pertain to the FS. The LWG understands that if an HQ>1 is identified, then that chemical will be evaluated in the FS.	EPA agrees revision of Table 11-2 only pertains to revision of the draft baseline ecological risk assessment as long as all chemicals with a hazard quotient greater than or equal to 1.0 based on the lines of evidence presented in the problem formulation are identified as COCs on a site-wide and AOPC basis and carried into the FS. EPA notes that the AOPCs as depicted in EPA's June 23, 2009 letter are approximate and may be refined based on the draft FS.
9. The dietary risk evaluation must be recalculated and the COCs and PRGs adjusted accordingly for use in the draft FS.	The LWG did not object to this comment is its January 20, 2010 letter.	No EPA response required.
10. Chemicals present in surface water and transition zone water evaluated above the relevant a human health water quality criteria (i.e., SDWA MCLs and CWA	The LWG understands that EPA will allow using these criteria in the FS in other evaluations in addition to those specifically mentioned in EPA's December 18, 2009	EPA acknowledges EPA Comments 251 and 253 on the Comprehensive Round 2 Site Characterization and Data Gaps Report.[i]

December 23, 2009 EPA Comment	February 5, 2010 LWG Response	EPA Resolution
AWQCs) should be carried forward into the Portland Harbor FS and used for the development of PRGs.	comments on the FS process. On this basis, the LWG will carry these criteria forward into the FS. The comment, which is presented as a comment on the BHHRA, directs the LWG to perform the evaluation for chemicals "evaluated above the relevant human health water quality criteria." Neither the comment nor any of the detailed text supporting the comment requires the comparison of data to ARARs on a point-by-point basis as proposed by some participants in the February 2 meeting. In fact, the comment is consistent with the LWG's understanding that ARARs are to be evaluated in the FS consistent with their evaluation in the BHRRA, as stated in our October 7, 2009 letter to EPA accepting EPA's August 7, 2009 RAO directive. For example, our letter notes that "in our recent discussions, EPA affirmed that the evaluation in the FS should use the methodologies in the risk assessment (again assuming no treatment, but where vertically integrated samples were evaluated against MCLs) as a guide to the evaluation against MCLs in the FS. Other comparative methodologies could be discussed in the evaluation of uncertainty." EPA has not responded to our October 7, 2009 letter, and, prior to the comments made at the February 2 meeting, the LWG	As a result, EPA agrees that the ARARs evaluation of surface water and the drinking water pathway should be performed consistent with EPA comments 251 and 253. However, EPA notes that near bottom surface water samples collected at the Portland Harbor site contain chemicals exceeding Region 6 tap water PRGs and/or SDWA MCLs but are not present above these thresholds in depth integrated samples. These chemicals include dioxin, certain carcinogenic PAHs, certain volatile organic compounds and perchlorate. Because depth integrated samples were not collected at these locations, the risk assessment must discuss the uncertainty associated with the exclusion of this data in the baseline human health risk assessment. In addition, the draft FS must include an assessment of the chemicals present in near bottom surface water samples above Region 6 tap water PRGs and/or SDWA MCLs when assessing contaminant mobility during the evaluation of remedial action alternatives in the draft FS for the Portland Harbor site. The FS must demonstrate that depth integrated samples in areas where near bottom samples exceed Region 6 tap water PRGs and/or SDWA MCLs will

December 23, 2009 EPA Comment	February 5, 2010 LWG Response	EPA Resolution
	had no reason to believe that EPA had a different view.	meet the threshold criteria of protectiveness and compliance with ARARs consistent with the risk assessment exposure assumptions. Near bottom surface water samples should be screened against SDWA MCLs and Region 6 tap water PRGs in the risk assessment to support these evaluations. For the evaluation of groundwater at the site, EPA requires the evaluation of groundwater data (including the transition zone) against fish consumption AWQCs (17.5 g/day) and SDWA MCLs.

[i] EPA Comments 251 and 253 state in part:

Comment 251: Willamette River surface water should be considered a potential future drinking water source. For assessing surface water (SW) as a drinking water source, surface water should be screened against MCLs and EPA Region 6 tapwater PRGs using max values from each sampling site using only integrated water data. The COPCs selected should be evaluated for a drinking water scenario for trespassers, workers, and residents, and for inadvertent ingestion from swimming for recreational users. Vertically integrated and transect surface water data should be used; near bottom samples should not be included. A site-wide average concentration should be generated.

Comment 253: SW as a Drinking Water Source – Scenarios that evaluate the risk from drinking surface water for workers and residents should be added to the CSM and to the RI baseline HHRA. These evaluations can be done using integrated SW samples to identify COPCs. Region 6 screening levels should be used in place of the tap water PRGs from Region 9 (for non-cancer screening levels assume an HI= 0.1).

TAB 7

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10
OREGON OPERATIONS OFFICE
805 SW Broadway, Suite 500
Portland, Oregon 97205

July 16, 2010

Mr. Jim McKenna
Co-Chairman, Lower Willamette Group
1519 SW Columbia, Suite A
Portland, Oregon 97201

Mr. Bob Wyatt
Northwest Natural & Co-Chairman, Lower Willamette Group
220 Northwest Second Avenue
Portland, OR 97209

Re: Portland Harbor Superfund Site; Administrative Order on Consent for Remedial Investigation and Feasibility Study; Docket No. CERCLA-10-2001-0240
EPA Comments on Portland Harbor draft Remedial Investigation Report

Dear Mrs. McKenna and Wyatt:

EPA has completed its review of the draft Remedial Investigation (RI) Report, dated October 27, 2009. EPA believes that this report represents a significant milestone for the Portland Harbor RI/FS, and appreciates the Lower Willamette Group's (LWG) significant efforts to develop this comprehensive report.

As you are aware, EPA provided initial comments on the draft Baseline Human Health and Ecological Risk Assessments, which drafts were subsequently included as Section 8 and 9 and Appendix F and G of the draft RI Report, in December 2009. We are providing our complete set of comments now, because EPA's earlier comments were focused on elements of the baseline human health and ecological risk assessments (BHHRA and BERA) considered critical to the identification of chemicals posing potentially unacceptable risk and development of preliminary remediation goals (PRGs). EPA appreciates that the LWG has been willing to move forward with scoping and development of the FS alternatives based on EPA's preliminary comments and corresponding revisions to the PRGs.

The purpose of this letter is to 1) provide EPA's comments on the draft RI and Baseline Risk Assessment Reports and the schedule for preparation of the revised draft reports, and 2) establish the deadline for LWG submittal of the draft Feasibility Study Report.

EPA Comments on Draft RI and Baseline Risk Assessment Reports

The attached comments include general comments and specific comments on the RI report and general and specific comments on the Baseline Risk Assessment sections of the Report. EPA's comments on the Baseline Risk Assessment Report supplement the initial comments provided in December 2009. EPA's attached comments have been catergorized as 1) directed changes, 2) clarifications, 3) issues, and 4) editorial for informational purposes. EPA expects the LWG to address all of the comments. EPA has attempted to provide clear direction on the specific revisions that are needed to resolve the comments. The directed changes include specific comments on the risk assessments where EPA has previously provided comments and direction to the LWG and those comments have not been adequately addressed. Because of the extensive nature of our comments and needed changes to the Report, EPA is requiring that revised draft RI and Baseline Risk Assessment Reports be prepared and submitted. The revised RI Report and Baseline Risk Assessment Reports are due to EPA 90 days from receipt of this letter.

Please be advised that, as stated in our April 21, 2010 letter to the LWG that provided direction on PRGs for use in the Portland Harbor FS, EPA is developing a benthic approach based on our review of the draft Baseline Risk Assessment and the Benthic Reanalysis Technical Memorandum dated November 13, 2009 and the Site-Specific SQGs based on Individual Bioassay Endpoints dated April 2, 2010. EPA is proceeding to develop the benthic approach as generally described our April 21, 2010 letter. EPA is not providing comments on the benthic approach presented in the Section 9 and Appendix G of the Baseline Ecological Risk Assessment, but intends to provide such comments with overall comments on the benthic approach. EPA's direction and schedule for incorporating revisions to the benthic approach will be provided when EPA transmits our comments on the benthic approach.

Deadline for submission of Draft Feasibility Study Report

EPA is also establishing the deadline for LWG submittal of the Draft FS Report. According to the Programmatic Work Plan for the Portland Harbor RI/FS, the Draft FS Report is due 150 days from receipt of this letter transmitting EPA's comments on the draft RI and Baseline Risk Assessment Reports. However, EPA acknowledges, based on our understanding of the current working schedule and ongoing discussions on a number of complex technical issues that are critical to the evaluation of cleanup options, including chemical fate and transport modeling and the benthic toxicity evaluation approach, that 150 days roughly corresponds to the expected timeframe for the Alternatives Screening Evaluation Check-in. The current projected working schedule shows that after Alternatives Screening Evaluation Check-In, the LWG would complete the evaluation of cleanup alternatives and submit the Draft FS report to EPA in June 2011. EPA is therefore establishing the due date for the draft FS report as June 15, 2011.

In summary, EPA wants to acknowledge that significant portions of the RI report, including maps and figures, tables and other information were well done and provide good summaries of relevant site data and information. EPA's comments are focused on areas of the report that were deficient, and changes are needed to make the report acceptable to EPA. EPA is willing to meet to discuss our comments. If you have any questions regarding the comments or

the schedule for revisions please contact Chip Humphrey at (503) 326-2678 or Eric Blischke (503) 326-4006. All legal inquiries should be directed to Lori Cora at (206) 553-1115.

Sincerely,

Chip Humphrey
Eric Blischke
Remedial Project Managers

cc: Greg Ulirsch, ATSDR
Rob Neely, NOAA
Ted Buerger, US Fish and Wildlife Service
Preston Sleeger, Department of Interior
Jim Anderson, DEQ
Kurt Burkholder, Oregon DOJ
David Farrer, Oregon Environmental Health Assessment Program
Rick Keppler, Oregon Department of Fish and Wildlife
Michael Karnosh, Confederated Tribes of Grand Ronde
Tom Downey, Confederated Tribes of Siletz
Audie Huber, Confederated Tribes of Umatilla
Brian Cunninghame, Confederated Tribes of Warm Springs
Erin Madden, Nez Perce Tribe
Rose Longoria, Confederated Tribes of Yakama Nation

EPA GENERAL COMMENTS ON THE PORTLAND HARBOR DRAFT REMEDIAL INVESTIGATION REPORT

July 16, 2010

RI Report - General Comments

Indicator chemicals

The RI Report focuses on indicator chemicals. EPA agreed to focus the presentation of site data on indicator chemicals for the ease of data presentation and clarity. However, the RI Report should clearly describe the basis for focusing presentation materials on a subset of chemicals at the Site and note that other chemicals are present at the site that pose potentially unacceptable risk to human health and the environment. The RI Report should describe how the results of the risk assessment and ARARs evaluation are used to identify the chemicals to be carried into the FS for the purpose of identifying COCs. Then the narrative can provide the rationale for why subsets of the larger contaminant list were developed for specific purposes in the RI Report.

Comprehensive Round 2 Site Characterization Summary and Data Gaps Report

The draft RI Report relies significantly on the Comprehensive Round 2 Site Characterization Summary and Data Gaps Report (Round 2 Report). It should be noted that the Round 2 Report was not approved by EPA. Although the RI Report does not need to repeat all information presented in previous documents, it needs to be the primary source for the description of the data collected, nature and extent of contamination, and risk assessments.

If the RI Report relies on any particular text, figure, appendix, or reference document found in the Round 2 Report or other preceding documents not formally approved by EPA and which is not placed into the RI Report, the RI Report must explicitly cite to the pages, figures, appendices, etc. of the previous report so that EPA can ascertain that it agrees and approves the reliance and use of such information described in the RI Report. Another way to address is this issue is to place all relevant information from previous reports into the RI Report, thus, eliminating the need to provide explicit and complete cross references to the previous reports.

The Round 2 Report contained significant information that was not included in the RI Report, or was presented in a different, but less useful or complete manner. Examples of this information include:

- A number of useful data presentations in the Round 2 Report were not included or presented with less complete information, including subsurface sediment data presentations and biota maps. These are called out in our specific comments.

- Section 4 on sources focuses on general information and fails to provide the necessary detail regarding specific sites, especially in the main text and summary sections. The presentation of the sources seems to be reasonable in a general and conceptual manner, as is that of the general pathway (overwater, erosion, etc.). However, it does not provide the reader with a clear summary

of the connection between the major river contamination problems and the apparently connected nearby sites which are or were the sources of that contamination.

- The RI Report should present a summary of the main sources of contamination in the Study Area, the location of these sources and what the apparent upland sources are or were. In addition, set of simpler maps that summarizes the sources of contamination should be provided. For example, instead of multiple sets of maps on groundwater plumes with different depths and different contaminants (which the report admits may not be complete), it may be more useful to have a single map that shows all the groundwater plumes which have any contaminant above MCLs and AWQCs, across the entire Study Area, the related off-shore contamination areas, and the upland site names (similar to the present map 4.4-3h). A similar should approach be taken with each of the other media.

- The Draft RI Report should describe more clearly the suspected major sources of contamination at the site. In particular, the report should better summarize and highlight the actual sources and locations of contamination, both in the text and in associated maps. The draft RI fails to use the available data to describe the major source areas in a clear, concise and understandable manner. In particular, the RI Report must note that the scope of the Portland Harbor RI includes characterization of the entire hydrologic sub-basin, including the Study Area, the river, and its related upland areas, together with the different related media and contaminants (sediments, soils, surface water, groundwater, transition zone water, NAPL (non-aqueous phase liquids), etc.), and their dynamic interactions.

- The updated CSM in Section 10 did not present key information from the Round 2 Report regarding potential sources of contamination. In many cases, the information on potential upland sources is more general than what was previously provided in Section 11.3 (CSM for iAOPCs) section as part of the Round 2 report or upland site summaries. EPA recognizes that the RI report is not focused on iAOPCs, but the information provided in this section of the Round 2 report is useful in understanding potential sources and pathways of contamination that may have impacted adjacent areas in the river. The CSM should reference relevant information and detail from previous CSM updates.

Data Interpretation/Presentation

Many sections of the RI Report contain descriptions comparing quantitative results spatially and/or temporally. In many cases, terms such as “higher” or “less than” are used even though the comparison is based on the results of a statistical analysis. The RI Report should clearly note when the use of qualifiers such as “higher” or “less than” are based on a statistically significant difference and when they are not.

The RI Report also tends to combine data, calculations and interpretations into a single set of information. The RI Report should clarify which information is based on actual data and which information is based on an interpretation or extrapolation from the data. The RI Report tends to mix analytical data (water, sediment, or other) with grouped calculations (averages, areas, etc.), secondary data (leaching tests from a group of area wide samples) and modeling extrapolated actual data. The end

result is that the RI Report does not distinguish data from interpretations and extrapolations of the data. It is important that the RI Report account appropriately for the uncertainty in the interpreted results.

Groundwater

The RI documents present an impressive and broad set of different types of data that have been obtained and developed to understand the very large "Study Area." With the sediment data set, it should be possible to define where the major sediment contamination problem areas and depths are located. However, the RI has not done a similarly good job of compiling or obtaining sufficient groundwater and Transition Zone Water (TZW) for the Study Area. Specific examples include:

- The draft RI Report does not describe groundwater as an exposure media, nor does it describe the risks posed to future drinking water users where groundwater exceeds non-zero MCLGs or MCLs. The RI Report should describe the ARAR screening process in addition to the baseline risk assessment, and should discuss the risks that are present based on ARAR screening, such as groundwater.

- The draft RI Report mischaracterizes the groundwater assessment sampling and makes unsupported conclusions about how many plumes are discharging to the river due to the lack of sufficient data. Given the lack of groundwater data on many sites, limited conclusions can be drawn from the samples that were taken in the river. The RI Report indicates that 113 sites have the likelihood of having contaminated groundwater. However, additional data were not collected further characterize these facilities as part of this RI. The RI Report must accurately describe the scope and purpose of the groundwater sampling that was done and provide a summary of the potential for groundwater discharges to the Portland Harbor site for the 113 sites identified as potentially having groundwater contamination.

- The RI Report should note that the groundwater pathway analysis focused on sites where existing information confirmed that contaminated groundwater was likely discharging to the river. The RI Report must state that the transition zone samples collected during this evaluation confirmed that contaminated groundwater is discharging to the river and does impact sediments and surface water. The RI Report needs to state that possible contaminated groundwater discharging to the river has not been fully characterized throughout the site, and that data gaps will need to be filled in during remedial design.

- The RI Report tends to discount groundwater sources at the site. For example, only a limited number of contaminated groundwater plumes discussed are discussed; many of the groundwater COCs are not discussed; and the baseline ecological risk assessments eliminated TZW data, compared to water TRVs, as a line of evidence for estimating risks to the benthic community. For each potential source area (upland and in-river sources), the entire combination of groundwater, sediment, and soil contaminants should be fully evaluated.

- It is not clear whether many of the LWG "upland site summaries" have been revised based on EPA comments submitted and updated for some of the major sites. Using older information may miss many plumes that may have been better characterized since that work was done. It is likely that, for example, sites such as Arkema, Rhone-Poulenc, GASCO, Siltronic, U.S. Moorings,

Terminal 4, Oregon Steel Mills (and the related Terminal 5), and Schnitzer adjacent to the International Slip have had significant changes in what has been found with additional site characterization and remedial activities.

- The RI Report does not account for groundwater plumes which are not located in sites adjacent to the river that may continue to impact the river through inflow to the stormwater discharge pipes, or the pipe bedding, and other related pathways. Note that this is the case in sites adjacent to the International Slip and probably in many other areas if these sites had been considered as sources and the entire area had been characterized more completely. This issue has already been documented in the Arkema and Rhone Poulenc areas, where the stormwater pipes have had to be relined. This issue concerns both groundwater and stormwater system connections, and not simply the proximity of contaminant plumes to the river.

- The report needs to acknowledge that the groundwater evaluation is further limited by not following known plumes from upland sites and sampling those plumes where they would discharge into the river. The TZW samples were collected in areas where groundwater contamination was likely based on an evaluation of groundwater discharge areas within the river and an assessment of upland groundwater contaminant plumes rather than tracking groundwater contamination in three dimensions from the source to the discharge zones in the river. The RI Report should compare the TZW sampling conducted for the Arkema and Siltronic sources and flow paths into the river (which did find the groundwater discharges, TZW impacts, and sediment problem areas) to the samples done in many of the other TZW areas; while this provides documentation of TZW contamination, it does not document the flow paths or show whether the contamination is at the center of those plumes or at the edges (for example the results from the sampling for Rhone Poulenc plumes under the railroad bridge area, or some of the bulk fuel facility sampling locations). The conclusion should be that TZW has been found to be impacted in many locations, but clearly identify the limitations of the characterization process.

- The draft RI Report does not describe groundwater as an exposure media, nor does it describe the risks posed to future drinking water users where groundwater exceeds non-zero MCLGs or MCLs. The RI Report should describe the ARAR screening process in addition to the baseline risk assessment, and should discuss the risks that are present based on ARAR screening, such as groundwater.

Modeling

Agency comments on the HST model (provided July 2009) recommended changes that may yield significantly different results and that will likely require recalibration as well as re-running the validation and the sensitivity analysis. The next draft of the RI should incorporate the agencies' recommended changes from July 2009 and any subsequent changes based on our current discussion regarding the contaminant fate and transport model. EPA expects that a revised HST/F&T model will be included with the draft FS.

Section 11

Section 11 is a repeat of material presented elsewhere in the Draft RI Report. Section 10 already summarizes all the preceding sections into a conceptual site model, and the executive summary already is a shorter, more reader-friendly summary of the whole document. As a result, this section should be – deleted with the exception of Section 11.11 which focuses on conclusions and next steps and should become the conclusion section of the RI Report.

TAB 8

EPA Comments Portland Harbor RI Report – Baseline Human Health Risk Assessment

No.	Section and Page Number	Comment	Comment Type
General – 1	NA	The draft Portland Harbor Baseline Human Health Risk Assessment (BHHRA) includes numerous statements regarding the fish consumption rates used to evaluate the risks to human health. The three primary non-tribal fish ingestion rates used in the draft BHHRA are characterized as high (17.5 grams per day [g/day]), higher (73 g/day), and highest (142 g/day). EPA disagrees with this characterization, believes them to be misleading, and believes that significantly higher ingestion rates may be appropriate to represent different local and ethnic populations that rely on fishing as part of their culture and/or as a substantial food source. As such, the three ingestion rates presented in the BHHRA should be characterized as low, moderate, and high. The rate of 17.5 g/day (equivalent to two 8-ounce meals per month) is based on the 90th percentile rate for uncooked freshwater and estuarine finfish and shellfish for individuals (consumers and non-consumers) of age 18 and over in the United States (EPA 2002b, data from USDA CSFII Study). The 90th percentile for fish consumers only from this USDA study is much higher, at 200 g/day. EPA uses the 17.5 g/day rate to approximate a fish-consuming population that does not include tribal or subsistence fishers. It is not an unreasonable rate, and should not be referred to as a high ingestion rate, but rather as a low ingestion rate. A non-tribal adult fish consumption rate of 73 g/day was used in this risk assessment based on data from the Columbia Slough. The possible uncertainties associated with the consumption rates derived from this study are appropriately discussed in the BHHRA. The BHHRA discussion and the data from the USDA study support use of a fish consumption value of 73 g/day as moderate consumption rate, not a higher consumption rate. The rate of 142 g/day used as the highest rate for non-tribal fishers in the draft BHHRA is the 99th percentile for consumers and non-	Directed Change

No.	Section and Page Number	Comment	Comment Type
		consumers from the same USDA study; the consumption rate for consumers only from this study is 506 g/day. The ingestion rate of 142 g/day is used by EPA in developing Ambient Water Quality Criteria (AWQC) for consumers who obtain much of their daily protein from fish. The consumption rate of 142 g/person/day was selected in the BHHRA to represent high-frequency, non-tribal fishers, and represents an appropriate "high" ingestion rate for the Portland Harbor (PH) risk assessment. Overall, the arguments concerning uncertainties in fish ingestion rates provided in the HHRA are not compelling. Further, EPA believes that the body of information available regarding fish consumption rates, both nationally and locally, makes it clear that the fish ingestion rates used in the BHHRA appropriately address a range of exposures that might occur for consumers of locally caught fish. Please revise text throughout the document to indicate the nature of these risk estimates, as indicated above, and substitute appropriate text to acknowledge the need to protect high consuming fish populations and discuss fish ingestion rates in that context.	
General – 2	NA	Although the extent of shellfish consumption in the Lower Willamette River is not known, certain information regarding the consumption of shellfish in the Lower Willamette River is available. The Oregon Office of Environmental Public Health, Department of Health Services (DHS) had previously received information from Oregon Department of Fish and Wildlife (ODFW) indicating that an average of 4,300 lbs of crayfish were commercially harvested from the portion of the Willamette River within Multnomah County in each of the 5 years from 1997 to 2001. Most of this catch was sold to the Pacific Seafood Company of Oregon. DHS also has information from local commercial crayfish harvesters indicating that Europe is a major portion of their market. Furthermore, as part of the McCormick and Baxter assessment in 1991, information obtained by DHS from the Oregon Crayfish	Note

No.	Section and Page Number	Comment	Comment Type
		Association indicated that the area around McCormick and Baxter was at one time a very productive crayfishery. It is likely that harvesting crayfish in the PH site has declined because of the advisory and because this stretch of the river was designated as a Federal Superfund site. In addition to the historical information regarding commercial crayfish harvesting in the Lower Willamette, DHS also occasionally receives calls from citizens interested in harvesting crayfish from local waters who are interested in fish advisory information. Between 2001 and 2007, DHS fielded eight calls from citizens who reported catching and eating crayfish from Portland-area waters (only one was specifically from the Study Area). DHS has no way of knowing what percent of individuals who catch and eat crayfish contact their office first to ask for fish advisory information. They estimate that for each person who contacts them regarding the safety of consuming crayfish from the Lower Willamette, there are many more who catch and consume the animals without contacting their office. The fact that collection of *Corbicula* is illegal is relevant but not particularly important for the pathway in general. Indications are that *Corbicula* are being collected and consumed to some extent (e.g., from the Linnton Community Center's discussion with transients). It is reasonable to assume that bivalve consumption is a current and potential future exposure pathway and that future biomass would increase. Therefore, the low clam mass that may limit current bivalve consumption does not apply to future exposure.	
General – 3	NA	In the draft BHHRA, the calculation of a chronic hazard index (HI) for each exposure pathway is not presented in the risk characterization tables (Section 5 tables). Per EPA's Risk Assessment Guidance (Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual, Part A), the chronic HI for each exposure pathway	Clarify

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		should be added to these risk characterization tables in the final HHRA. In addition, only those exposure pathways which have a chronic HI greater than 1 should be included in tables that show the calculation of the End-Point Specific HIs. Unnecessary tables totaling hundreds of pages that are now included in the draft BHHRA can and should be eliminated when HI are appropriately reported.	
General – 4	NA	Numerous statements are included in the draft HHRA regarding the compounding of conservative risk assumptions, which resulted in the LWG concluding that the final risk characterization results are unreasonable. This issue is also highlighted in the LWG's October 8, 2009, letter. EPA disagrees with this characterization. The approach used in this BHHRA follows standard EPA guidance on risk assessments and is similar to risk assessment approaches used on other Superfund sites. Overall, EPA believes the risk assessment for Portland Harbor is consistent with the application of reasonable maximum exposure assumptions and is not overly conservative. Further discussion on this issue is included in specific comments. EPA objects to certain language and information included in the discussion of uncertainties in the BHHRA. For example, in the presentation of uncertainty, the range of variation in HIs is greatly overstated. This is because each toxic endpoint in an exposure scenario is considered independently. Instead, each scenario should be evaluated based on the chemical(s)/endpoint combination resulting in the greatest HI. For example, in Table 5-186, the HI range for tribal fisher direct exposure to in-water sediment across all half-mile segments is listed as 0.00000008 to 1. This range is developed using the very lowest chemical/endpoint combination (naphthalene causing whole body effects) to the highest chemical/endpoint combination (arsenic causing skin effects). The lowest HI for a scenario is irrelevant for decision making; decisions are based on the highest calculated HI at each location. The correct range for tribal fisher sediment exposure should	Directed Change

No.	Section and Page Number	Comment	Comment Type
		be developed using the highest chemical/endpoint combination at each location (Table 5-36). This range is 0.002 (arsenic, skin effects) to 1 (dioxin toxicity equivalence quotient [TEQ], reproductive effects). In this example, the HI range in Table 5-186 is overstated by a factor of 25,000. This overstatement of HI uncertainty is typical of many other scenarios. However, if as described above, endpoint-specific HIs are calculated according to EPA guidance for only for those exposure pathways with a chronic HI greater than 1, all of the endpoint-specific HIs presented in Table 5-36 would be deleted from the BHHRA (an elimination of 49 pages for this one receptor/ exposure media/exposure route), as none of the exposure pathways have an HI greater than 1. This conclusion can be found on page 78 of the draft BHHRA where it states, "The tribal fisher scenario for in-water sediment results in no HIs greater than 1." The correct evaluation will need to be performed before the agencies have an appropriate view of uncertainty associated with non-cancer risks. Another uncertainty for non-cancer effects that was not discussed in the draft HHRA relates to the calculation of endpoint-specific HIs. In deriving these, only one health endpoint is used for each chemical, even though most chemicals have a myriad of health effects as exposures increase. As an example, a majority of the non-cancer impacts from the site are from PCBs and total TEQ. The endpoint used for deriving the RfD for PCBs is immunotoxicity, while the endpoint used for deriving the RfD for dioxin/furan TEQ and PCB TEQs is reproduction. In Table 5-144 (Child, Fish Consumption, Single-Species Diet, Common Carp, 95 percent UCL/ Maximum Exposure Scenario, Highest Ingestion Rate (60 g/day)), the endpoint-specific HI for total TEQ is 500, calculated using the RfD for 2,3,7,8-TCDD, which is based on a reproductive endpoint. A review of the toxicity data in the ATSDR Toxicological Profile for PCBs shows that a dose of 0.02 mg/kg/day in monkeys results in a "serious LOAEL (Lowest Observed	

No.	Section and Page Number	Comment	Comment Type
		Adverse Effect Level) for reproduction." If the reproductive endpoint for PCBs based upon the LOAEL of 0.02 mg/kg/day is used with the same Uncertainty Factor as the immunological endpoint to derive an RfD for a reproduction endpoint for PCBs, the RfD for reproductive effects will be 4 times the RfD for immunological effects. Using this ratio, the endpoint-specific HI for reproduction for this exposure scenario for PCBs would be 5,000/4 = 1,250. The total HI for reproduction effects, combining HIs for total TEQ (500) and non-dioxin-like PCBs (1,250), would increase from 500 to 1,750. For the chemicals that have the largest non-cancer contribution in the HHRA, the Uncertainty Section should discuss the possibility of under-predicting non-cancer health effects by using only one endpoint per chemical.	
General - 5	NA	There are several inappropriate discussions relating to "background" and "regional" risk levels, particularly regarding biota (game fish). EPA and the LWG agreed that biota data collected upstream of the Portland Harbor site by the LWG would not be used in the BHHRA. Therefore, no appropriate background data set for biota for Portland Harbor is available for use in the BHHRA, and any reference to background in relation to biota in the BHHRA should be deleted. EPA acknowledges our agreement to use upstream tissue data for informational purposes in the Remedial Investigation report. Comparisons are also made to risks from biota consumption in other "regional" risk studies (the EPA Columbia River Basin Fish Contaminant Survey, and the ODEQ mid-Willamette Basin study). Comparisons to these studies, which were initiated because of known or suspected contamination in the particular areas in which they were done, should not be included in the BHHRA. Comparisons to risks from other contaminant surveys are misleading as they are not relevant to the Portland Harbor Site. Background can be addressed using estimates for background sediment concentrations that are available for	Issue

No.	Section and Page Number	Comment	Comment Type
		Portland Harbor.	
General – 6	NA	Much of the language in the draft BHHRA that discusses the Willamette River as a potential future drinking water source is inappropriate. Under OAR 340-041-0340, Table 340A, domestic water supply is a designated beneficial use of the Willamette River, with adequate pretreatment. CERCLA sets out a mandate for remedies that are protective for both private and public users of surface water or groundwater. The Willamette River is potable and capable of serving as a potential drinking water source; thus, the expectation is that this resource will be protected and remediated to achieve such use (40 CFR 300.430(a)(1)(ii)(F)). This expectation is reflected in the current remedial action objectives and ARARs for the PH site and must be reflected in the HHRA for the site. Throughout the draft HHRA, where reference is made to the risk characterization done for potential future domestic use of surface water, much of the language will need to be deleted and/or modified to be consistent with the fact that surface water is potable and capable of serving as a potential drinking water source and that the expectation is that the resource will be protected and remediated to achieve such use. EPA has provided comments on this inappropriate language which occurs throughout the draft BHHRA.	Directed Change
General – 7	NA	Section 8.2, Risk Drivers, should be deleted, and Section 9, Conclusions, should be revised to summarize the chemicals and exposure scenarios that present the majority of the risk, as well as chemicals that exceed ARARs based on the evaluation presented in Section 6. These should be carried through into the FS; COCs should be identified in the FS based on the results of the BHHRA. One role of the BHHRA is to identify those chemicals that pose the greatest risks to current and future receptors, along with the media and exposures routes associated with those risks. This information is used to inform response actions.	Revise

No.	Section and Page Number	Comment	Comment Type
General – 8	NA	It is not appropriate for the BHHRA to focus on a subset of the chemicals posing potentially unacceptable risk based upon the considerations listed on pages 142-143. Inappropriate considerations include the relative percentage of each chemical's contribution to the total human health risk, uncertainties associated with exposures, frequency of detection (localized and study-area wide), comparisons of Portland Harbor site risk to risks in "regional" studies, and the magnitude of risk greater than 10^{-4} to 10^{-6}. These are risk management issues and will be dealt with outside of the BHHRA.	Directed Change
General – 9	NA	Chemicals of Concern are defined in EPA policy and guidance according to the following definitions: 1. A subset of the COPCs that are identified in the RI/FS as needing to be addressed by the response action proposed in the ROD (Guide to Preparing Superfund Proposed Plans, Records of Decision, and Other Remedy Selection Decision Documents, July 1999). 2. The hazardous substances, pollutants, and contaminants that, at the end of the risk assessment, are found to be the risk drivers or those that may actually pose unacceptable human or ecological risks (Role of Background in the CERCLA Cleanup Program. April 2002). For the purpose of the Portland Harbor BHHRA, chemicals for which the estimated lifetime excess cancer risk is greater than 10-6, or the non-cancer Hazard Quotient is greater than 1 should be identified as posing potentially unacceptable risk at the Portland Harbor site. This list of chemicals should used to identify COCs in the draft FS. Consistent with EPA policy on risk, the risk assessment information must be clearly presented separate from any non-scientific risk management considerations.	Issue
General – 10	NA	EPA and the LWG agreed that while ingestion of human milk by	Revise

No.	Section and Page Number	Comment	Comment Type
		infants (previously referred to as breast feeding) would not be included in the draft BHHRA, it should be included in the revised BHHRA. The ODEQ is currently finalizing a revision to its Human Health Risk Assessment Guidance that incorporates the breast feeding exposure pathway. This guidance was developed in conjunction with Oregon Office of Environmental Health Public Heath, ATSDR, & EPA Region 10, and should be used as the basis for evaluation of the breast milk exposure pathway. This multi-agency collaboration compared two physiologically-based pharmacokinetic (PBPK) models for infant exposure to human milk (the Haddad model, an eight-compartment PBPK model that has been validated by comparing estimated milk concentrations against concentrations measured in a Canadian Inuit population, and the Yang model, a three-compartment PBPK model) to an EPA model which is a single-compartment, first-order kinetic model. This model and the parameters used for it are based upon numerous sources, including EPA's Methodology for Assessing Health Risks Associated with Multiple Pathways of Exposure to Combustor Emissions (MPE Guidance), Human Health Risk Assessment Protocol for Hazard Waste Combustion Facilities (Combustion Guidance), Exposure Factors Handbook, Child-Specific Exposure Factors Handbook, and examples from other hazardous waste sites. This comparison has shown that the EPA model is accurate and protective and should be used for the risk characterization for infant exposure to human milk in the Portland Harbor BHHRA. The risk characterization results from this pathway will primarily affect the non-cancer evaluations for PCBs for biota consumption and other pathways. Inclusion of the breast milk pathway will need to be reflected in the conceptual site model (CSM) for the site, and revisions to Figure 3.1 should note that infant exposure to mother's milk should be shown as a	

No.	Section and Page Number	Comment	Comment Type
		potentially complete pathway for all receptors.	
General – 11	NA	The draft BHHRA categorizes exposure pathways as complete, incomplete, or complete and significant. All pathways should be discussed, and justification should be provided for placing pathways into the various categories, including those pathways that were not assessed in the BHHRA. The risk assessment should provide a complete pathway analysis, which is a critical aspect of the process.	Clarify
General – 12	NA	In Section 7 of the BHHRA and elsewhere, results of analyses are reported without including the data used or the details of these calculations. As critical information is lacking, these analyses cannot be reviewed by EPA and, therefore, none can be accepted. Either the data and calculations must be included, or citations to appropriate sections of the RI that present the needed data and calculations must be provided.	Clarify
General – 12	NA	The overall exposure duration for recreational and tribal fishers and for recreational beach users has not been clearly defined in the risk assessment. It is reasonable to assume that fishers and recreational users consist largely of nearby residents, given that a 30 or 70 year exposure duration is used for the RME evaluations. Cancer risk is proportional to the duration of exposure, and behavioral and physiological characteristics of children increase their exposure relative to adults. Hence the cumulative cancer risk incurred is greater than would be the case assuming only a 6 year exposure duration as a child or assessing exposure to adults only. To avoid underestimating the overall cancer risks for these receptors, RME exposures should be evaluated as 6 years as a child, with the remaining period as an adult, which is consistent with EPA risk assessment guidance. Further, as discussed in the specific comments, when evaluating cPAHs, age-dependent adjustment factors to the cancer slope factor – 10 for exposures before 2 years of age; 3 for exposures between 2 and 16	Revise

No.	Section and Page Number	Comment	Comment Type
		years of age – need to be combined with age-specific exposure estimates. Separating the child and adult scenarios will result in a substantial underestimation of the increased risks associated with exposures occurring between the ages of 6 and 16 years of age	
1	Glossary	In the definition for the "upper confidence limit on the mean," remove the word "conservative."	Revise
2	ES.1	The first sentence should be replaced with the following sentence that uses language from EPA risk assessment guidance: *"The BHHRA is an analysis of potential adverse health effects (current or future) caused by hazardous substance releases from a site in the absence of any actions to control or mitigate these releases.* ~~*to identify chemicals and exposure pathways that may result in potential unacceptable risks and to focus on those that are predicted to have the highest contribution to the estimated risk at the Portland Harbor Superfund Site (Site), consistent with the requirements of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).*~~*"*	Revise
3	ES.1	Modify the first sentence in the first paragraph as follows: *"The general objective of the BHHRA is to assess potential risks to human health from exposure to <u>site-related</u> chemicals present in or entering into environmental media (i.e., water or sediment) or bioaccumulating in the food chain to help determine the need for remedial action, to provide a basis for determining concentrations of chemicals that can remain in place and still be protective of public health, and to provide the basis for comparing the effectiveness of various remedial alternatives."*	Revise
4	ES.1	1st Paragraph: Add the following sentence to the end of this paragraph: *<u>"</u>The BHHRA also includes an analysis of those chemicals in*	Revise

No.	Section and Page Number	Comment	Comment Type
		groundwater (GW) and surface water (SW) where concentrations are greater than ARARs (MCLs and AWQC) for these two media. These chemicals should be carried forward into the FS."	
5	ES.1	In the 2nd paragraph, delete the word "conservative" before "health protective," as it is frequently misunderstood and is redundant with "health protective." This should be done throughout the document where these words are used together.	Clarify
6	ES.1	In the 1st paragraph, modify the following sentence as indicated: "*The BHHRA dataset includes ~~only~~ those ~~matrices relevant~~ data used for direct human health exposure pathways that were quantitatively evaluated in the risk characterization sections of the document: surface sediment (0 to 30.5 centimeter (cm) in depth), surface water, groundwater, seep water, clam and crayfish tissue, and fish tissue.*"	Revise
7	ES.1 page 2,	1st paragraph – Delete the following sentence from the 1st paragraph: *"~~Transition zone water (TZW) data were used in loading calculations to estimate surface water concentrations that were compared with surface water screening levels, but were not included in the risk characterization because there are no complete direct exposure pathways for humans to TZW.~~"*	Revise
8	ES.1, page 3:	At the end of this section, on page 3 (after the last bullet), add the following: *"In addition to the risk characterization done in the BHHRA, an ARARs evaluation of SW and GW is presented in Section 6 of this document. This evaluation compares maximum detected SW and GW concentrations to EPA Maximum Contaminant Levels (MCLs), EPA Ambient Water Quality Criteria (AWQC) for the protection of human health from fish consumption, and EPA Regional Screening Levels (RSLs) for tap water."*	Revise

No.	Section and Page Number	Comment	Comment Type
9	ES.2, page 3:	Modify the 1st sentence as follows: *"The risk characterization in the BHHRA evaluated the following exposure scenarios, as provided in the approved Programmatic Work Plan and subsequent agreements with or directives from the EPA related to the BHHRA approach:"*	Revise
10	ES.2, page 3:	In the table at the bottom of this page, the following pathways should be added: *"-Consumption of surface water by domestic users* *-Infant consumption of human milk for all receptors* *-Beach user exposure to GW seeps"* (If the review of stormwater data does not add any exposure points for beach users, delete this scenario from the table but explain in a footnote why beach users are not being evaluated.)	Revise
11	ES.2, page 4:	These scenarios should be added to the 7 bullets on the top of page 4, so that there are 9 (or 10) contiguous bullets, and the following language should be deleted from the end of this section on page 4: *"~~Scenarios included in the BHHRA at the direction of EPA include:~~* *~~Exposure to untreated surface water as a domestic water source by a hypothetical future resident~~* *~~Clam tissue ingestion~~* *~~Exposure to in-water sediment and surface water by commercial divers~~"*	Revise
12	ES.2, page 4:	In the first paragraph after the first set of bullets, modify the following sentences as indicated: *"~~A hypothetical~~ Potential future use of surface water as a drinking water source by residents was also included as an exposure scenario.*	Directed Change

No.	Section and Page Number	Comment	Comment Type
		Even though ~~there are no known or anticipated future uses of the~~ surface water in the LWR within Portland Harbor is not currently used as a domestic water source, as discussed above under OAR 340-041-0340 Table 340A, domestic water supply is a designated beneficial use of the Willamette River, with adequate pretreatment…" This modification should be used throughout the HHRA when referring to future use of SW as a drinking water source. *"Asian clams (Corbicula sp.) are the only clam species that were found in the Study Area during sampling events and ~~they~~, in addition to crayfish, were evaluated for shellfish consumption in the BHHRA. Although harvest and possession of Asian clams is illegal in the State of Oregon, ~~and although~~ conversations with transients indicated that shellfish (both crayfish and clams) ~~may be~~ are eaten. by them." (~~during their limited time in an area (Wagner 2004), there is no documentation of ongoing shellfish consumption by humans occurring in the Study Area~~ In addition, crayfish are commercially harvested in the Willamette River, although the extent of this harvest within the PH Superfund site is not known."*	
13	ES.2, page 4:	The discussion here regarding the Exposure Assessment should be revised to provide additional details on exposure scenarios, receptors, and exposure assumptions, including spatial. A brief discussion of each scenario should be included with enough information to give the reader an understanding of the different exposure scenarios and receptors evaluated in the risk assessment. Recall that one objective of the HHRA is to provide useful information to the affected public.	Clarify
14	ES.2, page 4:	Delete the last sentence on this page as indicated: *"~~However, for some exposure scenarios, such as fish consumption, the exposure assumptions were based on upper-bound (i.e., 90th, 95th, and 99th) percentiles only, at the direction of EPA.~~"*	Directed Change

No.	Section and Page Number	Comment	Comment Type
		This sentence incorrectly characterizes fish consumption rates as all upper-bound estimates and implies that the fish consumption pathway is inconsistent with the RME/CTE approach used for other pathways. The upper percentiles used for fish consumption are based on the entire population, which includes non-fish consumers, and are used to represent smaller populations with higher exposure. As discussed in General Comment 1, they are not upper-bound levels for the various populations of fish consumers.	
15	ES.3, page 5:	1st full paragraph Delete the last portion of the last sentence shown here: "~~regardless of the feasibility or practicability of use of the actual areas.~~"	Revise
16	ES.3, page 5:	Delete the last sentence in the last paragraph in ES.3: *"~~Because many of the exposure scenarios that were evaluated in the BHHRA are highly variable and do not have standard default exposure factors, uncertainties associated with the exposure factors are anticipated to have significant impacts on the risk estimates.~~"* The phrase "highly variable" represents a subjective judgment, and will have different meanings to different readers of the assessment. The analysis of uncertainties should avoid unsupported claims about the relative variability of different exposure scenarios. An objective discussion of uncertainties for each scenario and their relationship to the quantitative risk estimates is adequate.	Revise
17	ES.3, page 5:	Delete the following 2 sentences from the end of the first paragraph: *"~~Uncertainty or variability factors, which typically range from two to three orders of magnitude (100 to 1,000 times), are often used by EPA in deriving toxicity values for human health given the uncertainties in~~*	Revise

No.	Section and Page Number	Comment	Comment Type
		~~*the toxicological data. As a result, actual risks within the Study Area could be lower than the potential risk estimates calculated in the BHHRA.*~~*"* "Uncertainty or variability factors" are not used for the derivation of cancer slope factors. Rather, their use is limited to the development of non-cancer toxicity criteria. In addition, the text fails to note uncertainties in toxicity factors that may result in underestimates of risk (e.g., lack of test data on reproductive, developmental and/or immunological endpoints).	
18	ES.5, page 6:	In the first paragraph replace "lifetime of exposure" with "lifetime." In most scenarios, the exposure duration is less than a lifetime.	Revise
19	ES.5, page 6:	This section provides insufficient information on the large amount of risk characterization results. The summary should be revised to include a clearer discussion of at-risk populations, the spatial distribution of risks for these receptors, and uncertainties important for interpreting these risks. The discussion should focus on exposure scenarios where risks are above 10^{-6}, 10^{-5} and 10^{-4}, and HIs are above 1. Figures E-2 and E-3 provide little useful information and should be replaced with figures and/or tables for those scenarios that present the risk and hazard estimates for each population evaluated. The primary focus of the information presented should be the specific receptor populations, such that the reader can clearly discern the overall risk and hazard estimate to each population, and the specific exposures and contaminants that represent the primary contributors to risk. LWG should provide examples of graphics they intend to include to EPA for review prior to developing and submitting a revised draft of the HHRA. The Executive Summary in particular should be readable and understandable by the general public.	Clarify

No.	Section and Page Number	Comment	Comment Type
20	ES.5, page 7:	Throughout the text, figures, tables and maps, the phrase "RME Exposure…" should be used in place of "95% Upper confidence limit (UCL) or Maximum."	Revise, clarify
21	ES.5, page 9:	In the 1st paragraph**,** revise the following sentence as shown: *"Possible effects of preparation and cooking methods, which can reduce concentrations of lipophilic chemicals in fish tissue, were not considered. ~~PCB concentrations have been shown to be reduced up to 87 percent (Wilson et al. 1998) with various cooking methods."~~*	Revise
22	ES.5, page 9:	Delete the following sentences as indicated: *"~~In estimating risks in this BHHRA, the conservative assumptions regarding fish consumption were multiplied together, which magnifies the conservatism in the risk estimates. The cumulative effects of the numerous conservative assumptions made during this BHHRA are risk estimates that are potentially significantly higher than actual risks that may exist within the Study Area.~~"*	Revise
23	ES.5, page 9:	Delete the last sentences at the end of the first and third paragraphs and the 4th bullet on Page 11: *~~"On a regional scale, fish consumption results in risk estimates exceeding cumulative risks of 10^{-4} or HIs of 1 based on fish tissue data collected from the Willamette and Columbia Rivers outside of the Study Area (EVS 2000, EPA 2002c)." and "In regional studies of fish tissue data from the Willamette and Columbia Rivers outside of the Study Area (EVS 2000, EPA 2002c) both PCBs and dioxins/furans also resulted in cancer risks greater than 10^{-4} and/or HQs greater than 1 for fish consumption using exposure assumptions similar to those in the BHHRA.~~"*	Revise

No.	Section and Page Number	Comment	Comment Type
24	ES.5, Page 9, 2nd Paragraph:	This paragraph includes a discussion of the fact that some chemicals were identified as posing potentially unacceptable risk because their concentrations were based on N-qualified data. These chemicals should be listed here, with a brief discussion of the impacts on risk when N-qualified data are deleted. A summary of this discussion should be added to the Uncertainty section.	Clarify
25	ES.5, Page 10:	The first paragraph on page 10 should be revised to describe the results of the ARAR evaluation of GW and SW.	Revise
26	ES.6, page 11:	The following changes should be made to this section: Actual risk estimates should be presented in place of vague statements such as "results in risks within or below the EPA target cancer risk range of 10^{-6} to 10^{-4} ." 1st bullet - Delete the last two sentences in the first bullet which eliminate shellfish consumption as a risk driver: ~~*"The evaluation of shellfish consumption was done at the direction of EPA, and there is no information documenting whether shellfish consumption actually occurs on an ongoing basis within the Study Area. Therefore, fish consumption is the exposure scenario that is considered the major risk for the Study Area".*~~ 2nd bullet - Revise the text to include consumption of shellfish as a substantial contributor to risk estimates. Include a list of the primary contributors to risk and the hazard identified for each pathway. 3rd bullet – Revise the text in this bullet as indicated: *"The body of information available regarding fish consumption rates, both nationally and regionally, indicate that the fish ingestion rates used in the BHHRA appropriately address a range of exposures that might occur for consumers of locally caught fish in Portland Harbor,*	Directed Change

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		including high fish consuming populations." Delete the last sentence: *"~~The fish tissue consumption risks in the BHHRA incorporate assumptions that may under-estimate, or more likely over-estimate the actual risks~~."* 4th bullet –Delete the 4th bullet: *"~~On a regional basis, risks from exposure to bioacummulative chemicals in tissue exceed EPA target risk levels. For example, the PCB concentrations detected in resident fish from the Willamette and Columbia Rivers are approximately 20 to 100 times higher than the EPA target fish tissue concentration, when adjusted for the ingestion rates used in this BHHA based on a target risk level of 1 x 10^{-6}~~."* 5th bullet – Add another bullet which summarizes the ARAR evaluations of groundwater and surface water performed in Section 6 and lists the chemicals that result from this evaluation.	
27	Section 1.0 Introduction, Page 12, 1st Paragraph:	Modify the first paragraph as follows: *"This Baseline Human Health Risk Assessment (BHHRA) presents an evaluation of risks to human health for the Portland Harbor Superfund Site (Site) in Portland, Oregon. The BHHRA ~~is intended to~~ also includes an ARAR evaluation for SW and GW in Section 6. Together, these evaluations ~~assessments. This BHHRA is intended to~~ provide an assessment of human health risks for the Site…"*	Revise
28	Section 1.0 Introduction, Page 12:	The document suggests that this report is somehow different from other risk assessments because EPA directed the use of conservative assumptions. In fact, risk assessments performed under guidance from other federal agencies, states, and even other countries, assess risks and inform risk management decisions based on assumptions that report	Revise

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		risks in the upper range of those possible. The risk assessment for PH is thus typical in this regard. Accordingly, with the exception of the first sentence, the text in the third paragraph should be deleted.	
29	Section 1.0 Introduction, Page 13:	Revise the bullet: *"Identify the chemicals and pathways that contribute the majority of the risk ~~COCs that will be the focus of risk management decisions for the Site.~~"* Add this bullet: *"Compare SW and GW data to EPA AWQC, non-zero MCLGs, MCLs, and RSLs to identify chemicals that exceed these ARARs which will be carried forward into the FS."*	
30	Section 1.2., page 14:	Modify the last paragraph in Section 1.2 as shown: *"The approach of this BHHRA is based on EPA (1989, 1991b, 2001a, 2004, 2005a) and Region 10 EPA (2000a) guidance.~~, except where further health protective assumptions were used at the request or direction of EPA.~~"* The risk assessment for PH follows EPA guidance and is not atypical or overly health protective for risk assessments done for a Superfund RI/FS.	Directed Change
31	Section 1.4, page 16:	Modify the 3rd bullet as follows: *"Section 6, Screening and ARAR Evaluation of Surface Water and Groundwater – This section presents an evaluation of surface water and groundwater data relative to ~~screening levels~~ EPA's MCLs, RSLs, and AWQC. ~~and the results of the risk characterization presented in Section 5.~~ This evaluation was conducted separately from the risk characterization, consistent with agreements with EPA."*	Revise

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		Modify the 5th bullet in Section 8, Summary, as follows: *"This section summarizes the findings of this BHHRA and identifies chemicals and pathways that contribute the majority of the risk ~~risk drivers; that is, those COCs with the highest contribution to estimated risks~~ within the Study Area."*	
32	Section 2.1, Available Data Page 17**:**	Modify this section as shown: *"The risk characterization BHHRA dataset includes only those matrices relevant for direct human health exposure pathways that were quantitatively evaluated: surface sediment (0 to 30.5 centimeter (cm) in depth), clam and crayfish tissue, fish tissue, surface water, and groundwater seeps~~. TZW data were used in loading calculations to estimate surface water concentrations that were compared with surface water screening levels, as presented in Section 6, but were not included in the risk characterization because there are no complete direct exposure pathways for humans to TZW.~~"* As described in Section 2.1, data from outside the study area were used to assess risk from in-water sediments and for surface water, while only data from within the study area were used for screening for chemicals of potential concern (COPCs). EPA did not concur with this process. Data collected from outside the study area should be screened for COPCs to determine if additional COPCs would have been selected for these two media. If additional COPCs are identified, they must be carried through the BHHRA. If additional COPCs are not identified, the screening results can be shown in Appendix F5 and summarized in the Uncertainty section.	Revise
33	Section 2.1.1, Beach Sediment, Map	Replace Map 2-1 with the Human Use Area figures (Figures 1a, b, and c) from the RI/FS work plan, Appendix C. These figures and Maps 5-1, 5-2, and 5-3 do a much better job of showing the length of the beaches selected, because the beach area is portrayed with a line along the	Clarify

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	2-1, Page 18	entire beach length, as opposed to a single point as shown in Map 2-1.	
34	Section 2.3, Chemical Screening Criteria, Page 23:	1st paragraph: The text in this section indicates that frequency of detection was not used in the COPC screening process. Use of frequency of detection is outdated, and the text fails to note that the screening process should not be used if "adequate computer capability" is available. The text referring to frequency of detection should be deleted.	Revise and clarify
35	Section 2.3.1, page 24:	Modify the last sentence of this paragraph as shown: *"As required by EPA Region 10 (see e-mail from Dana Davoli to Laura Kennedy, October 17, 2008, in Attachment F1), the geometric mid-point of the slope factor range from EPA 2001 (0.089 per mg/kg-day) was used for evaluating cancer risks for both inhalation and oral exposures. This value was also used to calculate an acceptable soil screening level of 7.7 mg/kg."*	Revise
36	Section 2.3.4, Hypothetical Future Exposure to Untreated Surface Water For Domestic Use, Page 26:	Replace "Hypothetical" with "Potential" in the title for this section. 1st paragraph- Add the following sentence: *"Even though no current or future uses of the LWR within Portland Harbor as a domestic water source have been identified, as discussed above under OAR 340-041-0340 Table 340A, domestic water supply is a designated beneficial use of the Willamette River, with adequate pretreatment. Because the Willamette River is potable and capable of serving as a potential drinking water source, the expectation is that this resource will be protected and remediated to achieve such use (40 CFR 00.430(a)(1)(ii)(F)) under CERCLA."*	Directed Change
37	Section 2.4, Identification of Chemicals of	Modify the 2nd paragraph as follows: *"Also, surface water and groundwater data were compared with EPA's MCLs, RSLs and /or AWQC to identify additional COPCs ~~additional~~*	Revise

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	Potential Concern, Page 26	~~*screening criteria but were not quantitatively evaluated in this BHHRA for the scenarios associated with the screening criteria, per an agreement with EPA. The screening evaluation*~~ *This comparison of surface water and groundwater is described in Section 6."*	
38	Section 2.4, Table 2-13	It is not clear why only one of the surface water samples (W020) from Swan Island Lagoon was used for COPC screening for transients and recreational beach exposures and for the domestic water source. Please add an explanation, or use all of the data in the COPC screen.	Clarify
39	Section 2.4.1.2, page 27:	Samples from outside the initial study area (RM 3-9) were not included in the COPC screen of in-water sediments. As discussed in the comments on Page 17, Section 2.1, Introductory Paragraph, a COPC screen should be done for data outside the ISA. If additional COPCs are identified, they must be carried through the BHHRA. If additional COPCs are not identified, the screening results can be shown in Appendix F5, Supporting Documentation for the Uncertainty and Variability Analysis, and summarized in the Uncertainty section.	Revise
40	Section 2.4.2, page 28: 1st Paragraph -	Modify the 3rd sentence in this paragraph: *"The potential for bioaccumulation is evaluated separately in this BHHRA as part of the fish and shellfish tissue assessments <u>and in Section 6, where SW data are compared to EPA's WQC for human health.</u>"* Also make this modification in the same sentence of the 1st paragraph on page 30. For recreational and transient scenarios, all of the samples of SW within the Shipyard should be included in the COPC screen and exposure point concentration (EPC) calculations.	Revise
41	Section 2.4.5,	Delete "Hypothetical" from the title and from the first and second	Directed Change

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	pages 29-30:	sentences on page 30, The word "hypothetical" should be deleted throughout the BHHRA when referring to SW for domestic use. Note that "future" implies by itself something that is "hypothetical," "potential," "possible," etc. 1st Paragraph - As stated in General Comment 5, under OAR 340-041-0340, Table 340A, domestic water supply is a designated beneficial use of the Willamette River, with adequate pretreatment, and the surface water is potable and capable of serving as a potential drinking water source. Therefore, the first paragraph in this section should be deleted. Uncertainties associated with future use of surface water can be included in the Uncertainty section. Section 2.4.5 should also include a brief discussion of the sources of surface water contaminants. Although EPA agreed that "integrated data" could be used to select COPCs and develop EPCs for surface water as a drinking water source, it was assumed that surface water data from throughout the Portland Harbor site that could be integrated (i.e., by combining near bottom and near surface samples in a given location) would be used and that these data would be integrated as appropriate. Instead only surface water data from the river transects, Willamette Cove, Cathedral Park and the Shipyard were used. Water could be withdrawn from the river at any point for use as drinking water. Therefore, the COPC screening for this pathway should be revised using all appropriate data sets, including data from Round 3. See additional comments on Section 3.4.3.4.	
42	Section 3.1, page 31:	This section of the risk assessment should provide a more complete pathway analysis, which is a critical aspect of the process. The document goes to some detail in defining different categories for exposure pathways (complete, incomplete, complete and significant, etc.), but subsequently discusses only those pathways quantified in the risk assessment. All pathways should be discussed and justification provided for placing pathways into the various categories (potentially	Revise, clarify

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		complete, incomplete, potentially complete but evaluated under a different receptor category, or potentially complete but not evaluated because exposure is expected to be insignificant). As noted in EPA's comments on the Round 2 Site Characterization Report, further discussion is required to explain why certain exposure pathways are evaluated and others are not. The rationale for evaluation/non-evaluation should be included. Pathways not evaluated should be addressed in the Uncertainty section.	
43	Section 3.1, page 31:	The difference between a "potentially exposed" and "hypothetically exposed" population is not clear. In the first sentence here and throughout the risk assessment, delete the term "hypothetical" when discussing potential exposure pathways.	Directed Change
44	Section 3.2, page 33:	In the bulleted list continued from page 32, replace "Hypothetical domestic water use" with "residents" or a similar term. "Domestic water use" is an exposure pathway, not a current or potentially exposed concentration. In addition, The CSM in Figure 3-1 should delete "Hypothetical" for residential ingestion of surface water. As previously indicated, future is a sufficient caveat.	Directed Change
45	Section 3.2.2, Figure 3-1 and Table 3-1:	Infant ingestion of mother's milk and ingestion and dermal contact with household uses of surface water should be added as potential exposure pathways to the bulleted list. The following changes should be made to the CSM in Figure 3-1: Infant exposure to mother's milk should be shown as potentially complete for all receptors. When human milk consumption is included in the final risk assessment, it will apply to all exposure pathways for bioaccumulating chemicals such as PCBs, dioxins/furans, and DDX. Therefore, the human milk pathway should not be limited to fishers, and all receptors in the CSM should be marked with the "potentially complete pathway" symbol. Also, the word "Breast-feeding" should be	Revise

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		changed to "Infant Consumption of Human Milk" in Figure 3.1 and in the text to be consistent with EPA's Child Specific Exposure Factors Handbook (September 2008). Note (d) in Figure 3.1, "Breastfeeding is not quantitatively evaluated in the BHHRA" should be removed.	
46	Section 3.3.1.2, page 35:	The document is internally inconsistent with regards to the discussion of transients. In this section, the document concludes that a given transient would only be exposed in a single area. Later in the document, evidence is presented that suggests transients move among areas frequently. The HHRA should include language that clarifies that the assessment of transients includes an evaluation of individual use areas not only because transient may inhabit single beach areas, but also because such an evaluation provides a range of possible risks for individuals that either move frequently or remain at a single location.	Clarify
47	Section 3.3.1.2, page 36:	The document indicates that maintenance dredging is "mechanical" and workers involved in dredging would not contact sediments. Dredge operators may seldom be exposed to sediments, but other workers involved with maintenance and cleaning of equipment, in off-loading sediments to disposal sites, and likely other activities have greater exposure potential. Either provide a more complete analysis, or omit this discussion.	Clarify
48	Section 3.3.3.4, page 38: Title -	Delete "Hypothetical" in the title for this section. The text in this section should be modified to be consistent with the comments in General Comment 5 and on Section 2.4.5, as follows: *"As mentioned in Section 2.4.5, no known current ~~or anticipated future~~ use of surface water within the Study Area for a domestic water supply is known or planned. However, ~~Due to a requirement by EPA, the hypothetical~~ <u>because domestic water use is a designated beneficial</u>*	Directed Change

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		use of the Willamette River, ~~a use of untreated~~ river water as a domestic water source was assessed as a ~~hypothetical~~ future pathway for both adult and child residents, resulting in exposures through ingestion and dermal contact. In this scenario, exposure to surface water could ~~hypothetically~~ potentially occur throughout the Study Area."	
49	3.3.5.1, page 39:	In the last sentence, delete the word "high-end" in the following sentence: *"Site-specific information is not available for fish consumption rates for specific species, so a range of ~~high-end~~ ingestion rates and various diets were evaluated in this BHHRA for both adult and child consumers."*	Directed Change
50	Section 3.3.5.2, Tribal Fishers, page 39:	In the second sentence, change the word "suggest" to "show" in the following sentence: *"The results of the survey show ~~suggest~~ that tribal members have higher fish ingestion rates than the general public."*	Revise
51	Section 3.3.6.1, page 40:	The language in this section should be deleted and replaced with the following text: *"Although the extent of shellfish consumption in the lower Willamette River is not known, information regarding the consumption of shellfish in the lower Willamette River is available. The Oregon Office of Environmental Public Health, Department of Health Services (DHS) had previously received information from ODFW indicating that an average of 4300 lbs of crayfish were commercially harvested from the portion of the Willamette River within Multnomah County each of the 5 years from 1997-2001. Most of this catch was sold to the Pacific Seafood Company of Oregon. DHS also has information from local commercial crayfish harvesters indicating that Europe is a major*	Revise

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		portion of their market. Furthermore, as part of the McCormick and Baxter assessment in 1991, Ken Kauffman at DHS talked with the wife of a licensed commercial crayfish harvester who served (at that time) as the secretary-treasurer of the Oregon Crayfish Association. She indicated that the area around McCormick and Baxter was a very productive Cray fishery and that she and her husband had harvested there prior to the advisory on many occasions. *"In addition to this historical commercial crayfish harvesting information in the Lower Willamette, DHS also occasionally receives calls from citizens interested in harvesting crayfish from local waters who are interested in fish advisory information. Between 2001 and 2007, DHS fielded 8 calls from citizens who reported catching and eating crayfish from Portland-area waters, although only one was specifically from the Study Are). It is not known what percent of individuals who catch and eat crayfish contact DHS to ask for fish advisory information. DHS estimates that for each person who contacts them regarding the safety of consuming crayfish from the Lower Willamette, there are many more that catch and consume the animals without contacting DHS* *"Although the collection of Corbicula is illegal, this is not particularly important for the pathway in general. There are indications that Corbicula are being collected and consumed (e.g., from the Linnton Community Center's discussion with transients). It is reasonable to assume that bivalve consumption is a current and possible future exposure pathway and that future biomass would increase."*	
52	Section 3.4, page 31:	In this section and subsequently throughout the risk assessment, replace the term "95% UCL/max EPC" with "RME EPC." The repeated references to a "mean" EPC relative to one based on a 95 percent UCL or maximum concentration is misleading. The text in the second paragraph incorrectly states that exposure point concentrations would	Clarify

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		be calculated differently for central tendency (CTE) and reasonable maximum (RME) exposures. Consistent with EPA guidance (1992, 2000), the EPC should represent an estimate of the arithmetic average concentration for a contaminant based on a set of site sampling data. Because of the uncertainty associated with estimating the true average concentration at a site, the 95 percent UCL of the arithmetic mean should be used for this variable. The 95 percent UCL provides reasonable confidence that the true site average will not be underestimated. The average concentration, defined as the 95 percent UCL, should be used for both CTE and RME evaluations. The RME evaluation should be distinguished from CTE by accounting for variability in such variables as exposure frequency and intake rates.	
53	Section 3.4.1.2, page 43:	The document indicates that some transients may be mobile, moving throughout the Study Area, while others may spend the majority of their time at only one beach area. This section represents a third interpretation of transient movement within the Study Area, which is probably the appropriate one. Information available indicates that some individuals move around, some don't, and patterns of movement are unknown. The appropriate interpretation of exposures and risks, calculated by beach area for transients, is that they represent a reasonable range of possibilities for transients residing in the Study Area.	Revise, clarify
54	Section 3.4.2, page 43:	EPCs were calculated for those chemicals (COPCs) selected by screening data within the Study Area. As discussed in the comments on Section 2.4.1.2, and Section 2.1, a COPC screen should be done for data outside the Study Area. If additional COPCs are identified, they must be carried through the BHHRA. If additional COPCs are not identified, the screening results can be shown in Appendix F5, Supporting Documentation for the Uncertainty and Variability	Revise

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		Analysis, and summarized in the Uncertainty section.	
55	Section 3.4.2.2, page 44:	The document indicates that repeated exposure to sediments over a lifetime would occur over a wide area. The text then implies that calculation of risks by half-mile segments misrepresents possible exposure and risks for fishers that use the beach areas. The assessment thus misses one of the main points of taking the approach of breaking risk calculations into short river sections. Use of beach areas by fishers may involve use of more than one river segment, but use cannot be predicted with available data. Thus, the current approach provides a range of possibilities for fishers that frequent one or a few beaches, but not all areas of the river. Such information may be important for risk management of the site. The approach also provides information for fishers who may want to take sediment contamination into account when making fishing location choices. These points should be included in the discussion in this section. Again recall the public information objective of the baseline assessment.	Revise
56	Section 3.4.3.4, page 48:	Delete "Hypothetical" in the title for this section.	Directed Change
57	Section 3.4.5, page 49:	Clarify that the mean EPCs for fish and shellfish tissue were calculated assuming that all NDs were one-half the detection limit.	Clarify
58	Section 3.5.1, page 51:	The last sentence, "The actual exposure at a given location may be less than that assumed … due to location-specific conditions," does not convey the appropriate interpretation of site-specific risk assessments. First, all such assessments seek to characterize risks in the upper range of those possible, and therefore intentionally estimate exposures that might be high for the bulk of the population. Second, the use of central tendency exposure parameters seeks to provide information that better characterizes typical population exposures. Location-specific	Revise, clarify

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		differences do influence "actual" exposures, but it's not clear whether such influences would either take the estimates outside of what is defined as RME, or would always tend to cause CTE to be overestimated. Noting uncertainties in risk assessment discussions is appropriate, but such discussions need to address issues objectively.	
59	Section 3.5.1.1, page 51	The first 3 sentences in the second paragraph of this section should be modified as follows: *"~~Although~~ Because it is unlikely that significant beach sediment exposure would occur for a dockside worker on a ~~regular~~ daily basis, exposure assumptions for the dockside worker were developed using EPA default exposure values for an industrial worker for most parameters except for exposure frequency. For exposure frequency, it was assumed that a worker would only contact sediment one day per week while working at the industrial site, rather than 5 days per week, which is the EPA default value."*	Revise
60	Section 3.5.1.2, pages 51-52:	The document asserts that significant contact with sediments is unlikely during mechanical dredging. However, the situation is complex. Potential for exposure depends on equipment used and varies among workers carrying out different tasks. In general, equipment operators for mechanical dredging are not affected since they operate from cabs or control areas away from the sediment. However, laborers working near the excavation equipment or near discharge points could be affected. Therefore, delete the first part of the following sentence as shown: *"~~Although most maintenance dredging activities are mechanical and are unlikely to result in significant sediment contact~~, [T]he in-water worker exposure factor intake rates for in-water sediment are the same as the dockside worker for beach sediment, which in turn are the same*	Revise

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		as default exposure factors for soil for an industrial worker." Modify the following sentence as shown: *"For intake rates <u>for transients</u>, EPA required that <u>the soil ingestion rate and soil adherence factor be increased above those EPA defaults</u> values ~~greater than those~~ recommended for residential soil exposures ~~be used~~ for beach sediment and that residential, tap water ingestion rates be used for surface water."* After this sentence add: *"The higher soil ingestion rate (200 mg/day instead of 100 mg//day) and soil adherence factor (0.3 mg/cm^2 instead of 0.07 mg/m^2) were used as it is expected that transients living on a beach would have more contact with beach sediment than a residential adult might have with residential soil and dust. For example, transients will have limited access to washing facilities and could therefore more frequently transfer sediments from hand to mouth while eating, smoking, etc."*	
61	Section 3.5.1.5, page 53:	This section should be titled "Non-Tribal Fishers" as none of the discussion pertains to tribal fishers. This would help distinguish Section 3.5.1.5 from Section 3.1.5.6, which is specific to tribal fishers.	Clarify
62	Section 3.5.1.5.1, page 53:	Please make the indicated revisions to the text in this section: *"~~EPA does not have recommended default exposure parameters for fishing scenarios., so the exposure frequency and duration for fishers are based on EPA's requirements or best professional judgment.~~ EPA provided the exposure frequencies and durations for the fishers used in this BHHRA. High-frequency fishers were assumed to fish from the same beach area three days per week for the entire year (156 days/year) for ~~the default residential exposure duration (~~30 years~~)~~ for the RME. Low-frequency fishers were assumed to fish from the same beach area for two days per week for the entire year (104 days/year)*	Revise

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		~~for the default residential exposure duration (~~30 years~~)~~ for the RME~~.~~ ~~Although it is not known how much sediment contact actually occurs during fishing activities, default intake values for residential soil were used."~~ An EF is appropriate for a resident at a single location (address), but does not suggest that 30 years is appropriate for living in a given city or town. Thirty years is used, not because it's a residential ED, but because we don't have a good way to estimate "time in the Portland area," and 30 years doesn't seem unreasonable. The estimate could underestimate exposure for some unknown fraction of lifetime Portland area residents, and this issue should be taken up briefly under uncertainties. Also, no support exists for this portion of the second sentence: "a fisher is unlikely to have significant contact within in-water sediment." Therefore, delete this sentence. Modify the 4th sentence as shown: *"Based on exposure scenarios for in-water sediment (i.e., contact with sediment on fishing lines, anchors and ropes, hooks, or crayfish pots and ropes), the extent of contact with in-water sediment is expected to be ~~would be significantly~~ less than what would occur with residential soil."*	
63	Section 3.5.1.5.1, pages 53-54:	Add "(Non-Tribal)" after "Consumption" in the title for this section. It is inappropriate to refer to the non-tribal adult and child fish ingestion rates used for this HHRA as "high," "higher," and "highest." These rates must be changed to "low," "medium," and "high," respectively, and references to the ingestion rates as "high end" deleted. The rationale for this comment is discussed in greater detail in General Comment 1. Other parts of the HHRA where fish consumption rates are discussed and/or presented should also be modified, including the tables. In fact, many of the tables still contain reference to "low,"	Directed Change

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		"medium," and "high" ingestion rates, which are the descriptors agreed to by EPA for the non-tribal fish ingestion rates in the HHRA. For example, in Table 3-29, which is referenced in this section, the three ingestion rates for non-tribal adults, 17.5 g/day, 73 g/day, and 142 g/day, are identified as low, medium and high ingestion values, respectively; the three ingestion rates for non-tribal children, 7 g/day, 31 g/day, and 60 g/day, are identified as low, medium and high ingestion values, respectively. In addition, the text at the end of the first paragraph referring to the fish consumption advisories at Portland Harbor should be deleted. The advisories represent an institutional control, and the baseline risk assessment should address exposures and risk in the absence of any actions to control or mitigate exposures. Fish ingestion rates for "consumers only" should be included when discussing the EPA 2002b document to make it clear that the 90th and 95th percentile rates for "consumers only" are higher than the values used here. The manner in which the values of 17.5 g/day and 142 g/day are presented makes them sound unreasonable when, in fact, they are quite reasonable when compared to the "consumer only" values of 200 g/day and 506 g/day, respectively. In particular, the rates used in the draft BHHRA imply that fish consumers would need to take only a fraction of total fish and shellfish from Portland Harbor. These fractions should be presented. At the end of the 1st paragraph in this section, it should be added that a goal of site remediation is to ultimately remove the fish advisory. Therefore, rates for potential future fish consumption should be considered in the absence of a fish advisory or after any advisory is modified to allow for greater fish consumption.	
64	Section 3.5.1.5.4, page	Table 3-29, which is referenced in the text in this section, lists the 3.3 g/day shellfish consumption value as a "low value." The text in this section should be modified to be consistent with the table and with	Directed Change

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	56:	previous agreements with EPA.	
65	Section 3.5.1.2, page 56:	Delete the second sentence, as it represents an unsupported assumption. Replace the first three sentences in the second paragraph with the following sentence: *"Contact with sediment on anchors or hooks represents the most likely exposure route for contact with in-water sediments for tribal fishers."*	Revise
66	Section 3.5.1.3, page 57:	Add "Tribal" in front of "Fish" in the title for this section. ODEQ is proceeding to develop state water quality standards based on the CRITFC Fish Consumption Survey result of 175 g/day. This should be discussed in this section as support for the selection of 175 g/day as an appropriate fish consumption rate for tribal populations who regularly consume fish.	Revise, clarify
67	Section 3.5.1.6.3, page 58:	Modify the following sentence as shown: *"The combined intakes from anadromous salmonids <u>and</u> lamprey, <u>from</u> sturgeon, and <u>from</u> the remaining fish species in the above table were used to estimate risks from fish consumption."*	Revise
68	Section 3.5.1.8, page 59:	Title - Replace "Hypothetical" with "Potential" in the title for this section. Change the word "hypothetical" to "potential" when referring to domestic water in this section and throughout the HHRA. Inhalation of contaminants from surface water should be included as a part of the scenario, unless it can be shown that this is not an issue for the surface water contaminants that are selected for evaluation in Section 6.	Directed Change
69	Section 4.1,	In the first sentence, the word "dose" should be added before	Revise, clarify

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	page 62:	"response" so that it reads, "dose-response potency." "Inhalation SFs" should be changed to "Inhalation Unit Risk Values." "Inhalation RfDs" should be changed to "Inhalation Reference Concentrations."	
70	Table 4-2, Non-Cancer Toxicity Data	It is not clear where acronym "I" (RfDs for intermediate exposure duration) applies since the same letter "I" is also an acronym for IRIS.	Revise, clarify
71	Section 4.3, page 63:	Revise the text as shown: *"The California Environmental Protection Agency (Cal EPA 2008.) ~~includes SFs that have been peer-reviewed.~~"* The Cal EPA database includes additional peer-reviewed values, such as acute and chronic reference exposure levels.	Revise
72	Section 4.6, page 67:	In the 3rd bullet**,** the following sentence should be modified as shown: *"This approach <u>may</u> double-count <u>a portion of</u> the toxicity of the dioxin-like PCBs, as discussed in Section 7.3.6."*	Revise
73	Section 4.7, page 68:	It would be useful to provide more information on the COPCs for which the oral toxicity factor was modified. For example, from a review of Tables 4-1 and 4-2, it appears that this adjustment was not made for any slope factors, and was limited to the metals for RfDs. The approach used to evaluate dermal risk could underestimate risk by a factor of up to 2, since no adjustment to slope factors or RfD is required if oral absorption efficiency is greater than 50 percent.. This issue should be discussed as an uncertainty in Section 7.	Clarify
74	Section 5.1.2,	The following statement occurs in this section:	Revise

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	page 70:	"*All cancer risks were calculated using this same linear model, even though risk estimates for some scenarios exceed 10^{-2}, in which case, EPA guidance (EPA 1989) states that risks may be calculated using an exponential model.*" This text is incorrect, as the referenced guidance clearly states that the linear equation is valid only when estimated risks are less than 0.01. The exponential one-hit equation for high carcinogenic risk levels should (not "may") be used where estimated risks are greater than 0.01. At least one calculation for bass and one for carp (e.g., Total PCBs (adjusted) for WB bass, RM 11, and for WB carp from RM 4-8, both at 142 g/day) should be re-calculated using the exponential model. The last two sentences in this section should be modified as follows: *"Estimated total cancer risks were compared to 10^{-4}, 10^{-5}, and 10^{-6} cancer risk targets based upon the following language in EPA's National Contingency Plan (NCP):* "For known or suspected carcinogens, acceptable exposure levels are generally concentration levels that represent an excess upper bound lifetime cancer risk to an individual of between 10^{-4} and 10^{-6} "target range. *The 10^{-6} risk level shall be used as the point of departure for determining remediation goals for alternatives when ARARs are not available or are not sufficiently protective because of the presence of multiple contaminants at a site or multiple pathways of exposure."* When discussing risk characterization results in the HHRA, risk values should be compared to cancer risk values of 10^{-6}, 10^{-5} and 10^{-4}.	
75	Section 5.2, page 71:	The presentation of information in this and the following subsections should be consistent with EPA's Risk Characterization Policy (http://www.epa.gov/osa/spc/pdfs/rchandbk.pdf) to assist with preparation of a transparent and useful characterization of risk results. Accordingly, several global changes should be made to these	Directed Change

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		subsections: a) As previously discussed, the HI calculated by summing the HQs for individual chemicals should be added to all of the risk characterization tables in the HHRA. For example, in Table 5-138, the results for WB carp, RM 0 to 4, should have the HIs shown for each ingestion rate under non-cancer. This approach is used for cancer risk calculations in this and all other tables, but not for the non-cancer HIs. Only those exposure points where the HI is greater than 1 should be further evaluated in tables that show the endpoint-specific HIs. b) The HHRA (including numerous instances throughout this section) makes inappropriate statements regarding compounding uncertainties. While EPA and the LWG agreed to limit the discussion of uncertainties to either the end of each section (e.g., Exposure Assessment, Toxicity, Risk Characterization) in the HHRA or in the Uncertainty Section, statements on uncertainty are included throughout the discussion in this and other sections of the draft BHHRA. These statements that "risks could be higher or lower if" provide no useful information, or the text focuses only on those uncertainties that will result in an "overestimate" of risk. These sections must be revised to eliminate inappropriate statements on compounding uncertainties. Statements regarding uncertainties must be moved to the end of major sections or to the uncertainty section. The latter is the most appropriate place for more detailed discussion, such as those involving fish ingestion rates. The text repeatedly states that, "multiple conservative assumptions compound to result in an estimate of risk that can be many times (or orders of magnitude) greater than the likely actual risk posed by a particular site." EPA is not aware of any studies that support the generalization that deterministic risk assessments typically result in estimates of risk that are "orders of magnitude"	

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		greater than any that are likely to occur. The primary concern should not be related to the compounding of conservative inputs, but should focus on the choice of the inputs themselves. If values are chosen that fall outside the range of those possible, and are associated with a sensitive input to the exposure and risk calculations, then estimated risks can fall outside the upper end of those possible. However for the BHHRA, the inputs were carefully chosen to be representative of either current and/or potential future scenarios and to result in an estimation of Reasonable Maximum Exposure, as required by EPA Superfund guidance. The approach used in this HHRA follows standard EPA risk assessment guidance and is similar to risk assessment approaches used on other Superfund sites. There is no reason to conclude that the risk assessment for Portland Harbor should be considered exceptional with regard to reasonable maximum exposure assumptions. c) A summary discussion that is linked to one or more summary tables and graphs/maps should be presented at the end of each scenario to summarize the information that is provided in the many tables in this HHRA. For example, at the end of this Section 5.2.1, Beach Sediment Characterization Results, a summary table should be added that includes those beaches with cancer risks exceeding of 10^{-6}, 10^{-5}, and 10^{-4} for each receptor, with the actual cancer risk value for each beach by receptor and contaminant for that beach. The summary discussion should link to this table, to a discussion of Map 2-1, and to the graphs described below for this section and other sections. For some scenarios, like biota consumption, more than one summary table/graph may be needed. d) Graphical depictions of risk should be added to this section for each scenario to provide spatial information on those receptors	

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		and pathways with the highest risks: tribal and non-tribal fish consumption for adults and children, consumption of shellfish, in-water sediment exposure for fishers, wet suit diver, and exposure to beach sediment. These depictions should spatially show the risk characterization results for total cancer risks, and for cancer risks and non-cancer HIs for selected chemicals posing potentially unacceptable risk by exposure area. These figures should be tied into the discussion of the summary tables mentioned above in (b). LWG should allow for EPA review of graphics prior to completion of the revised draft. e) When discussing the risk from cPAHs, the sum of the risks from all cPAHs should be included as the primary risk results. These results should include a presentation of relative contributions of different cPAH species. cPAHs typically occur as a mixture, and individuals will most likely be exposed to all cPAHs present.	
76	Section 5.2.1, Pages 71-76:	A summary discussion should be presented at the end of this section that references a summary table showing all of the beaches that are above risk levels of 10^{-6}, 10^{-5}, and 10^{-4} for each receptor, with contaminants included. This presentation should also include graphs for tribal adult exposure to beach sediments, for total cancer risk by beach, and for cancer risk for arsenic, dioxin/furan TEQ, B(a)P, and total cPAH by beach. Other beach scenarios (e.g., recreational users, transients, and dockside workers) should also be shown. The graph should be organized by river mile (east and west) with corresponding sample numbers for each river mile shown. a) The total HI calculated by summing the HQs for individual chemicals should be added to all of the risk characterization tables. Tables showing endpoint-specific HIs can be eliminated for those scenarios where the total HIs for all chemicals are less than 1.0, but should be shown for endpoints with HIs that exceed 1, if more than	Revise, clarify

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		one endpoint shows such a result. b) Maps 5-1, 5-2, and 5-3 should include the calculated risk values for those beaches where estimated risks are greater than 1×10^{-6}. c) The discussions of arsenic are vague throughout this section and elsewhere in the risk characterization section. The discussions provided do not allow the reader to evaluate arsenic contribution to risks or at which beaches arsenic concentrations are greater than background levels. The points that need to be made are 1) arsenic occurs both naturally and as a result of environmental releases, and 2) assuming an estimated background of 7 mg/kg, the degree to which background concentration contribute to the EPC and risk should be described.	
77	Section 5.2.1.3.1, pages 72-73:	As previously noted, when referring to exposure areas that are above a defined risk, the actual risk value for the exposure area should be presented. For example, where risks associated with cPAHs are greater than 10^{-6} such as at beaches 04B024 and B003, , the specific risks should be presented.	Clarify
78	Section 5.2.2, pages 76-81:	A summary discussion should be presented at the end of this section that includes reference to two summary tables by RM for each side of the river. These tables should be included for those in-water sediment areas with estimated risks greater than 10^{-6}, 10^{-5}, and 10^{-4} for each receptor. Chemicals posing potentially unacceptable risk for each area and receptor should be included. Graphical depictions should be presenting showing cancer risk and non-cancer hazards associated with tribal adult fishers exposure to in-water sediment by one-half river mile segments for total cPAHs and dioxin/furan TEQs. Results for other fisher scenarios should also be presented in the figure. A similar graphical depiction of total cancer risk for commercial divers in wet suits by one-half mile segments for total cPAHs, B(a)P, dioxin/furan	Clarify

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		TEQ, PCB TEQ, and total TEQ. Results for the diver in a dry suit and for in-water workers should also be shown on the figures.	
79	Section 5.2.2, pages 76-81:	HIs calculated by summing HQs for individual chemicals should be added to all of the risk characterization tables. Tables showing endpoint-specific HIs can be eliminated for those exposure areas/scenarios where the total HI for all chemicals is less than 1.	Revise, clarify
80	Section 5.2.2, pages 76-81:	When referring to cancer risks from a chemical or class of chemicals in the narrative, that risk value should be provided. For example, in the second sentence on page 79, the risk from dioxins/furans, B(a)P, and total cPAHs should be clearly presented.	Clarify
81	Section 5.2.2, page 76:	Delete the following sentence, as it mischaracterizes the effect of multiplying exposure parameters: *"The health protective assumptions regarding direct exposure to in-water sediment were multiplied together, which magnifies the overall conservatism in the risk estimates."*	Revise
82	Sections 5.2.2.3.1 and Section 5.2.2.3.2, pages 79-80:	The last paragraphs in these 2 sections contain much of the same text provided in Section 5.2.2.3. The repetitive text in these two paragraphs can be deleted.	Revise
83	Section 5.2.3, page 81:	Delete the following sentence from the first paragraph, as it mischaracterizes the effect of multiplying exposure parameters**:** ***"****The health protective assumptions regarding direct exposure to surface water were multiplied together, which magnifies the overall conservatism in the risk estimates."*	Directed Change

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84	Section 5.2.3, pages 81-85:	HIs calculated by summing HQs for individual chemicals should be added to all risk characterization tables. Tables showing endpoint-specific HIs can be eliminated for those scenarios where the total HI for all chemicals is less than 1. A summary table showing river segments with SW contaminant concentrations above a cancer risk of 10^{-6} and 10^{-5} for each segment should be added at the end of this table. If the results of the screening assessment of potential future domestic water use using all of the relevant SW data identifies chemicals above screening levels in addition to arsenic, the results should be presented on a figure.	Clarify
85	Section 5.2.3.4, page 83:	Replace "Hypothetical" with "Potential" in the title for this section and elsewhere within Section 5.2.3. As previously discussed, additional surface water sampling data should be used for the screening for selection of COPCs, using both MCLs and EPA RSLs.	Directed Change
86	Section 5.2.3.4.1, page 84:	The text describing arsenic concentrations in surface water is difficult to decipher and, as presented, appears to imply that concentrations of arsenic in surface water in the Study Area are less than background, which does not appear to be the case. The discussion in this section should clearly note the degree to which arsenic is detected in surface water at concentrations greater than background and the contribution of naturally-occurring concentrations to the total risk estimates. The text should note the current MCL for arsenic as a benchmark to help putting the risk estimates in perspective.	Clarify
87	Section 5.2.4.1, page 85:	In the first paragraph, delete the third sentence, as it mischaracterizes the effect of multiplying exposure parameters: *"The health protective assumptions regarding direct exposure to groundwater seeps were multiplied together, which magnifies the overall conservatism in the risk estimates,"*	Revise

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88	Section 5.2.4.1, page 85:	HIs calculated by summing HQs for individual chemicals should be added to all of the risk characterization tables. Tables showing endpoint-specific HIs can be eliminated for those scenarios where the total HI for all chemicals is less than 1.0	
89	Section 5.2.5, page 86:	Delete the following from the first paragraph of Section 5.2.5: *"In estimating the risks in this BHHRA, the health protective assumptions regarding fish consumption were multiplied together, which magnifies the overall conservatism in the risk estimates. The cumulative effects of the numerous conservative assumptions made during this BHHRA are risk estimates that are potentially significantly higher than actual risks that may exist within the Study Area."*	Revise
90	Section 5.2.5, pages 86-91:	Delete the last paragraphs in Sections 5.2.5.1.1, 5.2.5.1.2, 5.2.5.2.2 and 5.2.5.3.2. Exposure assumptions summarized in these paragraphs have already been presented in an earlier section, and the uncertainties are repeated at the end of each subsection so as to suggest that the risk characterization results are extremely uncertain. Hence, the last paragraph in each of these sections should be moved to the uncertainty discussion. Wherever present, revise the following sentence as indicated: *"The calculated risks do not account for any ~~decrease~~ changes in tissue concentrations of chemicals that may occur during preparation or cooking of the fish."*	Revise
91	Section 5.2.5, pages 86-91:	When discussing fish consumption in the Uncertainty Section, revise the text as indicated: *"Fish consumption was assumed to occur at this level every day of every year for 70 years (or 30 years)."* Fish ingestion rates are annually amortized based on the estimated number of fish meals per month and typical serving sizes. This rate	Revise

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		does not imply that fish is ingested every day. In fact, all ingestion for a given rate could in theory occur over a few to several months, with no fish consumption for the rest of the year. In addition, such patterns could change over the course of 30 years, and greater fish consumption could occur in some years and less in others. The assumption is that over the course of 30 years, individual fish ingestion rates don't change substantively. This comment also applies to the discussion regarding consumption of shellfish on page 91.	
92	Section 5.2.5, pages 86-91;	A summary discussion that is linked to one or more summary tables and graphs/maps should be presented at the end of the section for tribal fishers and at the end of the section for non-tribal fishers. This section should include figures for each non-tribal scenario to provide spatial information for total cancer risks as well as contaminant specific risks and HIs by river mile. These figures should be tied into the discussion of the summary tables and should include the following information: a) Total cancer risks for adult (non-tribal) fish consumption of bass by river mile. The range in risks from the 3 consumption rates should be shown. b) Cancer risk for adult (non-tribal) fish consumption of bass by river mile for total PCBs (adjusted), total DDD, and total TEQ. The range in risks from the 3 consumption rates should be shown. Alternately, the highest ingestion rate of 142 g/day can be used alone. c) Endpoint-specific non-cancer HQs for child (non-tribal) fish consumption of bass by river mile for total PCBs (adjusted), total DDD, and total TEQ. The range in HQs from the 3 consumption rates should be shown. Alternately, the highest ingestion rate of 142 g/day can be used alone. d) Graphs similar to those described above for tribal fishers. Since	Revise, clarify

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		river mile calculations were not done for tribal fishers, it might be possible to include tribal fishers on the non-tribal fisher graphs. e) Graphs similar to those described above for carp. Results for river miles 3-6, 6-9, 0-4, 4-8, and 8-12 can be shown on one graph. For cancer and non-cancer HIs, cancer risk and HIs for total PCBs (adjusted), total DDD, and total TEQ should be shown in separate graphs by river mile segments. A legend with the figure should explain total PCBs and the three TEQ estimates. The HI calculated by summing the HQs for individual chemicals should be added to all of the risk characterization tables. A legend with the figure should explain total PCBs and the three TEQ estimates.	
93	Maps 5-7 through 5-14:	Maps 5-7 through 5-14 should be relabeled and should present additional information. Fish ingestion rates for 17.5 g/day should be labeled as "Low," not "High"; the shellfish consumption rate of 3.3 g/day should be labeled as "low"; etc. In addition, maps with every segment of the river highlighted are not useful. For bass, cancer risks and HIs for each river mile need to be added to the map. For the carp, crappie and bullhead data from Round 1, the cancer risks and HIs need to be added for each sampling segment for which an EPC was calculated.	Directed Change
94	Section 5.2.5.1, pages 88-90:	As discussed in General Comment 1, the descriptors for fish consumption rates need to be changed from high, higher, and highest to low, medium, and high, respectively.	Directed Change
95	Section 5.2.5.3, pages 90-91:	Delete this section as it contains inappropriate comparisons to regional risk levels. As discussed in General Comment 5, several inappropriate discussions are included that relate to background and "regional" risk levels in this section and other sections of the draft BHHRA, especially for biota. EPA and the LWG agreed that the biota data collected upstream of the	Revise

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		Portland Harbor site by the LWG could be presented in the RI for "informational purposes," but should not be used for a background assessment in the BHHRA. Therefore, no "background" data set exists for biota for Portland Harbor that can be used and/or evaluated in the BHHRA. Any reference to background in relation to biota in the BHHRA should be deleted. EPA acknowledges our agreement to use upstream tissue data for information purposes in the remedial investigation report. Comparisons are also made to risks from biota consumption in other "regional" risk studies (e.g., the EPA *Columbia River Basin Fish Contaminant Survey*, and the ODEQ mid-Willamette Basin study). These studies, which were initiated because of known or suspected concerns with contamination in the particular areas in which they were done, are not relevant to the Portland Harbor site. EPA's risk assessment guidance is clear that risks from all contaminants at the site are to be characterized. Following the risk characterization, comparisons to background risk can be discussed in a risk assessment, provided such data are available. However, this is not the case for biota in Portland Harbor. Comparisons to risks from other contaminant surveys are irrelevant and have no place in the BHHRA as they provide no useful information on the Portland Harbor Site risks or background risks. Contribution of background to the overall site risks can be addressed using background sediment data, which were collected specifically for use in the risk assessment.	
96	Section 5.2.6, pages 91-92:	As noted in the specific comments on Section 5.2.5, the following revisions should be made in this section: a) Delete the following sentence in the first paragraph: ~~"*In estimating the risks in this BHHRA, the health protective assumptions regarding shellfish consumption were multiplied together, which magnifies the overall conservatism in the risk*~~	Directed Change

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		~~*estimates. The cumulative effects of the numerous conservative assumptions made during this BHHRA are risk estimates that are potentially significantly higher than actual risks that may exist within the Study Area.*"~~ b) Uncertainties should be discussed in Section 7, Uncertainty Analysis. Move the last paragraph in this section to the uncertainty section Modify the following sentence: "*The shellfish consumption scenario assumes the same ingestion rate every day of every year for 30 years."* to note that, as stated in the comments above on fish consumption, shellfish consumption rates are annually amortized based on the estimated number of shellfish meals per month and typical serving sizes. This rate does not imply that the same amount of fish is consumed every day. When consumption of shellfish is discussed in the Uncertainty Section, the following phrase should be deleted: "*despite the fact that there is no documented ongoing consumption of shellfish in the Study Area and the harvest or possession of Asian clams, the species assessed in the BHHRA, is illegal*."	
97	Section 5.2.6, pages 91-92:	The discussion in this section should be linked to a summary table that shows cancer risks by river mile on each side of the river for clams and by sample point for crayfish. Sample numbers should be included. Figures or graphs should be included that depict the total cancer risk results due to ingestion of clams (based on undepurated samples) for each river mile on each side of the river, cancer risks for total PCBs (adjusted), total carcinogenic PAHs (not just benzo(a)pyrene), total dioxin/furan TEQs, total PCB TEQs, and total TEQ by river mile segment. For non-cancer HIs, total PCBs (adjusted), total dioxin/furan TEQ, total PCB TEQ, and total TEQ should be shown in separate figures by river mile segment. Similar figures should be included showing risks and hazard associated	Revise, clarify

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		with consumption of crayfish. Results at each sampling point on each side of the river (east and west) should be shown on one graph, and the river mile included with the sample point number. Multiple sample points will be mapped for some river miles. Graphs should be provided for total cancer risks for each river mile on each side of the river. For cancer, total PCBs (adjusted), total Aroclors, and total TEQ should be shown in separate figures by river mile segment. Non-cancer HIs for total PCBs (adjusted), total Aroclors, and total TEQ should be shown in separate graphs by river mile segment.	
98	Section 5.2.6, pages 91-92:	The consumption rate of 3.3 g/day should be referred to as "low" not "medium." The use of the word "low" for 3.3 g/day was agreed to by EPA and the LWG and was used in the Round 2 Report. A discussion which describes the number of meals per month to which consumption rates of clam or crayfish equate should be included here. For example, for clams, 3.3 g/day is less than one 8-ounce meal every 2 months, and 18 g/day is approximately two an one-half 8-ounce meals/per month.	Directed Change
99	Section 5.2.6, pages 91-92:	The document concludes that Study Area-wide cancer risks from consumption of undepurated clams are 2 to 3 times higher than those from Study Area-wide cancer risks from depurated clams, and that corresponding non-cancer hazards are 1 to 2 times higher. The database for COPCs in depurated clam tissue is limited to 5 of the 22 clam samples, and these 5 samples are from the northern stretch of the river (1E and 2W) and the southern stretch of the river (10W, 11E, and 12E). It is not appropriate to compare risks from these 5 depurated samples from the edges of the site to the 22 non-depurated clam samples from the entire length of the site from RM 1 to RM 12, or to compare non-depurated clams to depurated clams from only the edges of the site (1E and 2W; 10W, 11E, and 12E) and assume that the results are representative of the entire site. As no supporting calculations are presented in the draft BHHRA, it is not clear what samples were used for these calculations, and EPA cannot determine if the calculations are	Issue

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		correct. These supporting calculations should be included in Attachment F5. In drawing conclusions from this analysis, the discussion should be clear that these data only provide information on 5 sampling locations, all of which are on the edges of the site rather than in areas with particularly high cPAH concentrations.	
100	Section 5.2.6, pages 91-92:	Additional clarification is needed for some of the assumptions used in both the ALM and the IEUBK. It appears that the values for exposure frequency to in-water sediments should be the same as those presented as central tendency for exposure frequency for each respective receptor in Table 3-27 unless additional rationale for the values cited in Tables F4-1 and F4-2 can be provided. In addition, the basis for the site-specific values for the adult baseline blood-lead level and absolute GI absorption should be more clearly explained. To the extent possible, the default values in the IEUBK for soil lead concentration, house dust lead concentration, lead concentration in air and in drinking water should be replaced with site-specific values.	Clarify
101	Section 5.3, pages 96-97:	As discussed previously, the descriptions of "high," "higher," and "highest" for the three non-tribal fish consumption rates should to be changed to "low," "medium," and "high," respectively.	Directed Change
102	Section 5.3, pages 96-97:	Delete the last two sentences in the first paragraph.	Directed Change
103	Section 5.3, pages 96-97:	Modify the last paragraph in this section as follows: "Chemicals *were identified as preliminary COCs if they resulted in a cancer risk greater than 1 x 10^{-6} or an HQ greater than 1 under any of the exposure scenarios for any of the exposure point concentrations evaluated in this BHHRA~~, regardless of the uncertainties~~. Preliminary COCs and the associated exposure scenarios are presented in Table 5-187. ~~The final COCs, which are based on consideration of the uncertainties in this BHHRA, are presented in Section 8. Certain chemicals and media contribute significantly more than others to~~*	Revise

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		~~*overall risk for the Study Area. A more detailed description of risk drivers for the Study Area is provided in Section 8.*~~"	
104	Section 5.3, pages 96-97:	The summary of the ranges of variation in HI values is overstated here and in Table 5-186, as indicated previously in the general comments. This exaggeration occurs because each toxic endpoint in an exposure scenario is considered independently. Instead, each scenario should be evaluated based on the chemical(s)/endpoint combination resulting in the greatest HI. For example, in Table 5-186, the HI range for tribal fisher direct exposure to in-water sediment across all half-mile segments is listed as 0.00000008 to 1. This range is developed using the very lowest chemical/endpoint combination (naphthalene causing whole body effects) to the highest chemical/endpoint combination (arsenic causing skin effects). The lowest HI for a scenario is irrelevant for decision making; decisions are based on the highest calculated HI at each location. Using the approach presented in the BHHRA, one would show dramatic ranges in HI for every scenario in every risk assessment. The correct range for tribal fisher sediment exposure should be developed using the highest chemical/endpoint combination at each location (Table 5-36). This range is 0.002 (arsenic, skin effects) to 1 (dioxin TEQ, reproductive effects). In this example, the HI range in Table 5-186 is overstated by a factor of 25,000. The values in the bullets and in Table 5-186 will also change because many of the endpoint-specific tables will have been removed because the total HIs for many scenarios are less than 1.	Revise
105	Section 6.0, Page 98:	The title of this section should be changed to *Screening and ARAR Evaluation of Surface Water and Groundwater*. This evaluation should utilize the maximum detected concentration of each chemical in individual SW samples included in the RI, including near bottom samples, samples collected during various source evaluations at Portland Harbor, and pore water samples collected in the biologically active zone (0 to 40 cm). These results should be compared to EPA	Directed Change

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		AWQC (at fish consumption rates of 17.5 and 142 g/day), non-zero MCLGs, MCLs, and RSLs. Any chemical for which the maximum detected concentration is greater than its AWQC (at both ingestion rates), non-zero MCLG, or MCL should be included in Table 8-1 and carried forward into the FS. The limitations of this screening process should be discussed in the uncertainty section of the risk assessment. The revised Section 6 should include a table or series of tables that present the various screening values and which values are exceeded for each chemical. Sampling locations where specific screening criteria are exceeded should be documented in a table and presented on a map or series of maps similar to Map 6-1 that is currently in the draft BHHRA. The labeling of sample locations on the tables and maps should presented such that the maps and tables can be used together to identify chemicals that exceed criteria.	
106	Section 7.0, page 104:	Revise the first paragraph to delete the following sentence: *In a deterministic risk assessment multiple conservative assumptions compound to result in an estimate of risk that can be many times (or orders of magnitude) greater than the likely actual risk posed by a particular site."* There is no information presented in this section or anywhere else in the risk assessment to support such a claim.	Revise
107	Section 7.0, page 104:	EPA disagrees with the characterization presented in the second paragraph that only a probabilistic risk assessment (PRA) can provide a quantitative estimate of uncertainty. At a minimum, a quantitative assessment of the uncertainty associated with each numerical value used in the risk assessment is possible. The text in this section fails to note that default and/or "upper-bound" values were used in the risk assessment only when reliable alternative values are not available, and were used to ensure that any bias introduced into the risk assessment	Issue

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		did not result in an underestimate of actual site risks. Further, this section fails to note that the reliability of any numerical probabilistic assessment of uncertainty is dependent on a reliable knowledge of the distribution of plausible values for each of the variables used in the assessment, and that the guidance cited specifically states that a tiered approach to a PRA is advocated, which begins with a point estimate risk assessment. Important considerations include the time required to perform the PRA, the additional resources involved in developing the PRA, the quality and extent of data on exposure that will be used in the assessment, and the value added by conducting the PRA. Unless specific information can be provided here regarding how a PRA would enhance the decision-making process for Portland Harbor, this paragraph should be deleted.	
108	Section 7.0, page 105:	Last paragraph of this section: Delete the 2nd sentence, which begins: "*The objective of the uncertainty analysis is to understand the overall degree of conservatism...*" While conservatism is one important aspect of the uncertainty analysis, the analysis also informs the risk managers of gaps in knowledge, unsupported assumptions and extrapolations, data gaps and other data issues, and other sources of uncertainty that may affect risk estimates and subsequent risk management for the site. This language implies that the results of the HHRA are always overly conservative, when in actuality the results may under-predict risks in some instances. The objective of the uncertainty analysis should be a balanced discussion of the assumptions on which the risk estimates are based.	Directed Change
109	Section 7.1.1, page 105:	The assertion in the text that, "*target species were selected to provide the most conservative estimate of risk,*" is unjustified. The fish species for the HHRA evaluation were selected to be representative and reasonably conservative and to consider the factors given in the last sentence of this paragraph, "*Factors in selecting the target species included: consumption by humans, home range, potential for*	Directed Change

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		bioaccumulation, trophic level of species, and abundance." EPA, its partners, and the LWG agreed to the species selected. It is certainly not clear that all species not included in the quantitative analysis would be "less conservative." Therefore, the following sentence should be deleted: "*The target species were selected to provide the most conservative estimate of risk to human health and are a source of uncertainty when used to represent the risk from consumption of all biota within the Study Area.*"	
110	Section 7.1.2, page 106:	The text in this section should be revised to provide additional information regarding tissue concentrations in the WA DOE study and concentrations of similar fish in Portland Harbor, and to clarify whether the results are comparable based on whether the measurements are based on whole body or fillets with skin. If the results from the DOE study are presented as risk estimates, the calculations must be provided somewhere in the risk assessment. Delete the word "significant" from the last sentence.	Revise
111	Section 7.1.3, page 107:	The following statement occurs in the first paragraph: "*Depending on the species and chemical, the difference in concentrations between fillet and whole body tissue can be minimal or more than a factor of 10, as discussed in Attachment F5."* As discussed in our comments on Attachment F5, a table should be provided that shows data used and results that supports the conclusion (e.g., "*factor of 10"*) presented here. Analyses not reported in the risk assessment cannot be evaluated or approved by EPA.	Revise, clarify
112	Section 7.1.4, pages 107-108:	This section concludes that, **"***With the exception of a few metals, average chemical concentrations were higher in undepurated clam tissue collected at the Study Area than in depurated clam tissue*. The database for COPCs in depurated clam tissue is limited to 5 of the 22 clam samples, and these five samples are from the northern stretch of the river (1E and 2W) and the southern stretch of the river (10 W, 11E,	Issue

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		and 12 E). Hence, it is not evident that the results from these samples are representative of conditions from the entire length of the site from RM 1 to RM 12. At a minimum, the risk assessment should discuss the uncertainty associated with such a limited data set for depurated clam tissue, and present a balanced discussion of the appropriateness of extrapolating these limited results to represent tissue concentrations in more contaminated areas of the site.	
113	Section 7.1.5, page 108:	The text indicates that mercury concentrations were higher in bass fillet with skin, and that the reverse was true for carp where mercury concentrations were higher in fillet without skin. The report (either in this section or in Attachment F5) needs to present the data used for this analysis to allow the conclusion to be assessed.	Clarify
114	Section 7.1.6, pages 108-109:	The text states that, "*It should be noted that DLs were above ACGs for PAHs, and PAHs were not detected in Round 1 fish tissue. However, fish metabolize and excrete PAHs, and thus there is less likelihood for PAHs to bioaccumulate in fish. PAHs were detected in Round 3B fish tissue, as well as in Round 1, 2, and 3B shellfish tissue, indicating that data were sufficient to estimate risk from PAHs in both fish and shellfish tissue."* Include a brief discussion as to why the PAHs were not detected in Round 1 fish tissue but were detected in Round 3 fish tissue. Clarify how the non-detect data for individual cPAHs from the Round 1 tissue data were used in calculating EPCs.	Clarify
115	Section 7.1.6, pages 108-109:	Tables F2-7 through F2-13 in Attachment F2 show non-detect results greater than the maximum detection limit per exposure area for different medium, species, tissue type, and exposure area (only Study Area-wide results are shown). These non-detect data, which are extensive, and are in many cases much greater than the maximum detection limit, were excluded prior to calculation of EPCs. The uncertainty discussion in Attachment 5 should include an analysis of how use of these non-detect data above the maximum detect value	Issue

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		would have affected the risk characterization. A summary of that analysis should be included in a separate sub-section of Section 7.	
116	Section 7.1.9, page 110:	In the Executive Summary and in summary/ conclusion sections of this HHRA, the fact that risks from consumption of black crappie and bullhead fillet tissue likely underestimate the actual risks should be included as a part of the discussion. This underestimation occurs because these fillet samples were only collected in Round 1 and were not analyzed for PCBs, dioxin or furan congeners, as stated in the text.	Issue
117	Section 7.1.10, page 111:	Delete the last sentence of the second paragraph. The first full paragraph on page 111 discusses the results of PBDE analysis for sturgeon, salmon and lamprey done as a part of the ODHS study, and then performs a conservative risk calculation using maximum detected values for PBDEs. Although this is useful information for salmon, sturgeon and lamprey, it is not directly applicable to resident fish species (e.g., carp and bass) that tend to have higher levels of bioaccumulative compounds (like DDX, PCBs and dioxins/furans) than salmon, lamprey and sturgeon. Without resident fish data on PBDEs, the conclusion that PBDEs are unlikely to contribute to the overall risks is not defensible. The EPA Region 10 lab has recently completed analyses of PBDEs in selected samples of resident biota from the PH Round 3 sampling (20 carp samples (10 fillet and 10 rest of body), 38 bass samples (19 fillets and 19 rest of body), and 6 clam samples). This data was recently made available to the LWG.	Issue
118	Section 7.1.10, page 111:	No studies are cited to support the conclusion here that "*… if VOCs were present in tissue, VOCs would volatilize during cooking.*" Volatilization would be an important, albeit variable, factor for VOCs in fish and shellfish tissue, as would the potential production of toxic metabolites that may be retained in the fish tissues. This discussion should be revised by presenting empirical information regarding the potential, or lack of potential, for VOCs to accumulate in fish and	Revise

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		shellfish tissue. In addition, the discussion of TZW water loading to surface water should be replaced with the conclusions derived from the ARARs analysis to be presented in Section 6.	
119	Section 7.1.10, page 112:	The last sentence in the last paragraph of this section states that emerging contaminants are not related to CERCLA releases and the results of the BHHRA. While technically correct, the real issues from a human health perspective are (1) the potential (or lack thereof) for Portland Harbor sources to release unregulated chemicals, and (2) lack of data on which to base human health risk assessment. These issues should be discussed briefly in this section.	Clarify
120	Section 7.1.11, page 112:	Additional analysis of the uncertainty in eliminating N-qualified data should be discussed in this section. Samples that had N-qualified data cannot be reanalyzed at this point to confirm the N-qualified chemicals. Therefore, for biota COPCs that were eliminated because of N-qualified data, Attachment F5 should review the results of these N-qualified chemicals in abiotic media within the exposure areas for those biota (e.g., 1 mile for bass, 1 mile on either side of the river for clams) to show that these eliminated COPCs are not present in the abiotic media at levels that pose a risk to human health. A summary of this analysis should be included this section.	Clarify
121	Section 7.1.12, pages 112-113:	The following sentence should be modified as indicated: *"The home ranges for common carp~~, black crappie~~ and brown bullhead may be as large as the Study Area and possibly even larger, and the home range for bass ~~Is~~ may be larger or smaller than the ~~span from~~ the one ~~to seven~~ mile~~s~~ assumed in the HHRA. For example, bass may only reside on one side of a river mile reach instead of throughout the one mile reach on both sides of the river as assumed for the HHRA."* The results of the ODFW study suggest that black crappie are unlikely	Revise

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		to have such a large home range as that suggested in the sentence and that bass can have a home range that is limited to only one side of the river within a river mile.	
122	Section 7.1.12, page 113:	The text does not present a complete discussion of composite samples. The issue is two-fold. First, subsamples need to be collected in a manner that is representative of the beach (e.g., grid, stratified random, etc.), and second, the area sampled should reasonably represent an exposure unit. Both of these issues should be discussed in this section.	Clarify
123	Section 7.1.12, page 113:	The statement that beach risks evaluated using composite samples are within the EPA acceptable range of 10^{-4} to 10^{-6} should not imply that they are acceptable, as the NCP's point of departure is 10^{-6}. Therefore, delete the last sentence or modify it to include actual cancer risk estimates for beaches that are above 10^{-6}.	Revise
124	Section 7.1.15, page 114:	Revise the text in this section to delete the reference that the COPC selection process biased the risk estimates for fish consumption relative to other pathways. The discussion fails to note that, by comparison, the screening process tends to underestimate overall risk.	Revise
125	Section 7.2.3, page 115:	Delete the following sentences: ~~*"As required by EPA Region 10, this BHHRA included exposure scenarios that are not well documented, so it is unknown to what extent exposures currently occur, if at all, within the Study Area. In addition, this BHHRA evaluated risks associated with a hypothetical future scenario, which is not anticipated to reasonably occur in the future based on current information for the Study Area. The uncertainties associated with these potential and hypothetical exposure scenarios are discussed in the following subsections."*~~ Consistent with EPA Superfund guidance, EPA and its partners chose only those scenarios that are reasonably anticipated to occur and are consistent with current statutory or regulatory requirements (e.g.,	Directed Change

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		designated beneficial use of the river as a source for drinking water).	
126	Section 7.2.3.1, pages 115-116:	The following sentence in the first paragraph should be deleted: "~~*However, there is no documentation of ongoing shellfish consumption by humans occurring in the Study Area, and the harvest or possession of Asian clams, which is the species assessed in this BHHRA, is illegal*~~." In addition, the following sentence in the last paragraph should be revised as shown: *"The evaluation of risks from shellfish consumption in this BHHRA is a ~~conservative~~ health protective approach.~~, as it is not known whether shellfish consumption actually occurs on an regular basis within the Study Area~~."* The rationale for these changes is provided below: The following comments were received from David Farrer from the Oregon Office of Environmental Public Health regarding consumption of crayfish: *"Our office has received information from ODFW indicating that an average of 4,300 lbs of crayfish were commercially harvested from the portion of the Willamette River within Multnomah County each of the 5 years from 1997-2001. Most of this catch was sold to the Pacific Seafood Company of Oregon. DHS also has information from local commercial crayfish harvesters indicating that Europe is a major portion of their market. Also, as part of the McCormick and Baxter assessment in 1991, Ken Kauffman in our office talked with Debbie Scott (503-631-2440) who is the wife of a licensed commercial crayfish harvester, and she served (at that time) as the secretary-treasurer of the Oregon Crayfish Association. She indicated that the area around McCormick and Baxter was a very productive crayfishery and that she*	Directed Change

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		and her husband had harvested there prior to the advisory on many occasions. In addition to this historical commercial crayfish harvesting information in the Lower Willamette, DHS also occasionally receives calls from citizens interested in harvesting crayfish from local waters who are interested in fish advisory information. Between 2001 and 2007, DHS fielded 8 calls from citizens who reported catching and eating crayfish from Portland-area waters (only one was specifically from the Study Area). We have no way of knowing what percent of individuals who catch and eat crayfish contact our office first to ask for fish advisory information. We estimate, however, that for each person who contacts us regarding the safety of consuming crayfish from the Lower Willamette, there are many more who catch and consume the animals without contacting our office. " Although the current consumption of crayfish is unknown, this is not relevant for the HHRA. Crayfish collection and consumption within the site is likely suppressed because of the crayfish advisory and knowledge that the harbor is a Superfund site. The effects of institutional controls, such as an advisory, are relevant in a baseline HHRA. In addition, the HHRA is to consider future use. Increased harvesting and consumption of crayfish from the site is perhaps even likely once remedial activities ease public concerns about contamination in the harbor. The Linnton Community Center project is not conclusive proof that clam consumption "*does not occur on an ongoing basis within the Study Area.*" As discussed in the HHRA, conversations were conducted with transients who are expected to live in the area for shorter periods of time than Portland area residents. Therefore, the Linnton information is only relevant for transients and does not provide information on clam consumption by permanent Portland residents. In addition, the fact that collection of Corbicula is illegal is relevant but	

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		not particularly important for the pathway in general. Indications are that Corbicula are being collected and consumed. More importantly, Corbicula are used as surrogates for bivalve consumption. It is reasonable to assume that bivalve consumption is a potential future exposure pathway and that low clam biomass that may limit current bivalve consumption does not apply to future exposures. Note also that the HHRA provides no discussion of productivity. If productivity is high, such that biomass is frequently replaced, biomass could be a less important issue currently.	
127	Section 7.2.3.2. page 116:	Modify this section to read as follows: "*Commercial diving companies in the Portland area were contacted to develop a better understanding of potential diver exposures within the Study Area. All of the diving companies that were contacted indicated that the standard of practice for commercial divers is the use of dry suits and helmets when diving in the LWR (Hutton 2008, Johns 2008, and Burch 2008). EPA Region 10 reported observing divers in wet suits and with regulators that are held with the diver's teeth within the Study Area, so a wet suit diver and associated ingestion for the "in the mouth" regulator exposure scenarios were included at the direction of EPA. Evaluation was also performed of helmet diving with use of a neck dam, which allows polluted water leakage into the diving helmet. Commercial divers as recently as 2009 have been observed using techniques to don a diving helmet which increase exposure (Sheldrake personal communication with RSS, 2009, DEQ, 2008). The observed wet suit divers were performing environmental investigation and remedial activities, which are not activities evaluated as part of a commercial diver scenario. Also, it is not known whether the individuals who were observed diving in wet suits on specific occasions are diving within the Study Area on a regular basis, as they do not work for the commercial diving companies in the Portland area. Recreational diving also takes place in Portland Harbor (Oregon*	Revise

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		Public Broadcasting Think Out Loud, "Are you going to swim in that?" August 22, 2008). Therefore, including a wet suit diver scenario with associated ingestion from use of a recreational type regulator, rather than a full face mask or diving helmet, and full body dermal exposure in this BHHRA (in addition to a dry suit diver scenario) is an appropriately health protective ~~conservative~~ approach given that commercial contractors continue to have difficulty in using appropriate personal protective equipment and decontamination procedures for Superfund and unrelated commercial work, and that recreational diving does continue to occur, exposing some divers to harbor contaminants."	
128	Section 7.2.3.3, page 116:	Replace "*Hypothetical*" with "*Potential Future*" in the title for this section. As described in General Comment 6, under OAR 340-041-0340, Table 340A, domestic water supply is a designated beneficial use of the Willamette River, with adequate pretreatment. CERCLA sets out a mandate for remedies that are protective for both private and public users of surface or groundwater. Surface water is potable and capable of serving as a potential drinking water source; thus, the expectation is that the resources will be protected and remediated to achieve such use (40 CFR 300.430(a)(1)(ii)(F)) in the absence of pretreatment. Therefore, the text in this section should be revised as indicated:" *Surface water in the LWR within the Study Area is not currently used as a domestic water source~~, nor are there plans to use surface water within the Study Area as a domestic water source in the future~~. According to the City of Portland, the primary domestic water source for Portland is the Bull Run watershed, which is supplemented by a groundwater supply from the Columbia South Shore Well Field (City of Portland 2008). ~~In addition, the Willamette River was determined not to be a viable water source for future water demands through 2030 (City of Portland 2008)~~. Under OAR 340-041-0340, Table 340A,*	Directed Change

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		domestic water supply is a designated beneficial use of the Willamette River, with adequate pretreatment. CERCLA sets out a mandate for remedies that are protective for both private and public users of surface or groundwater. Willamette River surface water is potable and capable of serving as a potential drinking water source; thus, the expectation is that the resources will be protected and remediated to achieve such use (40 CFR 300.430(a)(1)(ii)(F)) in the absence of pretreatment. The fact that surface water is not currently being used or that no one currently plans to use this resource is not justification for not attaining or using criteria to protect the river. *~~Even if the Willamette River were to be used as a domestic water source, which is not likely, that would only occur after adequate pretreatment to meet Safe Drinking Water Act standards and Oregon rules. Under OAR 340-041-0340 Table 340A, domestic water supply is a designated beneficial use of the Willamette River, but only with adequate pretreatment and natural quality that meets drinking water standards.~~* *Therefore, the evaluation of ~~untreated~~ surface water as a potential future domestic water source~~, even under hypothetical future conditions,~~ is a ~~conservative~~ health protective approach and consistent with EPA regulations and guidance.~~approach and is not an indication of current or reasonably anticipated future risks at the Study Area.~~"*	
129	Section 7.2.4, pages 116-117:	This section discusses uncertainties for complete but insignificant pathways that are not discussed elsewhere in the document. As discussed in previous comments, the pathway analysis should provide a justification for not quantifying risks for these pathways at the time the CSM is discussed, to provide the frame of reference for the uncertainty discussion. As is, the earlier parts of the document contain no explanation for the decision to eliminate pathways mentioned in this section.	Issue

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130	Section 7.2.5, pages 117-118:	Modify the first paragraph as shown: *"Assumptions about exposure factors typically result in ~~a high degree of~~ uncertainty in any risk assessment. ~~Because many of the exposure scenarios that were evaluated in this BHHRA are highly variable and do not have standard default exposure factors, uncertainties associated with the exposure factors are anticipated to have some of the greatest impacts on the risk estimates~~."*	Revise
131	Section 7.2.5, pages 117-118:	The suggestion that a lack of "*standard default exposure factors"* will result in an high level of uncertainty is unsupported. Standard default exposure factors provide national uniformity for risk assessments that are assessing similar exposure scenarios. In addition, default exposure factors (body weight, soil ingestion and drinking water rates) reduce the need for detailed site-specific exposure information to be collected at every site in that they reflect typical exposure patterns for a large segment of the population. There is no basis for the *a priori* assumption that exposure factors based on local practices and other site-specific information would provide substantially different exposure estimates than the use of default values. Unless specific information can be presented regarding alternate values, and how these alternate values would be expected to substantially differ from those used in the risk assessment, these statements should be deleted.	Issue
132	Section 7.2.5, pages 117-118:	Modify the 3rd sentence in the 2nd paragraph as follows: ***"****In the case of the scenarios assessing the use of untreated surface water as a domestic water source, both the RME and CT scenarios represent ~~hypothetical~~ potential future exposures."*	Directed Change
133	Section 7.2.5, pages 117-118:	Modify the 3rd paragraph as follows: *"For fish consumption, a range of ingestion rates ~~representing possible high end consumption scenarios~~ were used to evaluate ~~the impact of~~ variability on the risk estimates (see discussion of exposure parameters*	Directed Change

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		for tissue ingestion scenarios below). As recommended by EPA guidance, ~~T~~these ~~high-end~~ ingestion rates were used with EPCs calculated using both the mean and 95% UCL on the mean (or maximum concentrations for EPCs when sample size was less than 5), and thus the resulting risks in this BHHRA ~~do not necessarily~~ represent ~~the entire~~ a range of possible human health risks, including ~~but rather~~ estimates that might fall into the high end of those possible."	
134	Section 7.2.5.1, pages 118-119:	The text in this section focuses on whether all in-water sediments in the Study Area are used by the various receptors assessed in the draft HHRA. While this uncertainty is appropriate to address, the discussion misses the point of using an analysis by one-half mile segments. The information from this approach, both risks for specific in-water areas and the range of risk estimates for the LWR, can be used along with current and projected site use and chemicals posing potentially unacceptable risk to help focus the feasibility study. Further, the public can use the information for each one-half mile segment to help them choose among areas of the river to use. This concept also applies to beaches. These reasons for focusing on one-half mile segments should be added to this section. As indicated above, this discussion should dovetail with maps/figures that show how risks vary by one-half mile segment within the site, and should recall the need to provide the general public with risk information.	Issue
135	Section 7.2.5.2, pages 119-120:	Modify the following phrase in the 1st paragraph: *"the use of untreated water from the Lower Willamette as a source of drinking water by transients for 2 years ~~on an ongoing basis is highly unlikely~~ is assumed to be health protective."* The ED represents an assumption that a given transient will move on within 2 years, or leave and then return, and that 2 years of exposure would represent a high-end value. Unless the LWG can provide survey data that shows that transients do not commonly drink river water, the ED simply represents best	Revise

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		professional judgment and cannot be characterized as highly unlikely.	
136	Section 7.2.5.2, pages 119-120:	The following changes should be made in the 3rd paragraph in this section: *In addition to the direct contact scenarios mentioned above, risks were assessed from exposure to surface water as a ~~hypothetical~~ potential future domestic water source. This scenario assumes untreated surface water is used as a domestic water source ~~is drunk and bathed in~~ 350 days a year for 30 years (adult resident) or 6 years (child) ~~resident), using tap water ingestion rates~~. ~~As with the transient scenario, this scenario is equally unlikely for residents in the area.~~ The LWR within the Study Area is not currently used as a domestic water source, but could be used as such in the future ~~nor are there any future plans to use the LWR within the Study Area as a domestic water source.~~"*	Directed Change
137	Section 7.2.5.3 page 120:	Revise the first paragraph sentence to read as indicated: "*Fish tissue ingestion rates were developed using fish consumption data from a national study of fish consumption (CSFII, USDA), from a creel survey of Columbia Slough fishers north of the Study Area, and from the CRITFC Columbia River Fish Consumption Study (CRITFC) study ~~with variable exposure factors and environmental data that not site specific, or that are derived from anecdotal evidence~~. The CRITFC Fish Consumption Survey provides fish consumption data for the Columbia River Basin for four of the six tribes who are parties to the Consent Decree for the PH site. In addition, although the Columbia Slough Study was not done in PH and it likely underestimates fish consumption because of the way the fish consumption data were collected, the Columbia Slough is within one-half mile of the northern part of the PH site, so that it is reasonable to assume that fishers in the PH site may have similar fishing practices and fish consumption rates as those fishing in the Slough.*	Revise

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138	Section 7.2.5.3 page 120:	Modify the following sentence to read: *"The 90th percentile rate from the same study was used as the ~~high~~ low (17.5 g/day) ingestion rate for adult fishers in the BHHRA."*	Directed Change
139	Section 7.2.5.3, pages 120-121:	This section provides an incomplete and misleading analysis of the uncertainties associated with biota ingestion rates. As previously discussed, many inappropriate statements are made in this section and throughout the risk assessment regarding fish and shellfish consumption, including fish and shellfish consumption rates. These statements must be corrected in all instances.	Issue
140	Section 7.2.5.3, pages 120-122:	As previously discussed, EPA disagrees with the characterization of the 3 adult non-tribal fish ingestion rates used in this risk assessment as high (17.5 g/day), higher (73 g/day), and highest (142 g/day). These consumption rates should be referred to as low, medium, and high. There are other uncertainties in the fish consumption rates from the USDA study associated with regional, cultural and economic differences. For example, under-representation of peoples whose culture includes greater fish consumption would result in under-estimation of consumer-only consumption rates, particularly on a regional basis. Such biases could be exacerbated by regional differences in access to fishing resources and ability to pay for commercial fish in local stores, among others. For example, consumers in Louisiana could have access to large quantities of local crayfish, a resource not available to consumers in Colorado. Available data from the USDA study are based on a study sample of a few thousand people selected to be representative of the general population, which is unlikely to account for specific variability at a regional or local level. While the USDA study provides valuable data on fish consumption, the information may lack sufficient power to determine the direction of uncertainties relative to specific consumption rates for	Directed Change

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		fisher populations at the LWR.	
141	Section 7.2.5.3, page 121:	Delete the following sentence from the first paragraph on this page: ~~*"So, the use of high-end percentiles for all three ingestion rates in the BHHRA provides conservative estimates of reasonable maximum and central tendency exposures."*~~	Directed Change
142	Section 7.2.5.3, page 121:	Delete the following sentence: *"~~All three of the ingestion rates used for adult fishers in the BHHRA are higher than average fish ingestion rates reported from the respective studies.~~"* The ingestion rates used in this HHRA are not above average when consumer-only ingestion rates from the CSFII are considered. In fact, the language in the Uncertainty section discusses the fact that the ingestion rates of 17.5 and 142 g/day are much lower than the average of those rates for consumers only. Consumers represent an important subpopulation to be protected.	Directed Change
143	Section 7.2.5.3, page 121:	Delete or modify this sentence as shown: "*In addition to the uncertainties behind the rates of fish consumption, it was assumed that the frequency of consumption occurred at the same ingestion rate every day of every year for 30 years for the adult fisher scenarios."* The reference to consuming fish or shellfish "*every day of the year*" is misleading, as the values for ingestion of fish and shellfish represent annualized rates. For example, the rate of 17.5 g/day is equivalent to two 8-oz meals per month. Using a daily rate is a method to simplify the risk calculations, and does not imply that fish and shellfish are consumed on a daily basis.	Issue
144	Section 7.2.5.3, page 121: -	Modify the following sentence as indicated: *"Furthermore, 100% of the fish consumed was assumed to be caught <u>within a 1 mile stretch on both sides of the river for bass and within a 3 mile stretch on both sides of the river for crappie, carp and bullhead trout</u> ~~at the same location~~ over 30 years.~~, and n~~ <u>No</u> reduction in concentrations of contaminants during food preparation and cooking*	Revise

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		was assumed, <u>although reductions can occur depending on cooking and methods of preparation</u>." The focus on river miles for bass provides a range of possible risks for individuals that frequent one or several areas to fish, provides more spatially-specific information for use in the FS, and may allow members of the public to modify their fishing habits based on risk levels.	
145	Section 7.2.5.3, page 122:	Revise the text in the first full paragraph following the bulleted list as shown: "*The ~~same~~ CRITFC Fish Consumption Survey that was used as the basis for the tribal fish ingestion rate also indicated that none of the respondents fished the Willamette River for resident fish and at most, approximately 4% fished the Willamette River for anadromous fish. <u>However, future use of the site by tribal members may increase."</u>* Add the following sentence at the end of this paragraph: "*<u>It is important to note that ODEQ is proceeding to develop state water quality limits based on a tribal ingestion rate of 175 g/day."</u>* ODEQ's adoption of this consumption rate for their WQC should be discussed in the risk assessment, including this Uncertainty section, as support for the selection of 175 g/day as an appropriate fish consumption rate for tribal populations who regularly consume fish.	Revise
146	Section 7.2.5.3, pages 122-123:	The comments on Section 7.2.3.1 should also be addressed in this section. While some of the uncertainties in the shellfish consumption rates are appropriately addressed in this section, additional discussion should be included regarding the USDA study which relies on surveys on a national level. For most of the nation, access to local freshwater and estuarine shellfish is limited or non-existent. Thus, the national survey likely captures consumption based on commercial species (e.g.,	Note

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		shrimp), rather than those locally caught. It is difficult to make any firm conclusions that shellfish consumption rates used in the risk assessment are overly conservative for Portland Harbor. This conclusion is especially applicable for current exposure for crayfish and for potential future exposures for both crayfish and bivalves.	
147	Section 7.2.5.3, page 122**:**	Revise the text in the second paragraph following the bulleted list as indicated: "*However, it is not known to what extent shellfish consumption occurs~~, as there is no documentation of ongoing shellfish consumption by humans occurring in the Study Area~~.*"	Directed Change
148	Section 7.2.5.3, page 123**:**	Revise the following sentence in the first paragraph as shown: *<u>Although fishers normally fish and/or collect those resources that are available in their area</u>, it is not known to what extent fishers would substitute alternative local types of shellfish. ~~if the shellfish in the survey were not available~~*"	Directed Change
149	Section 7.2.5.3, page 123**:**	Delete the following sentence: *~~"However, for freshwater habitat only, which is the same as the Study Area, the mean nationwide shellfish consumption rate is 0.01 g/day; upper percentiles for freshwater shellfish consumption rates are not available."~~*	Directed Change
150	Section 7.2.5.3, page 123**:**	Delete or revise the following sentence to clearly note that daily consumption rates represent mathematical artifacts to account for annual rates: *"Shellfish consumption was assumed to <u>occur</u> at the same rate every day of every year for 30 years."*	Directed Change
151	Section 7.2.5.3, page 123**:**	Revise the following sentence as indicated: *"It is unlikely that the Study Area supports ~~shellfish~~ <u>Corbicula</u>*	Directed Change

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		populations large enough to supply the quantity of tissue needed to satisfy the~~se hypothetical~~ ingestion rates used in the HHRA." Also, add the following as the last sentence to this paragraph*:* *"However, it is reasonable to assume that bivalve consumption is a potential future exposure pathway at the rates used in the HHRA."*	
152	Section 7.2.5.3, page 123**:**	Revise the following sentence in the third paragraph as indicated: *"Because ~~some~~ risks associated with consumption of fish and shellfish ~~consumption scenarios~~ exceeded the NCP target risk range of 10^{-4} to 10^{-6} as well as the point of departure of 10^{-6}, uncertainties associated with fish and shellfish consumption could ~~impact~~ affect the decisions made in the FS. ~~conclusions of this BHHRA.~~"*	Revise
153	Section 7.2.5.4, page 123**:**	As discussed in the comments re: Attachment F5, it is not clear how the ranges (e.g., "*from 1 to 8 times" and "from 0.1 to 7 times*") were calculated. Provide a table here or in F5 that shows the data that were used for these comparisons, as well as the comparison results for both whole body and fish fillet. EPA cannot review and approve information that is not provided in the HHRA.	Revise, clarify
154	Section 7.2.6.2, pages 124-125**:**	It is not clear whether the text in the first paragraph refers to specific chemicals as a group or to individual sample results. Absent any clear, concise explanation of the process described here and the specific implications on risk and hazard estimates, the paragraph should be deleted from this section and from Attachment F5.	Clarify
155	Section 7.2.6.3, page 125:	According to the information presented in Attachment F5, the ratios between the maximum and minimum concentration values shown are less than 3. For in-water sediments, the ratios are less than 4. When comparisons are made within an exposure area for biota (which is the appropriate comparison, rather than Study Area-wide, given the heterogeneity in sources in PH), the vast majority of the ratios of the	Clarify

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		maximum EPCs to the mean are equal to or less than 2, and the remaining ratios are less than 4. EPA believes it is important that this information be presented in the main body of the risk characterization, as it shows that there are not major differences between risks calculated using the mean of the concentration data and those calculated using the maximum for individual exposure areas.	
156	Section 7.2.6.4, pages 125-126:	Adjustments for preparation and cooking can be important for assessing exposure. However, the issue is complex, and the overall effect on chemical concentrations is dependent on the chemical class of the contaminant and specific preparation and cooking methods. EPA guidance (EPA 2000) indicates that adjustments to exposure based on preparation and cooking should not be done in the absence of data and other information on local preferences for preparation and cooking for target populations such as native Americans or other ethnic groups. The overall effect of reduction based on cooking methods is typically less than 50 percent (EPA 2000). Uncertainties in this term seem unlikely to make a large difference in estimated risks. If reduction due to cooking methods is to be presented as an important uncertainty in risk results, the available data should be summarized, the uncertainties in applying these data to Portland Harbor discussed, and the possible effect of not including fish cooking methods put into proper perspective. This analysis should be presented in Attachment F5 and summarized here.	Issue
157	Section 7.2.6.6, page 127:	The text in the second paragraph states that *"The results for PCBs in whole body tissue samples analyzed for both PCBs as Aroclors and as individual PCB congeners were compared to evaluate the significance of correlations in order to evaluate the uncertainty associated with the use of Aroclor data. The correlation of the PCB Aroclor and PCB congener data were significant (compared to a probability value of 0.05) for all species evaluated (common carp, smallmouth bass, black*	Revise, clarify

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		crappie, brown bullhead, and crayfish).” This analysis is not presented in any part of the HHRA. The data, analyses, and results should be presented in Attachment F5, and should focus on biota within each exposure area rather than being site-wide.	
158	Section 7.2.6.6, page 127:	Delete the following text from the second paragraph: “~~*Windward (2005) analyzed fish tissue from the Lower Duwamish Waterway as PCB Aroclors and as individual PCB congeners. The PCB Aroclor data and PCB congener data were significantly correlated for both fillet and whole body tissue.*~~” The Duwamish Waterway data is not relevant to the PH study, as the site is not in freshwater and the species assessed were not the same as those in Portland Harbor. Only the data from Portland Harbor should be discussed.	Issue
159	Section 7.2.6.6, page 127:	The text in the 3rd paragraph states: “*However, for fillet tissue, Round 1 samples were analyzed for PCB Aroclors only, and Round 3 samples, which were collected for smallmouth bass and common carp, were analyzed for PCB congeners only. Because PCB congener data are available for smallmouth bass and common carp fillet tissue, cumulative risks for exposure to fillet tissue from ingestion include only the most recent tissue data for these two species*.” EPA did not agree to eliminate the tissue data from Round 1 for smallmouth bass and carp, resulting in the calculation of EPCs for these fillet samples using only data collected in Round 3. Attachment F5 should present an analysis that compares total PCBs calculated from Aroclors using the Round 1 fillet data to total PCBs calculated from congener analysis using Round 3 data for these 2 species. This should be done by exposure area, in addition to site-wide, and the results of the analysis should be summarized in this section.	Issue

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160	Section 7.2.6.7, page 128:	The last sentence states that *"According to these studies, the magnitude of uncertainty could be as much as a factor of ten."* Based on the limited information presented here, it appears 10 represented the maximum degree of variance. Additional information regarding the minimum and range from the cited studies should also be presented, as well as whether the information is relevant to the exposure media for which risk was characterized in the risk assessment. Data and analyses that are specific to the media and chemicals assessed at the PH site should be presented to justify the statement that the "*the magnitude of uncertainty could be as much as a factor of ten,"* as bioavailability is medium and chemical-specific.	Issue
161	Section 7.2.6.8, page 129:	Total cPAH and dioxin/furan TEQ should be added to Figure 7-1. Error bars should not extend below zero. Clarify whether the values on the west side were higher than on the east side, and thus no ratios of east to west side concentrations were less than 1.	Revise, clarify
162	Section 7.2.6.8, page 129:	Revise the last sentence in this section as follows: "*Therefore, the characterization of risk for bass in this risk assessment is a health protective estimate that is unlikely to underestimate risks~~. uncertainties associated with exposure areas for smallmouth bass likely overestimate risks and may impact the conclusions of this BHHRA when considering risks on a river mile basis."~~*	Directed Change
163	Section 7.3.1, page 130:	The language in this section indicates that EPA guidance, Assessing Susceptibility from Early-Life Exposure to Carcinogens (EPA 2005), was not used because it does not identify exposure factors for specific age classes. For the calculation of early life risks, the report multiplied the risk for B(a)P for the child recreational beach user by a factor of 3. Since the B(a)P risk for this receptor is 5×10^{-6}, the report concludes that even if this risk were three times higher, it would be within the target risk range of 10^{-6} to 10^{-4}. This calculation is inadequate in	Issue

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		representing the early life risks. Child receptors in the BHHRA other than child recreational beach user could potentially be affected by this calculation. Other child receptors that should have been considered are the child fisher, the child tribal fisher, the child consumer, and the child resident (though there are no mutagenic COPCs for the child resident). Early life risks should have been calculated for additional COPCs that may be mutagenic. For example, Table 5-86 for the child tribal fisher identifies dibenzo(a,h)anthracene as a COPC. This chemical is considered by EPA to be mutagenic, as are all other carcinogenic PAHs.	
164	Section 7.3.1, page 130:	The risk assessment compares the individual cancer risk of B(a)P to the 10^{-6} to 10^{-4} range. Total cumulative cancer risk from all carcinogenic PAHs should be evaluated instead.	Issue
165	Section 7.3.1, page 130:	The risk assessment incorrectly calculates the lifetime risk for the population by multiplying the risk for B(a)P by 3 to give the early life risk. To correctly determine the early life risk for a population with an average life expectancy of 70 years, the cancer potency should be weighted by a factor of 10 for exposures that occur from birth to 2 years of age, and by a factor of 3 for exposures that occur from 3 years to 16 years of age. The remaining exposure is weighted by a factor of 1. The risks associated with each of the three relevant time periods need to be summed to provide an overall estimate of cumulative risk.	Issue
166	Section 7.3.1, pages 131-132:	In the fifth sentence, revise the text to note that chromium VI is reduced to chromium III in an aqueous environment if an appropriate reducing agent is available. Further, the text here should more clearly note that EPA currently considers the carcinogenic potential of hexavalent chromium via oral exposure as “cannot be determined.” The text should also note that other Tier 3 sources of toxicity criteria (the New Jersey Dept of Environmental Protection and the California EPA) have derived quantitative dose-response criteria for evaluating the	Revise

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		cancer risks associated with oral exposures to hexavalent chromium.	
167	Section 7.3.5, page 132:	The third sentence should be revised to read: "*The studies did not find a conclusive association between PCB exposure and cancer; however they were limited by small sample sizes, brief follow-up periods, and confounding exposures to other potential carcinogens.*"	Revise
168	Section 7.4.2, page 134:	Delete the following text from the second paragraph: ~~*"In some cases, background concentrations correspond to risk estimates above the target risk thresholds established by EPA (i.e., cancer risk of 10^{-6} to 10^{-4}). This increases the uncertainty in estimating risks from fish or shellfish ingestion that are attributable to hazardous substance releases within the Study Area. For example, in the Columbia River Basin Fish Contaminant Survey, HIs were greater than 100 and cancer risks were as high as 2×10^{-2} for the highest tribal fish consumption rate (389 g/day) (EPA 2002c)."*~~ As previously discussed, no appropriate "background" data and risk results for biota are available to compare to the results in the PH HHRA. The Columbia River Basin Fish Contaminant Survey is not appropriate to be used for background comparisons.	Issue
169	Section 7.4.2, page 134:	Delete the 3rd paragraph: ~~*"The presence of PCBs in fish above the EPA target fish tissue concentration in the Willamette River Basin was evaluated using a watershed-scale model (Hope 2008). The model results suggested that atmospheric sources of PCBs could have yielded the concentrations observed in fish tissue. If the model results are correct, atmospheric sources of PCBs alone result in tissue concentrations that exceed the target risk level of 1 x 10-6 for fish consumption rates higher than 16 meals per month".*~~	Issue

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		This study does not represent "background" data.	
170	Section 7.5, page 135:	The following sentences should be deleted: ~~*"In estimating the risks in this BHHRA, the conservative assumptions were multiplied together, which magnifies the conservatism in the risk estimates."*~~ and ~~*"The cumulative effects of the numerous conservative assumptions made during this BHHRA are risk estimates that are likely higher, and potentially significantly higher, than actual risks that may exist within the Study Area."*~~	Directed Change
171	Section 8.0, page 137:	The second sentence in the first paragraph should be revised to read as follows: "*In addition, surface water and groundwater data were compared to EPA's MCLs and AWQC to identify those chemicals and locations where SW and GW are above these two ARARs.* ~~*evaluated as a potential source of contamination for biota that are consumed by humans, and TZW data were evaluated as a potential source to untreated surface water that would potentially be is hypothetically used as a domestic water source."*~~	Directed Change
172	Section 8.0, page 137:	Revise the first sentence in the second paragraph as follows: *"Populations evaluated in the risk characterization portion of the BHHRA were identified based on human activities that are known to occur now and/or which could occur in the future within the Study Area, ..."*	Revise
173	Section 8.0, page 137:	Revise the last bullet as follows: "~~*Hypothetical*~~ *Potential future resident –* ~~*Hypothetical direct*~~ *Future exposure to untreated surface water used as a domestic water source."*	Directed Change
174	Section 8.1.1, page 138:	Delete the following sentence in the first paragraph: ~~*"In estimating the risks in this BHHRA, the health protective*~~	Directed Change

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		~~*assumptions regarding fish consumption were multiplied together, which magnifies the overall conservatism in the risk estimates."*~~	
175	Section 8.1.1, page 138:	Revise the fourth sentence in the first paragraph as indicated: *"The cumulative effect~~s~~ of ~~numerous conservative~~ health protective assumptions made during this BHHRA are risk estimates that are potentially ~~significantly~~ higher than actual risks that may exist within the Study Area."*	Revise
176	Section 8.1.1, page 138:	All endpoint-specific HIs referred to for each scenario in this summary should be consistent with EPA General Comment 4.	Clarify
177	Section 8.1.1, page 138:	The summary discussions of each scenario in this section should provide more detail on the range of risk for each receptor. This discussion should be linked to the summary graphs described in our comments on Section 5, which provide spatial information on those pathways posing the greatest risks. These graphs would show the risk characterization results spatially for total cancer risks and for cancer risks and HIs for selected chemicals posing potentially unacceptable risk by exposure area.	Clarify
178	Section 8.1.1.1, pages 138-139:	Revise the first sentence to read as follows: "*Fish consumption risks were calculated for the adult and child non-tribal fish consumers, based on three different ingestion rates representing low, medium, and ~~a range of potential~~ high end consumption scenarios."*	Revise
179	Section 8.1.1.1, pages 138-139:	Delete or revise the text in the third sentence and in all subsequent text in this section and Section 8.1.1.2 as indicated*:* *"~~Fish consumption was assumed to occur at the same ingestion rate, every day of every year"~~* The reference to consuming fish or shellfish "*every day of the year*" is	Revise

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		misleading in that the fish and shellfish ingestion rates represent annual rates converted to average daily rates.	
180	Section 8.1.1.1, pages 138-139:	Revise the last sentence as indicated: *"It was assumed that all fish consumed were resident fish caught within the Study Area (within a one mile area on both sides of the river for bass and within a 3 mile stretch of both sides of the river for crappie, carp and bullhead trout). ~~a single exposure area for spatial scales smaller than the Study Area~~."*	Revise
181	Section 8.1.1.1, pages 138-139:	In the last sentence in this section and the rest of Section 8, delete the phrase "*use of maximum detected concentrations as EPCs*", as this is not a major uncertainty when maximum EPC values are compared to mean values appropriately.	Revise
182	Section 8.1.1.2, page 139:	Revise the first sentence as follows: "*~~It is not known to what extent~~ Current and potential future shellfish consumption rates for the site are not known. ~~actually occurs, and there is no documentation of ongoing shellfish consumption by humans occurring in the Study Area.~~*"	Revise
183	Section 8.1.1.3, pages 139-140:	Modify the second sentence to read as follows: "*Each ½-river mile segment was considered a potential exposure area.~~, regardless of the feasibility or practicality of use of the area~~."*	Revise
184	Section 8.1.1.3, page 140:	Delete the following text in this section and in other places it occurs in the BHHRA, as no data have been provided here or in any other part of this HHRA to justify the claim that the degree of uncertainty associated with bioavailability of chemicals in sediment could affect the risk estimates by a factor of 10. *~~"The magnitude of uncertainty associated with the bioavailability of chemicals in sediment could be as much as a factor of ten. Given that~~*	Revise

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		~~*uncertainty associated with the bioavailability of chemicals in sediment could be as much as a factor of ten, it is probable that actual cancer risks are lower than the risk estimates, which did not account for bioavailability*.”~~	
185	Section 8.1.1.4, page 140:	Unless specific information is provided to support the assertion, delete the sentences in the last paragraph in this section regarding “*the factor of 10*” for bioavailability.	Revise
186	Section 8.1.2, Figures 8-2 and 8-4:	As noted in the general comments, all endpoint-specific HIs for each scenario presented in the summary should be evaluated based on the chemical(s)/endpoint combination resulting in the greatest hazard index. In addition, many endpoint-specific HI tables will be eliminated when only total HIs above 1 are segregated into endpoint-specific HIs. The titles “*Ranges for 95% UCL or Maximum Exposure*” should be changed to “*Ranges for RME Exposure.*” This comment, which has been made earlier in this comment set, should be applied throughout the document and its tables, figures and graphs when referring to the RME exposures and risks.	Revise
187	Section 8.1.3, pages 141-142:	The statement here that EPA does not recommend the use of data such as the N-qualified results overstates the actual recommendations presented in the guidance. In fact, EPA guidance recommends that when the identity of a chemical is uncertain, site history and other information should be used to establish whether there is reason to believe that the chemical may be present. As discussed in comments on page 112, Section 7.1.11, the list of chemicals presumptively identified in the Round 1 tissue samples should be compared to analytical results from sediment samples collected within the exposure areas related to the tissue samples (e.g., 1 mile for bass, 1 mile on either side of the river for clams) as a means to determine whether there is reason to presume that chemicals for which the results are N-qualified are likely to be present in the tissue samples. If these analytes	Issue

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		are not present in the sediment at concentrations that present a risk to human health, they may be excluded as PRGs.	
188	Section 8.1.3, pages 141-142:	The list of chemicals in Table 8-1 must include all of those chemicals that resulted in a cancer risk greater than 10^{-6} or an HQ greater than 1, with the exception of those chemicals that present a risk to human health based only on N-qualified data.	Revise
189	Section 8.1.3, pages 141-142:	Additional columns and chemicals will need to be added to Table 8-1 for surface water and groundwater, as described below. The conclusions from the ARAR evaluation in Section 6 should be included when discussing chemicals posing potentially unacceptable risk in Section 8.1.3, and Table 8-1 should be modified as discussed in Section 6.	Revise
190	Section 8.1.3, pages 141-142:	Table 8-1 should revised to include an additional abbreviation for those scenarios/chemicals that exceed a cancer risk of 10^{-5}. The abbreviations for exceedances of 10^{-6} (X) and for exceedances of 10^{-4} (#) should remain. Cells where any endpoint-specific HI is above 1 for at least one BHHRA scenario should be shaded.	Revise
191	Section 8.2, pages 142-150:	The role of the BHHRA is to identify potential exposures and risk to human health. The risk characterization step should summarize the major risk estimates calculated, the assumptions and the extrapolations made during the estimated risk calculation, and the residual uncertainties and their impact on the range of plausible risk estimates. It is not the role of the BHHRA to focus on a subset of the chemicals posing potentially unacceptable risk based upon the considerations listed on pages 142 and 143, which include the relative percentage of each chemical's contribution to the total human health risk, uncertainties associated with exposures, frequency of detection (localized and study-area wide), comparisons of Portland Harbor site risk to risks in "regional" studies, or the magnitude of risk exceedance above 10^{-4} to 10^{-6}. These represent risk management issues, and as such	Directed Change

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		are beyond the scope of the BHHRA. Accordingly, Section 8.2 should be deleted and Section 9, Conclusions, and the Executive Summary should summarize chemicals posing potentially unacceptable risk and exposure scenarios as defined by cancer risk greater than the 10^{-6} point of departure level and non-cancer hazard endpoint-specific HIs greater than 1, as well as chemicals that exceed ARARs based on the comparison to be completed in Section 6.	
192	Section 9.0, page 151:	In addition to summarizing estimated risks by exposure scenario and the primary contributors to the risk estimates, this section should include a discussion of surface water data relative to WQC and MCLs from Section 6. The text should reference Table 8-1, and provide summary information for all chemicals posing potentially unacceptable risk in the scenarios listed in the table. Each chemical should be listed for each scenario with their corresponding cancer risk and/or HI values. A discussion that focuses on chemicals and exposure scenarios that have the highest risks can then be included. For chemicals that exceed ARARs based on the evaluation presented in Section 6, the conclusions section should briefly explain the basis for the selection.	Revise
193	Section 9.0, pages 151-152:	Revise the text in this section as indicated: a) Delete the following sentence from the first bullet: "~~*However, there is no information documenting whether shellfish consumption actually occurs on an ongoing basis within the Study Area*~~." b) Revise the second paragraph by deleting the indicated text: "~~*While it is not probable that the maximum values of the uncertainties apply for every tissue consumption exposure scenario and chemical, this magnitude of uncertainty needs to be considered relative to the maximum cancer risks and noncancer hazards presented in this BHHRA and indicates that risks may actually be*~~	Directed Change

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		~~*less than 10^{-4} (excess cancer risk) or HI of 1 for certain scenarios.*~~" c) Delete the text in the fourth bullet as indicated: ~~*"On a regional basis, risks from exposure to bioaccumulatives in tissue exceed EPA target risk levels. For example, the PCB concentrations detected in resident fish from the Willamette and Columbia Rivers are approximately 20 to 100 times higher than the EPA target fish tissue concentration, which is based on a target risk level of 10-6, when adjusted for the ingestion rates used in this BHHRA"*~~.	
194	Attachment F2, Section 2.2, page 3:	Screening for COPCs was performed using only the in-water sediment data and surface water data from within the Study area. Data outside the study area were not included. However, the risk characterization was performed using both data sets. EPA did not agree to this elimination of the data outside the study area from the COPC screening. The Uncertainty section should contain analyses showing whether COPCs were eliminated from the BHHRA as a result of eliminating these data during the COPC screening step.	Issue
195	Attachment F2, Section 3.2, pages 11-14:	Additional discussion and analysis are needed regarding the exclusion of the PCB congener data from the in-water sediment samples collected by the City of Portland for its outfall sediment investigation. These samples were excluded because of insufficient congener data (<100 PCB congeners for total PCBs, and <12 congeners for PCB TEQ) to calculate a summed total PCB congeners and total PCB TEQ. It is not clear if the 85 in-water sediment samples were excluded because the no congener analysis was conducted or because the detection limits were too high. Consistent with EPA guidance, non-detect data where the detection limit is greater than the maximum detected value should only be excluded when their inclusion results in the calculated EPC to be greater than the maximum detected concentration. In either instance, the overall effect on the in-water sediment COPC selection process and	Issue

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		EPC calculations should be discussed.	
196	Attachment F2, Section 6.1, page 17:	Further explanation is needed why the 95 percent UCL on the mean was used for an EPC, even in instances when ProUCL recommended using alternate values, such as the 99 percent UCL. This discussion should include the specific EPCs for which the 95 percent UCL was selected when other values were recommended, and the overall effect on cancer risk and non-cancer hazard estimates in the HHRA. Unless sufficient justification can be provided, risk and hazard estimates for these chemicals may need to be revised.	Issue
197	Attachment F2, Tables F2-8 through F2-13:	These tables present non-detect sample results where the reported detection limit is greater than the maximum detected values for the chemical in each medium/exposure medium/exposure point. These results are briefly discussed in the Uncertainty section of the main body of the risk assessment (Section 7.2.6.2), but not in Attachment F5. EPA guidance notes that non-detect values for which the detection limit is greater than the maximum reported concentration for a specific chemical/media should be excluded when inclusion of the data results in a calculated EPC that exceeds the maximum reported concentration. However, it appears the LWG has made an *a priori* decision to uniformly exclude these data without an analysis of what effect their inclusion would have on the quantitative risk assessment. A more thorough quantitative analysis of the treatment of these data should be included in Attachment F5 for all medium/exposure medium/exposure points, particularly including results for surface water and in-water sediments where the ratio of the non-detected concentrations above the maximum detected concentrations approached two orders of magnitude. A summary of the results from F5 should also be included in Section 7.2.6.2 of the main body of the risk assessment.	Revise, clarify
198	Attachment F5, Section 1, page	Delete the last sentence: "~~*While the maximum values of the uncertainties presented below do not*~~	Directed Change

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	1:	~~*apply to every exposure scenario and chemical, the magnitude of each uncertainty indicates that risks in the BHHRA may underestimated since, or more likely overestimate risks for certain scenarios, particularly exposure to PCBs from consumption of fish*~~."	
199	Attachment F5, Section 2.1, page 1:	This section should present the data to support the conclusions regarding contaminant levels in whole body versus fillet samples. It should also include a discussion noting that differences between fillet and whole body samples also depend upon the manner in which the fillet is separated from the rest of the fish. If a lot of belly fat or other fat is left on the fillet, the distinction between the fillet and whole body samples would be substantially decreased. Per the e-mail from Laura Kennedy on January 21, the following sentence should be revised as shown: "*Whole body concentrations were calculated from these results on* ~~*an organic carbon- weighted*~~ *a weighted-average basis, which provided the opportunity to compare concentrations of chemicals in the fillet tissue* with concentrations in the whole body tissue for the same fish tissue sample.*"*	Issue
200	Attachment F5, Section 2.3, page 3:	The discussion of fish consumption rates presented in this section adds no useful information and should be revised to include more information about the range of potential fish consumption rates. The purpose of using a range of fish consumption values for fishers in the HHRA was to present the range of cancer risks and non-cancer hazards that might occur for low to high consumers of fish taken from PH. In addition, the discussion in this section is biased towards demonstrating how risk may be overestimated, rather than presenting a balanced presentation that includes rationale for the possibility that risks may have been underestimated as well. The discussion in this section should include comparisons with consumption rates higher than those used in the HHRA. For example, it would be appropriate to provide a	Revise

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		comparison of the 142 g/day rate (for both consumers and non-consumers) used in the HHRA to the comparable consumption rate of 509 g/day for consumers only from the same CSFII study, and to indicate that risks for adult non-tribal fishers may have been underestimated by a factor of 4. A similar comparison should be made for non-tribal child consumers using comparable consumption rates. Simply presenting a calculated mean and an upper percentile value provides the user with little useful information regarding the distribution and variance of the data. Given that remedial Superfund risk assessments are intended to present an estimate of risks towards the upper end of the probable distribution, these discussions provide no useable alternative descriptors of plausible, alternate upper-percentile values on which to base the RME evaluations.	
201	Attachment F5, Section 2.4, page 4:	It is not clear how the ranges in risk estimates presented in this section are calculated. Please provide information that shows the specific data used for these comparisons.	Clarify
202	Attachment F5, Section 2.4, page 4:	Revise the last sentence as shown: "*This indicates that assuming an individual consumes only a single species of fillet tissue could over estimate risks by a factor of up to 7*." to "*This comparison indicates that cancer risks for an individual who consumes only a single species of fillet could be higher by a factor of 0.1 to 7, depending on the species, than an individual who consumes a multi-species diet*."	Revise
203	Attachment F5, Section 2.5, page 4:	This section requires either complete revision or it should be deleted. The discussion here referring to the uncertainty associated with the 95 percent UCL is incorrect. The 95 percent UCL represents a one-sided confidence limit. By definition, setting the confidence interval at 95 percent (p=0.05), the calculated UCL will be equal to or greater than the true mean 95 percent of the time. The uncertainty and statistical power of calculating the value remains constant regardless of the	Issue

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		sample size. In addition, it is not clear how the fact that individual exposure point EPCs for Brown Bullhead and Common carp differed from the respective Study Area-wide EPCs by a factor of 2 represents an uncertainty, rather than simply an acknowledgement of localized heterogeneity of contaminant concentrations across such a large area.	
204	Attachment F5, Section 2.6, page 5:	Revise this sentence as shown: "*Except for the EPC calculated for location 7W for clams, ~~F~~for the calculation of all shellfish station tissue EPCs, the maximum concentrations were used because fewer than five composite tissue samples were collected per station.*"	Revise
205	Attachment F5, Section 2.4, page 4:	Delete the outlier test for shellfish described here and presented in Table 5-2. It is not clear why this test is being done, given the large heterogeneity in sources in PH. The fact that the result from a particular location differs markedly from other results provides no useful information without any additional spatial context or information regarding related chemical concentrations in sediment and pore water. Ultimately, the test does not provide any clarification to the uncertainty being addressed in this section, as stated in the text: "*The outlier tests provide information on the spatial variability of risk estimates for which the maximum concentration was used though do not decrease the uncertainty associated with using the maximum concentrations to estimate risks.*"	Issue
206	Attachment F5, Section 2.6, Tables 5-3, 5-4, and 5-5:	Additional information and discussion should be included for the results in Tables 5-3, 5-4, and 5-5, which show the comparison between the maximum to mean concentration values in surface water, in-water sediments, and biota. For example, it is assumed that the maximum values shown in the tables are limited to those chemical/exposure media where the maximum value was used as the	Issue

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		EPC to calculate risk for that chemical/exposure media. If the cancer values shown from biota correspond to those from the highest ingestion rate (142 g/day) for adult non-tribal fishers, and the non-cancer HIs correspond to the highest ingestion rate for non-tribal children, this should be clarified in the text and tables. The discussion of the results for each table should be presented separately, rather than stating that, "the ratios of the maximum concentrations to the mean concentrations are generally within an order of magnitude." For surface water (Table 5-3), almost all of the ratios between the maximum and minimum concentration values shown are less than 2. Only at RM 6 (west) for B(a)P, which at 2.7, is the ratio greater than 2. Ratios for in-water sediments (Table 5-4) are typically less than 3, and all ratio are less than 4. When comparisons are made within an exposure area for biota (which is the appropriate comparison rather than an area-wide comparison, given the heterogeneity in sources in PH) the vast majority of the ratios for biota (Table 5-5) are equal to or less than 2, and none exceed 4. These results are important to discuss here and in the main body of the risk characterization, as they reveal that there is little difference in the risks calculated using the mean of the concentration data and those calculated using the maximum, and that this is not a major source of uncertainty.	
207	Attachment F5, Section 2.7, page 6:	The discussion of possible adjustment factors in this section presents an incomplete and misleading discussion of the potential reduction of contaminant concentrations in cooked versus uncooked fish tissues. The overall reduction will vary depending on preparation and cooking methods, as well as being chemical-dependent. The section should discuss the range of reduction factors and note that preparation methods such baking, broiling, and grilling have been associated with only modest reductions in contaminant concentrations. An appropriate conclusion for the assessment is that unless preparation and cooking methods are known for populations of interest, sport anglers, tribal	Issue

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		fishers, etc., the overall uncertainty is unknown, and the overall effect may in fact be much more modest than the 87 percent cited.	
208	Attachment F5, Section 2.8, pages 6-7:	Modify the first sentence as follows: "*Studies have shown that conditions in environmental media (e.g., pH, organic carbon content) can affect the bioavailability of a chemical (Ruby et al. 1999, Pu et al. 2003, Saghir et al. 2007)* ~~*by a magnitude of up to ten.*~~" It is not clear what media (abiotic or biotic) or to which chemicals this "factor of ten" is supposed to apply. As bioavailability is chemical-, media-, and exposure route-specific, and given that there is no site-specific information on bioavailability for the PH site, no rationale for using the generic statement that uncertainty "by a magnitude of up to ten" exists, and none can be provided by citing literature data.	Issue
209	Attachment F5, Section 2.9, page 7:	This section is misleading and should be modified. The EPA document titled Cancer Dose-Response Assessment and Application to Environmental Mixtures (EPA/600/P–96/001F, September 1996) presents the rationale for the use of 3 different cancer slope factors for PCBs. Three slope factors are provided: 2 per mg/kg-day for high risk and persistence PCBs, such as Aroclor 1260 and 1254; 0.4 per mg/kg-day for low risk and persistence PCBs, such as Aroclor 1242; and 0.07 per mg/kg-day for lowest risk and persistence PCBs, such as Aroclor 1016. The high risk and persistence value should be used for those exposure pathways associated with environmental processes that tend to increase risk, including: food chain exposure; sediment or soil ingestion; dust or aerosol inhalation; dermal exposure (if an absorption factor has been applied); the presence of dioxin-like, tumor-promoting, or persistent congeners in other media; and early-life exposure (all pathways and mixtures). The low risk and persistence value should be used for those exposure pathways that tend to decrease risk, including: ingestion of water-soluble congeners, inhalation of evaporated	Issue

No.	Section and Page Number	Comment	Comment Type
		congeners, and dermal exposure if no absorption factor has been applied. The lowest risk and persistence value should be used where congener or isomer analyses verify that congeners with more than four chlorines comprise less than one-half percent of total PCBs, suggesting that potency is best represented by the least potent tested mixture. All of the pathways assessed in the HHRA are included under the criteria for use of the high risk and persistence cancer slope factor of 2 per mg/kg-day. Even for scenarios where adults only (not children) ingest water, the lower cancer slope factor (0.4 per mg/kg-day) should not be used, as risks are calculated using surface water data that would contain both water soluble congeners and those found in water-borne colloidal material and particulate matter.	
210	Attachment F5, Section 2.10, page 7:	Please add data and a table to support the conclusions that "*The differences ranged from a ratio of 1 to 700 for noncancer hazards, and 1 to 400 for cancer risks.*"	Issue
211	Attachment F5, Additional Uncertainty Discussions:	For balance and completeness, the discussion of uncertainties in this section should also include the following: a) <u>Limiting Endpoint-Specific HIs for a Chemical to One Endpoint</u>: In deriving endpoint-specific HIs, only one health endpoint is used for each chemical, even though most chemicals can have a myriad of health effects as exposures increase. While the individual HQ for additional effects will be lower than that based on the critical study, not considering these additional endpoints may underestimate the potential for adverse effects. For the chemicals that have the largest non-cancer contribution in the HHRA, the uncertainty section should discuss the possibility of under-predicting non-cancer health impacts by using only one endpoint per chemical, and any supporting analyses should be included in Attachment F5. b) <u>Uncertainties Resulting from Elimination of Exposure Pathways in the draft HHRA</u>: The risk assessment should provide a more	Clairy, revise

No.	Section and Page Number	Comment	Comment Type
		complete pathway analysis, which is a critical aspect of the process. Section 3.2.1 initially describes different categories for exposure pathways (complete, incomplete, complete and significant, etc.), but subsequent discussion focuses only on those pathways quantified in the risk assessment. All pathways should be discussed and justification provided for placing pathways into the various categories. The potential for underestimating risk by not evaluating those pathways considered complete but insignificant should be addressed in Attachment F5. c) Elimination of Data from Outside the Study Area in Screening for COPCs in In-water Sediments and Surface Water: During the screening for COPCs described in Section 3, data from outside the Study Area were not used for in-water sediments or for surface water. The Uncertainty section should include a screen of these data that were excluded to show that additional COPCs would not have been selected for these two media. d) Exclusion of Non-Detected Concentrations that Are Higher Than the Highest Detected Concentration: Tables F2-7 through F2-13 in Attachment F2 show non-detect data that are greater than the maximum detection limit per exposure area for different media, species, tissue type, and exposure area. There are a substantial number of non-detect results, and in many instances the detection limit is much greater than the maximum detected concentration for the respective analytes. These data were excluded from the calculation of EPCs. The uncertainty discussion should include an analysis of the effect of excluding these non-detect data when calculating EPCs, and how their inclusion may have affected the risk characterization results. e) Uncertainties in the Dermal Toxicity Assessment: The approach used to evaluate dermal risk could underestimate risk by a factor of	

No.	Section and Page Number	Comment	Comment Type
		up to 2, since no adjustments to slope factors or RfDs are required if oral absorption efficiency is greater than 50 percent. f) Comparison of Undepurated and Depurated Clam Samples: Data and calculations used for these analyses should be included in this Attachment and summarized in the Uncertainty section. Conclusions from this comparison should be limited to the 5 sampling sites where data from depurated and undepurated samples are available. g) Polychlorinated Biphenyls: The text in Section 7.2.6.6 describes an analysis of the correlation of the results of whole body tissue samples for PCBs as Aroclors and as individual congeners. This analysis is not presented in any part of the HHRA. The details of this analysis should be presented in Attachment F5 for bass and carp, and should focus on biota within each exposure area rather than only on a site-wide basis. According to Section 7.2.6.6, fillet tissue samples collected in Round 1 were analyzed for Aroclors only, and Round 3 samples (smallmouth bass and common carp) were analyzed for PCB congeners only. EPA did not agree to eliminate the tissue data from Round 1 for smallmouth bass and carp fillet. Attachment F5 should contain an analysis that compares the total PCBs calculated from Aroclors using the Round 1 fillet data to the total PCBs calculated from congener analysis using Round 3 data for these two species by exposure area as well as on a site-wide basis. These analyses should be included in Attachment F5 and summarized in Uncertainty section of the main body of the BHHRA.	

TAB 9

General Responses to EPA's Directive Comments on the Baseline Human Health Risk Assessment

Issue Category	BHHRA Directive Comments	General Response
Risk Management Recommendations	General	For the record, the LWG's position is that no risk management decisions were made in the draft BHHRA and that EPA guidance was followed in providing appropriate risk characterization. As discussed in the September 9th meeting, risk management recommendations for human health will be presented in a document separate from the revised BHHRA. The risk management recommendations would include information such as the following: • Uncertainty discussion (magnitude of uncertainty and considerations on overall risks) beyond that presented in the BHHRA • Support for the selection of certain chemicals for focus in the FS (e.g., cPAHs for direct contact with sediment) • Information about how PRGs should be applied based on human exposures (e.g., clam consumption PRGs should only be applied in areas where harvest could occur) • Whether a sediment-tissue relationship exists and the strength of that relationship Based upon the above information, the document will identify those chemicals recommended for consideration as chemicals of concern (COCs) in the FS.
Use of COCs in the FS and Beyond	105, 191	The LWG believes that chemicals that exceed screening levels but that have not been further evaluated through risk characterization should be considered chemicals of potential concern (COPCs) and not chemicals of concern (COCs). As discussed during the September 9th meeting, chemicals that are evaluated in the revised BHHRA that exceed screening levels will be designated COPCs. COPCs will be carried forward into risk characterization, which will identify those chemicals resulting in

Issue Category	BHHRA Directive Comments	General Response
		cancer risks greater than 10-6 or hazard quotients greater than 1. Those chemicals will be considered in the risk management recommendations, which will recommend the chemicals to be considered COCs in the FS. Sediment PRGs will be developed for COCs, so if a PRG cannot be developed (e.g., due to a lack of sediment-tissue relationship), the chemical will not be recommended for consideration as a COC.
ARAR Evaluation in the BHHRA	26, 105, 171, 191	The LWG believes that it is not consistent with guidance to include an ARAR evaluation in the risk assessment. In addition, EPA's directed changes are not consistent with an ARAR evaluation as RSLs are not ARARs and neither the NRWQC nor the Oregon WQS are currently based on 142 g/day. The BHHRA did, however, evaluate fish consumption scenarios that assumed ingestion rates of 142 and 175 g/day and also evaluated a domestic water use scenario using untreated surface water data for transect and vertically integrated sample locations pursuant to EPA direction. As discussed at the August 20th and September 9th meetings, the revised BHHRA will not include an ARAR evaluation. Surface water and transition zone water (TZW) will be included in a screening evaluation consistent with prior agreements with EPA. The screening evaluation will compare detected concentrations in surface water with NRWQC, NRWQC divided by 10 (to represent an ingestion rate of 175 g/day), MCLs, non-zero MCLGs, and RSLs; and detected concentrations in TZW with NRWQC, MCLs, non-zero MCLGs, and RSLs. Chemicals that exceed the screening criteria will be identified as COPCs in a table, separate from Table 8-1, in the revised BHHRA and will be carried forward into the FS for further evaluation related to contaminant mobility. An ARAR evaluation will be included in the FS.
Risk Driver Section in the BHHRA	General 8, 26, 191	The LWG believes the use of the term "risk driver" and the discussion

Issue Category	BHHRA Directive Comments	General Response
		in Section 8.2 of the draft BHHRA is consistent with guidance. RAGS Part A Section 8.6.1 states that the summary of risk information should include discussion of: "*the major factors driving the site risks (e.g., substances, pathways, and pathway combinations).…confidence that the key site-related contaminants were identified and discussion of contaminant concentrations relative to background ranges.…and level of confidence in the exposure estimates for key exposure pathways and related exposure parameter assumptions*". As discussed at the August 20th and September 9th meetings, Section 8.2 will remain in the revised BHHRA, but the term "Risk Driver" will not be used throughout the revised BHHRA. Instead, terms such as "primary contributor to risk" will be used. Section 8.2 will discuss the relative magnitude of risks associated with the various chemicals and exposure pathways evaluated in the BHHRA.
Directed Changes to Text		
Deletion of Factual Statements and Comments on Remedy	26, 63, 128, 148, 149, 151	The LWG disagrees with EPA's directed changes requiring the removal of factual information from the draft BHHRA. The LWG believes that the addition of statements asserting a need for remediation or goals of remediation in the BHHRA is not consistent with guidance. As discussed at the August 20th and September 9th meetings, factual (i.e., objective) language can remain in the revised BHHRA. Judgmental language (both that in the draft BHHRA and that directed by EPA) will not be included in the revised BHHRA. The need for remediation or goals of remediation will not be discussed in the revised BHHRA. Discussion of remedial goals will be included in the FS consistent with the RAOs.
Deletion of EPA Direction	14, 26, 30, 125	The LWG disagrees with EPA's directed changes requiring the deletion of references to prior EPA direction from the draft BHHRA.

Issue Category	BHHRA Directive Comments	General Response
		As discussed at the August 20th and September 9th meetings, language stating that evaluations were done at the direction of EPA can remain in the revised BHHRA. Language implying opinion or judgment about the prudence of that direction will be removed.
Description of Drinking Water Scenario	General 6, 12, 36, 41,43, 44, 48, 56, 68, 85, 128, 132, 136, 173	The LWG believes that the drinking water scenario was described in the draft BHHRA consistent with RAGS A, and the drinking water scenario was quantitatively evaluated using transect and vertically integrated surface water samples per prior direction from EPA. The LWG does not believe it is appropriate to discuss the need to remediate a resource or ARAR issues in a risk assessment. The LWG also believes "hypothetical" accurately describes the scenario that untreated water would be used for domestic purposes, as evaluated in the surface water drinking scenario. Under OAR 340-041-0340, Table 340A, domestic water supply is a designated beneficial use of the Willamette River, but only with adequate pretreatment. As discussed at the August 20th and September 9th meetings, the term "hypothetical" can be used when describing the use of the Lower Willamette River (LWR) as a domestic water source, as long as factual information is provided to support that characterization. Language regarding the designated beneficial use of the LWR and the need to protect the resource will be included in the revised BHHRA. Language regarding the need to remediate the resource will not be included. The following language is an example of how the scenario will be described in the revised BHHRA: "*Even though no current or future uses of the LWR within Portland Harbor as a domestic water source have been identified, as discussed above under OAR 340-041-0340 Table 340A, domestic water supply is a designated beneficial use of the Willamette River, with adequate pretreatment. Because the Willamette River is capable of serving as a potential drinking water source, the expectation is that this resource*

Issue Category	BHHRA Directive Comments	General Response
		will be protected to achieve such use with adequate pretreatment." Per recent EPA direction, the drinking water scenario will be quantitatively evaluated in the revised BHHRA using the transect and vertically integrated surface water samples and the averaged concentrations of near-bottom and near-surface surface water data where both samples were collected. The full surface water data set will be evaluated separately in the screening evaluation presented in Section 6.
Characterization of Ingestion Rates	General 1, 14, 49, 63, 64, 93, 94, 98, 101, 138, 140	The LWG recognizes that the ingestion rates from the USDA CSFII Study are for both consumers and non-consumers; however, the rates used in the draft BHHRA are equal to the 90th and 99th percentiles, which are considered upper-bound exposures per RAGS A: "If statistical data are available for a contact rate, use the 95th percentile value for this variable. (In this case and throughout this chapter, the 90th percentile value can be used if the 95th percentile value is not available.)" Furthermore, the draft BHHRA did not consider the fraction of fish consumed from the site, did not account for reductions due to preparation and/or cooking methods, and assumed consumption of resident fish only (i.e., no anadromous fish such as salmon). Therefore, applying the 90th and 99th percentile ingestion rates for all fish and shellfish consumption combined in a national diet study to consumption of resident fish only exclusively from Portland Harbor is an uncertainty, as discussed in the draft BHHRA. As discussed at the September 9th meeting, ingestion rates will be presented in the revised BHHRA as the numeric rates (i.e., grams per day or meals per month) and the source of the rates will be presented, consistent with the text in the Programmatic Work Plan. Characterization or descriptors of the ingestion rate (e.g., "low", "high") will not be included in the revised BHHRA.
Deletion of Language	General 4, 75, 83, 96, 102, 170,	The LWG believes that the combination of multiple conservative

Issue Category	BHHRA Directive Comments	General Response
Regarding Compounding of Conservative Assumptions	174, 193, 198	assumptions does result in risks for certain scenarios that are greater than those that are "reasonably anticipated to occur at a site", which is the definition of reasonable maximum (RAGS A, Page 6-4). For example, it is not anticipated that an individual would eat 19 meals of whole body carp caught within the Study Area that had no preparation or cooking every single month for 30 years. However, the LWG recognizes that the concept of reasonable maximum exposure (RME) involves the use of professional judgment. Per RAGS Volume 3 Part A, "*the 90th to 99.9th percentiles of the risk distribution are collectively referred to as the* ***recommended RME range***", and the risk manager chooses the specific percentile to represent the RME individual. As discussed at the September 9th meeting, language regarding the compounding of conservative assumptions will not be included in the revised BHHRA. Factual information about the range of the exposure assumptions and how the combination of those assumptions may fall within the RME range of 90th to 99.9th percentiles can be included in the revised BHHRA.
Clam Consumption Scenario	12, 96, 126, 147	The LWG believes the draft BHHRA accurately describes the shellfish consumption scenario because there is no documentation that shellfish consumption actually occurs on an *ongoing* basis within the Study Area (italics indicate emphasis added). ODFW provided the crayfish landing reports for 2005 through 2007, and there were no reported commercial crayfish landings for the Willamette River in Multnomah County during this time. As stated by EPA, an average of 4,300 lbs of crayfish was commercially harvested from the portion of the Willamette River within Multnomah County in each of the 5 years from 1997 to 2001. The draft BHHRA included an evaluation of crayfish consumption consistent with prior EPA direction. The Linnton Community Center study may support the assumption that transients currently consume bivalves. However, there are significant

Issue Category	BHHRA Directive Comments	General Response
		concerns with the validity of that survey, and the exposure duration for transients is much less than that used in the draft BHHRA to evaluate clam consumption. In addition, there is no empirical basis for the assumption that bivalve biomass would increase in the future without additional evaluation of future conditions, including habitat and accessibility. As discussed at the August 20th and September 9th meetings, the clam consumption scenario can be factually discussed in the revised BHHRA. Language regarding the evaluation of shellfish consumption at the direction of EPA and that the harvest and possession of Asian clams is illegal can remain in the revised BHHRA. Information from the Linnton study will be cited as such. Language implying opinion or judgment about the clam consumption scenario will not be included in the revised BHHRA.
Regional Tissue Concentrations	26, 193	The LWG believes that the regional tissue concentrations provide important context to the public in understanding the fish consumption risk results. As discussed at the September 9th meeting, regional tissue data can be included in the RI. Information included in the RI can be included in the revised BHHRA in a factual manner but not to qualify risks for the Site. If regional tissue data are included, the following context needs to be provided: concentrations are higher at the Site than in the regional tissue, the sources of the regional tissue concentrations are unknown, regional efforts are underway to reduce concentrations, and additional information about the studies (e.g., fish species, size of fish).
Other	108, 109, 133, 141, 142, 150, 162	The LWG believes that the language in the draft BHHRA is accurate and consistent with risk assessment guidance and disagrees that the changes directed in these comments are needed. As discussed at the September 9th meeting, the BHHRA will be

Issue Category	BHHRA Directive Comments	General Response
		revised per these directed changes.

TAB 10

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10
OREGON OPERATIONS OFFICE
805 SW Broadway, Suite 500
Portland, Oregon 97205

September 22, 2010

Mr. Bob Wyatt
Northwest Natural & Co-Chairman, Lower Willamette Group
220 Northwest Second Avenue
Portland, OR 97209

Re: Portland Harbor Superfund Site; Administrative Order on Consent for Remedial Investigation and Feasibility Study; Docket No. CERCLA-10-2001-0240
General Responses to EPA Directed BHHRA and BERA Comments

Dear Mr. Wyatt:

On July 19, 2010, EPA submitted comments to the Lower Willamette Group (LWG) on the draft Portland Harbor Remedial Investigation Report. Included in these comments were approximately 80 directed comments on the baseline human health and ecological risk assessments (BHHRA and BERA). EPA and the LWG met to discuss these directed comments on August 20, 2010 and September 9, 2010. At the close of the second meeting, EPA and the LWG had reached agreements to resolve all the directed comments. The LWG provided a general framework for resolving EPA's directed comments on the BERA and BHHRA in a September 15, 2010 letter, based on the LWG's understanding of the agreements

EPA has reviewed the September 15, 2010 letter and attachments and agrees, with clarifications, that EPA's directed comments on the BERA and BHHRA should be revised in accordance with the general framework, and that the proposed resolution described in LWG's general responses matches our understanding of the meeting outcome. EPA clarifications are presented below:

1) Risk Management Recommendations: The results of the uncertainty analysis presented in the BERA and BHHRA should also be incorporated into the risk management recommendations. In addition, although EPA recognizes the difference in EPA policy with respect to risk management and the BERA and BHHRA, EPA would like the risk management sections for both the BERA and BHHRA to be presented together in either a stand alone document or as part of the risk assessment summary in the draft FS. EPA would like to further note that some chemicals without a strong tissue-sediment relationship may contribute substantially to the overall risk to human health and the environment based on the spatial extent and magnitude of the risk estimate.
2) Uncertainties that Contribute to Under Estimating Risk: It is unclear that "most" uncertainties discussed in the BERA will be described as resulting in overestimation of

HQ's and risks. It is more accurate to say "many" uncertainties may result in overestimation of HQ's and risks.

3) Deletion of Language Regarding Compounding of Conservative Assumptions: EPA would like to note that it may be difficult to look at compounding risks in a quantifiable manner without performance of a probabilistic risk assessment.

Because we did not discuss all the directed comments, a final determination that the LWG has addressed the directed comments can not be made until a redline-strikeout version of the BERA and BHHRA reports are submitted. EPA expects that the general resolutions proposed in the September 15, 2010 letter will be incorporated into the revised BERA and BHHRA reports as appropriate.

Finally, EPA thanks the LWG for its efforts in working to resolve the directed comments. EPA looks forward to continued efforts on the LWG's part to resolve the non-directed comments on the draft remedial investigation and baseline risk assessment reports. If you have any questions this matter, please contact Chip Humphrey at (503) 326-2678 or Eric Blischke (503) 326-4006. All legal inquiries should be directed to Lori Cora at (206) 553-1115.

Sincerely,

Chip Humphrey
Eric Blischke
Remedial Project Managers

cc: Greg Ulirsch, ATSDR
Rob Neely, NOAA
Ted Buerger, US Fish and Wildlife Service
Preston Sleeger, Department of Interior
Jim Anderson, DEQ
Kurt Burkholder, Oregon DOJ
David Farrer, Oregon Environmental Health Assessment Program
Rick Keppler, Oregon Department of Fish and Wildlife
Michael Karnosh, Confederated Tribes of Grand Ronde
Tom Downey, Confederated Tribes of Siletz
Audie Huber, Confederated Tribes of Umatilla
Brian Cunninghame, Confederated Tribes of Warm Springs
Erin Madden, Nez Perce Tribe
Rose Longoria, Confederated Tribes of Yakama Nation

TAB 11

General Responses to EPA's Non-Directive Comment Key Issues on the Baseline Human Health Risk Assessment

November 18, 2010

Issue Category	BHHRA Non-Directive Comments	General Response	Resolution
Change to Exposure Scenarios	General 10, General 12(ii), 10, 45, 52, 163	Exposure scenarios for the BHHRA and the approach for evaluating those scenarios were previously identified in the EPA approved (approval date of July 6, 2006) "Technical Memorandum for Human Health Risk Assessment: Exposure Point Concentration Calculation Approach and Summary of Exposure Factors (dated April 21, 2006)". In addition, the exposure scenarios were evaluated in the Round 2 Comprehensive Report without comment from EPA, or the comment was addressed in the draft BHHRA. Changes to these exposure scenarios are now being requested by EPA without information on why a change is warranted at this time. The following changes are being requested in EPA's comments: • Evaluation of ingestion of human milk by infants for all receptors (this previously was identified as an exposure pathway for fish consumers only) • Combining adult and child scenarios • Addition of beach user exposure to groundwater seeps • Use of the 95% UCL/maximum concentration for all exposure scenarios • New child receptors: child fisher, child tribal fisher, and child consumer (it is not clear whether these are actually requests for new receptors or just a misstatement about the receptors evaluated in the BHHRA)	Based on the October 15 meeting, EPA will require that the evaluation of ingestion of human milk by infants be included for all receptors where PCBs, DDx, and/or dioxins are COPCs. EPA will require that the adult and child scenarios be combined. Per discussion between Elizabeth Allen, Mike Poulsen, and Laura Kennedy and a subsequent email from Elizabeth Allen on October 26, the child and adult receptors can be presented separately, as is done in the draft BHHRA. An additional scenario for combined child/adult exposures would be included as well as a separate table for those scenarios that currently include both child and adult receptors (the scenario would add the child risk to the adult risk, which would be modified for 24 years versus the 30 years used in the adult only scenario). For cPAHs, early life exposures using age-dependent adjustment factors will be included in both the child (0-6 years) and the combined child/adult scenarios. The adult only scenarios will not be changed. The PRGs used in the FS will continue to be based on adult exposure scenarios and not on the combined child/adult scenarios because the PRGs based on adult exposures are considered protective of human health. EPA will commit to the use of PRGs based on adult exposure scenarios in writing. EPA will not require the addition of beach

Issue Category	BHHRA Non-Directive Comments	General Response	Resolution
			user exposure to groundwater seeps, use of the 95% UCL/maximum concentration for all exposure scenarios, or new child receptors.
Change in Dataset	32, 38, 39, 40, 54, 194	The data sets used in the draft BHHRA were based on prior discussions and agreements with EPA, as documented in the Issue Resolution table for the Round 2 Comprehensive Report and the Meeting Summary Memo dated June 9, 2008. EPA is now requesting changes to those data sets. To include additional data and/or modify the data evaluated in the BHHRA would be a significant effort. The following changes are being requested in EPA's comments: • Inclusion of data outside of the Study Area in identifying COPCs • Additional surface water data for transient and recreational beach user exposures	EPA will not require the changes to the data sets used in the BHHRA that were requested in the identified non-directive comments.

Issue Category	BHHRA Non-Directive Comments	General Response	Resolution
Clarification Needed	10, 110, 120, 159, 187	Clarification is needed from EPA.	EPA provided the following clarifications: #10 – The parenthetical note in EPA's comment can be deleted. #110 – The revised BHHRA should provide some qualitative or quantitative information regarding the portion of the life cycle of anadromous fish that would be spent in Portland Harbor. Information (qualitative or quantitative) about PCB concentrations in the Queets, Quinault, and Chehalis rivers relative to Portland Harbor should be presented, if available. #120 and #187 – Prior to eliminating a chemical as a COC based on N-qualified data, the sediment data for the tissue COCs should be evaluated. If the N-qualified chemicals in tissue of small home range species (i.e., smallmouth bass, clams, and crayfish) result in a risk greater than 10^{-6} and are positively identified in sediment within the same exposure area, the chemical should be identified as a chemical potentially posing unacceptable risk. #159 – The revised BHHRA should provide additional analysis of the Round 1 and Round 3 data to confirm that the use of the Round 3 data does not bias results.

Issue Category	BHHRA Non-Directive Comments	General Response	Resolution
Summary of Risk Results	76, 78, 92, 97	EPA requested that a summary discussion be included at the end of the risk characterization section for each exposure medium evaluated in the BHHRA. The LWG proposes that the summary discussion should identify those chemicals with cancer risks greater than 10^{-6}, 10^{-5}, and 10^{-4} and hazard quotients greater than 1.	EPA agrees with the response.
Carcinogenic PAHs	164	The draft BHHRA included risk estimates for both individual and total carcinogenic PAHs. The LWG agrees to add discussion of the risk results for total carcinogenic PAHs in the revised BHHRA, but does not agree that the risk results for total carcinogenic PAHs should be presented instead of individual PAHs.	EPA agrees with the response.
Additional Language, Information, and/or Analyses Will Be Provided	65, 90, 100, 160, 167, 177, 185, 195, 196, 197, 199, 201, 206, 207, 210, 211	The LWG accepts the comment and will include additional language, information, and/or analyses in the revised BHHRA in addressing the comment.	EPA agrees with the response.

Issue Category	BHHRA Non-Directive Comments	General Response	Resolution
Probabilistic Risk Assessment (PRA)	107	The LWG agrees that the tiered approach to PRA begins with a point estimate risk assessment, which is what was done in the BHHRA. However, RAGS Volume 3 Part A clearly states "In the point estimate approach, parameter uncertainty is addressed in a qualitative manner for most variables". This is true for the BHHRA, as shown in Table 7-1 where the range of uncertainty could not be quantified for many variables. The advantages to a probabilistic risk assessment (PRA) are stated in RAGS Volume 3 Part 3 "In general, compared to a point estimate risk assessment, a PRA based on the same state of knowledge may offer a more complete characterization of variability in risk, can provide a quantitative evaluation of uncertainty, and may provide a number of advantages in assessing if and how to proceed to higher levels of analysis". The LWG believes it is important to acknowledge the limitations of the uncertainty assessment that was included in the BHHRA.	The text will be revised to indicate that a quantitative evaluation of uncertainty is included in the BHHRA.
Changes to Text			

Issue Category	BHHRA Non-Directive Comments	General Response	Resolution
Use of the Term "Conservative"	1, 5, 175	The use of the term "conservative" is consistent with EPA guidance. For example, RAGS Part A (page 6-5) states that, "The intent of the RME is to estimate a *conservative* exposure case (i.e., well above the average case) that is still within the range of possible exposures", and the EPA 2002 guidance Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites states that "the exposure point concentration (EPC) is a *conservative* estimate of the average chemical concentration in an environmental medium" No changes to the BHHRA are proposed by the LWG in response to these comments.	Overall, EPA agrees with the response. However, where the term "conservative" is used in combination with "health-protective", EPA requests that one of the terms be used.
Modification to Suggested Language	2, 3, 6, 50, 71, 145	EPA provided suggested revisions to the text of the BHHRA. The LWG proposes modifications to the suggested language for purposes of clarity and/or consistency.	EPA agrees with the response.
Description of RME Exposure Point Concentration	20, 52, 186	The draft BHHRA used the phrase "95% Upper confidence limit (UCL) or Maximum" when referring to the exposure scenario based on those exposure point concentrations (EPCs). EPA has requested that the term RME exposure be used instead. However, the exposure scenario involves multiple ingestion rates, so it is not a single "RME exposure". The LWG proposes using RME EPCs in the revised BHHRA to characterize the exposure scenario. The exposure point concentration summary tables will continue to present the basis of individual EPCs as either a UCL or a maximum.	The EPCs will be described in a factual manner in the BHHRA (i.e., the EPC will be identified as the mean, 95% UCL, or maximum). The terms RME and CT will not be used in reference to the EPCs.
Risk Management Recommendations	General 9	This issue was addressed in the responses to EPA's Directive Comments.	EPA agrees with the response.

Issue Category	BHHRA Non-Directive Comments	General Response	Resolution
Use of COCs in the FS and Beyond	General 7, General 9, 29, 103, 188	This issue was addressed in the responses to EPA's Directive Comments.	EPA agrees with the response.
ARAR Evaluation in the BHHRA	General 7, 4, 8, 25, 27, 29, 31, 37, 40, 84, 118, 189, 192	This issue was addressed in the responses to EPA's Directive Comments.	Per resolution of the RI comments, the screening of surface water and transition zone water data, which previously had been included in Section 6 of the draft BHHRA, will be moved to the RI Report.
Risk Driver Section in the BHHRA	General 7, 31	This issue was addressed in the responses to EPA's Directive Comments.	EPA agrees with the response.
Changes to Text			
Deletion of Factual Statements and Comments on Remedy	7, 15, 16, 17, 21, 28, 58, 66, 74, 127, 158, 169, 183, 184, 208	This issue was addressed in the responses to EPA's Directive Comments.	EPA agrees with the response.
Deletion of EPA Direction	11, 28	This issue was addressed in the responses to EPA's Directive Comments.	EPA agrees with the response.
Description of Drinking Water Scenario		This issue was addressed in the responses to EPA's Directive Comments.	EPA agrees with the response.
Characterization of Ingestion Rates	137, 139, 146, 178, 200	This issue was addressed in the responses to EPA's Directive Comments.	EPA agrees with the response.
Deletion of Language Regarding Compounding of Conservative Assumptions	22, 81, 87, 89, 106, 175	This issue was addressed in the responses to EPA's Directive Comments.	EPA agrees with the response.
Clam Consumption Scenario	General 2, 51, 182	This issue was addressed in the responses to EPA's Directive Comments.	EPA agrees with the response.
Regional Tissue Concentrations	General 5, 23, 95, 168	This issue was addressed in the responses to EPA's Directive Comments.	EPA agrees with the response.

Issue Category	BHHRA Non-Directive Comments	General Response	Resolution
Agree	General 3, General 11, General 12(i), 9, 13, 18, 24, 33, 35, 47, 53, 55, 57, 59, 60, 61, 62, 67, 69, 70, 73, 77, 79, 80, 82, 86, 88, 91, 99, 104, 111, 112, 113, 114, 115, 116, 117, 119, 122, 123, 124, 129, 130, 131, 134, 135, 143, 144, 152, 153, 154, 155, 156, 157, 161, 165, 166, 172, 176, 179, 180, 181, 190, 202, 203, 204, 205, 209	The BHHRA will be revised consistent with the comment.	EPA agrees with the response.
Other	19, 34, 42, 46, 72, 121	While the LWG believes that the language in the draft BHHRA is accurate and consistent with risk assessment guidance and disagrees that the changes requested in these comments are needed, the BHHRA will be revised per these comments.	EPA agrees with the response.

Issue Category	BHHRA Non-Directive Comments	General Response	Resolution
Inclusion of the PBDE fish tissue data in the BHHRA	Email from Chip Humphrey on 11/4/10 (not included in EPA's original comments on the draft BHHRA)	The LWG and EPA had previously agreed to a data lockdown date of June 2008 for the BHHRA. EPA's comments on the draft BHHRA in December 2009 and July 2010 did not request the inclusion of the PBDE data. PBDEs were not included as an analyte in Round 3 per an agreement with EPA. The Round 3 fish tissue were subsequently provided to EPA for analysis of PBDEs with the understanding that the tissue were being used to assist in analytical method development and the data would not be included in the Portland Harbor RI/FS. The LWG disagrees with including the PBDE fish tissue data in the revised BHHRA based on prior agreements with EPA.	

TAB 12

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10
OREGON OPERATIONS OFFICE
805 SW Broadway, Suite 500
Portland, Oregon 97205

December 8, 2010

Mr. Bob Wyatt
Northwest Natural & Co-Chairman, Lower Willamette Group
220 Northwest Second Avenue
Portland, OR 97209

Re: Portland Harbor Superfund Site; Administrative Order on Consent for Remedial Investigation and Feasibility Study; Docket No. CERCLA-10-2001-0240
General Responses to EPA Non-Directed RI, BHHRA and BERA Comments

Dear Mr. Wyatt:

On July 19, 2010, EPA submitted comments to the Lower Willamette Group (LWG) on the draft Portland Harbor Remedial Investigation RI) and baseline risk assessment (BRA) Reports. Over the past few months, EPA and the LWG have been engaged in series of discussions to resolve all remaining comments on the draft RI Report. These discussions culminated with three sets of tables that provided the LWG's responses to the key issues associated with EPA's non-directed comments on the RI Report and the baseline human health and ecological risk assessments (BHHRA and BERA). The LWG submitted the tables to EPA on November 18, 2010.

EPA has reviewed the LWG responses, as summarized in the tables, and has determined that the vast majority of issues associated with addressing EPA's comments have been resolved. However, there were three comments for which the LWG did not agree to make the specified changes. These comments are related to the conceptual site model (Linking Sources to In-Water Contamination), the data lockdown date, and the inclusion of the PBDE fish tissue data in the BHHRA. EPA has determined that these comments must be addressed to complete the RI and BRA Reports, and hereby directs the LWG to revise the draft RI and BRA Reports as described in Attachment 1.

EPA has also identified a number of clarifications that are required to ensure that other comments are fully addressed. EPA is providing clarification of our comments on the use of statistical outliers in the background data set, the scale of the ecological risk assessment, the presentation of hazard quotients in the BERA summary tables, and the use of biota-sediment accumulation factors for certain chemicals in the BERA shorebird evaluation. EPA's clarifications are also presented in Attachment 1.

Because we did not discuss all of the comments or details on how the individual comments will be addressed, a final determination that the LWG has addressed the directed and non-directed comments can not be made until redline-strikeout versions of the RI and BRA Reports are submitted. However, EPA believes that addressing all directed comments and non-directed comments consistent with previous direction and agreements, and the direction and clarifications in this letter and attachment, should resolve EPA's RI and BRA Report comments.

EPA is willing to work with the LWG to resolve the RI comments in the most expeditious manner possible and will establish a deadline for submitting a redline-strikeout version of the RI and BRA Reports once the full RI data set is finalized. EPA does not believe that finalization of the RI and BRA Reports necessarily should delay progress on the draft FS Report.

Finally, EPA thanks the LWG for its efforts in working to resolve the RI and BRA comments. EPA looks forward to continued efforts on the LWG's part to develop and submit a draft Feasibility Study Report by June 15, 2011. If you have any questions this matter, please contact Chip Humphrey at (503) 326-2678 or Eric Blischke (503) 326-4006. All legal inquiries should be directed to Lori Cora at (206) 553-1115.

Sincerely,

Chip Humphrey
Eric Blischke
Remedial Project Managers

cc: Greg Ulirsch, ATSDR
Rob Neely, NOAA
Ted Buerger, US Fish and Wildlife Service
Preston Sleeger, Department of Interior
Jim Anderson, DEQ
Kurt Burkholder, Oregon DOJ
David Farrer, Oregon Environmental Health Assessment Program
Rick Keppler, Oregon Department of Fish and Wildlife
Michael Karnosh, Confederated Tribes of Grand Ronde
Tom Downey, Confederated Tribes of Siletz
Audie Huber, Confederated Tribes of Umatilla
Brian Cunninghame, Confederated Tribes of Warm Springs
Erin Madden, Nez Perce Tribe
Rose Longoria, Confederated Tribes of Yakama Nation

Attachment 1
EPA Response to Non-Directed Comment Resolution Tables
December 8, 2010

EPA Direction on key issues where LWG did not agree to incorporate comments

RI Comment - Linking Sources to In-Water Contamination: EPA comments G-6 and G-9 requested that the LWG evaluate the magnitude of upland contamination associated with various migration pathways to help understand the linkage between upland and in-water contamination. This information would be primarily presented in a revised CSM (Section 10 of the RI Report). This information is required by Section 7.4 of the Statement of Work (SOW) which states that the "Respondents will identify source areas that are contributing to contamination to the in-water portion of the Site". This information is further required based on Section 6.2 of the April 2004 Programmatic Work Plan which states that the "RI will not be considered complete until potential sources have been identified" and that "Prior to development of remedial goals and strategies, an evaluation of potential sources of chemicals driving unacceptable risks will be conducted."

EPA first raised the need an evaluation of upland sources of contamination during our review of the February 2007 Comprehensive Round 2 Site Characterization Summary and Data Gaps Report (Round 2 Report). As documented in a March 9, 2009 email between Eric Blischke and Keith Pine, EPA proposed the following resolution: "The assessment should include not only an assessment of whether the pathway is complete but also the magnitude of the contamination associated with the migration pathway. This information should be presented in a semi-quantitative fashion for each chemical evaluated in the CSM in order to better understand the relationship between upland sources of contamination and the in-water distribution of contamination. A more detailed, quantitative evaluation, will be required for the feasibility study." As documented in the same email, EPA "agreed that a strict screening step was not necessary. However, EPA's position is that some assessment of the likelihood of a given contaminant migration pathway impacting the river is required."

In order to address comments G-6 and G-9, EPA requires additional information in Section 10 of the revised RI report that considers the magnitude of current and historical upland sources as they relate to the distribution of in-water contamination. EPA has developed a CSM outline (Appendix A) that summarizes the information that should be presented in the revised CSM. This outline is based on the site-wide CSM for PCBs presented in Section 11.2 of the Round 2 Report. EPA would like to clarify the evaluation of upland sources is not a nature and extent of contamination evaluation but rather of sufficient detail to support the CSM and meet the objectives specified in the programmatic work plan. EPA directs the LWG to prepare a revised CSM consistent with the attached outline for all 13 indicator chemicals presented in Section 10 of the draft RI report.

RI Comment - Data Lockdown Date: EPA commented that the LWG "Expand the data set for the RI to include data collected subsequent to June 2008." EPA believes that this information is relevant to characterizing the Portland Harbor site. On November 1, 2010, the LWG developed a proposal for addressing the comment that included updating the RI data base but did not agree to updated certain maps and figures in the RI Report. EPA believes that the recently collected data such as sediment data collected in the vicinity of the International Slip and RM 11E are directly relevant to the RI from the standpoint of the nature and extent of contamination and sediment data collected from the Downtown Reach are directly relevant to the RI from the standpoint of site boundary determination, the recontamination evaluation and the CSM. In addition, it is important that the RI Report be as up to date as reasonably possible since it represents a comprehensive summary of site conditions that will be referred to for many years in the future. Finally, the previously established data lockdown date of June 2008, which was set as the cutoff date so the LWG could proceed with preparation of the draft RI report and risk assessment reports, will be approximately 3 years old by the time a final RI report is received. In order to address this comment, EPA directs the LWG to make the following changes to the revised RI Report and Site Data Base:

1. The data lockdown date for the RI should be changed from June 2008 to the date of EPA comments on the draft RI and baseline risk assessment reports (July 19, 2010). Data sets that must be incorporated into the RI data base and RI report include: Data collected in the downtown reach, the data collected offshore of RM 11E, the U.S. Moorings data, the data associated with the BP-Arco post-source control in-water data, data collected by Northwest Pipe and Casing in the vicinity of the International Slip and the Post Office Bar data. In addition to the above data sets, the LWG should make reasonable efforts to identify any significant new data sets relevant to the RI since the June 2008 cut off within two weeks following the date of this letter. EPA will then finalize the RI data set.
2. The data lockdown date for the risk assessments will remain unchanged (i.e., June 2008) with the following exceptions: A) The recent PBDE fish tissue data shall be presented in the RI and used to evaluate risks to human health in accordance with all fish consumption exposure scenarios. The recently issued reference dose values available on EPA's Instigated Risk Information System (IRIS) data bases should be used for the risk estimates. The risk assessment information for PBDE's may be presented as an addendum. B) The recent Osprey egg data should be used to validate the bird egg uptake model as previously agreed to by the LWG.
3. The LWG shall develop and provide to EPA and updated electronic project data base as soon as practicable.
4. Text shall be added to the appropriate paragraphs of Sections 5 and 10 of the revised RI summarizing the new data (including downtown reach data) in a manner consistent with revised RI Report.
5. A new set of RM 11-12 maps shall be developed and presented for all indicator chemicals due to the significance of the RM 11E data set. In addition a new series of maps that depict indicator chemicals in the downtown reach for surface sediments shall be included as part of Section 5 of the RI Report.

6. Tables 5.6-3 through 5.6-6 and Table 5.6-13 shall be updated to reflect the updated data sets. Table 5.6-13 in particular is directly relevant to the downtown reach data and should be updated to reflect the substantial amount of downtown reach data to support the CSM discussion presented in Section 10 and elsewhere.
7. New text shall be added to Section 10, CSM, that refers to the post-data lockdown data discussed in Section 5.6 (i.e., downtown sediment data collected by the City). The new text in Section 10 should evaluate whether the additional upstream data is sufficient to support establishment of an upstream site boundary.

BHHRA Comment - Inclusion of the PBDE Fish Tissue Data in the BHHRA: This comment was provided to the LWG as part of our data lockdown comment with respect to the RI Report (see above). EPA disagrees that the PBDE analysis was solely for the purpose of method development. EPA has determined that the PBDE data is sufficient to assess risk within Portland Harbor, support regional watershed efforts and monitor the effectiveness of the site remedy with respect to PBDEs. As a result, EPA directs the LWG to present the risks associated with PBDEs in bass, carp and clam tissue consistent with the fish consumption scenarios developed in the Portland Harbor baseline human health risk assessment. This comment shall not change the agreed upon PRGs to be used in the draft FS. EPA reserves the right to require the development of PRGs for PBDEs in the future (e.g., proposed plan and/or final FS) if deemed necessary.

EPA clarifications on other key issues

RI Comment - Background Statistical Outliers: EPA previously directed the LWG to exclude statistical outliers that were geographically clustered from the background data set. However, EPA did allow the LWG to present background statistics with the outliers retained in the data set. Although the resolution states that EPA agrees with the response, it was agreed during our discussions with the LWG that some revisions for clarity will be made. This is not reflected in the LWG response. EPA would like to note for the record that the LWG agreed to make some revisions for clarity.

BERA Comment - Assessing Risk at the Individual Sample Scale: EPA specific comment 122 states in part: "Present individual composite risk, not using a 95% UCL concentration." In the response to comments, the LWG agrees to present location specific TRV exceedances for individual samples but also states that the limited spatial extent and/or low magnitude of the HQ exceedance are not necessarily ecologically significant. However the resolution is not clear that a composite by composite evaluation of tissue TRV exceedances will be performed consistent with the Problem Formulation. EPA expects a composite by composite comparison as required by the Problem Formulation. In addition, the risk assessment shall evaluate surface water data on a point by point basis for small home range receptors. The LWG may present information related to ecological significance in the risk characterization section of the BERA.

BERA Comment - Use of BSAFs/BSARs in shorebird calculations: The LWG did not include BSARs to estimate dietary concentrations for the evaluation of shorebirds. LWG representatives have stated that this was not done because the r squared values are below

0.3. However, it is unclear whether BSARs were developed for chemicals that were also modeled using the mechanistic food web model. Consistent with Table 6 of the Problem Formulation document, prey concentrations should be predicted based on lab and worm BSAF/BSARs where prey data are not available at individual beaches. Chemicals for which BSAF/BSARs shall be used are summarized below:

- Benzo(a)pyrene
- Total PCBs
- PCB TEQ (birds)
- Dioxin TEQ (birds)
- Total TEQ
- Aldrin
- Sum DDE
- Total DDx

The LWG should develop BSARs/BSAFs for the above chemicals for use in the dietary evaluation of shorebirds consistent with the problem formulation. BSARs/BSAFs are not required for chemicals that do not pose a risk to shorebirds nor for chemicals for which the r squared value is below 0.3.

BERA Comment - Include HQs in Summary Tables: EPA commented that HQs should be presented (rather than an "X") in the risk assessment summary tables. The LWG countered that this was a complex endeavor. In order to resolve the comment, EPA provided example tables to the LWG. In the LWG's proposed resolution, the LWG states that "EPA agreed that it is acceptable to present tables summarizing the chemicals with HQs greater than 1.0 using X's (e.g., Tables 7-39, 11-1), so long as subsequent tables summarizing the risks for a receptor group (e.g., Table 7-40) or multiple receptor groups (e.g., Table 11-2) provide sufficient information to characterize the magnitude, extent, and ecological significance of risks. EPA also agreed that HQs are not required for tables showing the results of screening calculations." To the extent practicable, HQ's must be presented consistent with the example tables provided to the LWG.

Appendix A – CSM Outline

In order to provide the necessary information in Section 10 to address comments G6 and G9, EPA requires an updated CSM that includes an evaluation of the magnitude of upland contamination and contaminant migration pathways. The updated CSM shall be presented according to the following outline which is based on the information presented in Section 11 of the Round 2 Report. The evaluation of upland sources should not be considered a nature and extent of contamination evaluation but rather of sufficient detail to support development of a comprehensive CSM that considers contaminant sources, migration pathways and exposure media. EPA requires this outline to be followed for all 13 indicator chemicals presented in Section 10 of the draft RI report.

1. Chemical Distribution – describe chemical distribution for the media listed below:
    a. Sediment
    b. Surface Water
    c. TZW
    d. Biota
2. Potential Sources – discuss potential sources both from a broad usage perspective and a pathway specific basis.
    a. Usage of chemical – historical and current: Describe what is known about the use of the chemical on a industry sector basis. Describe the types of industries that existed in Portland Harbor that are known to have handled, manufactured or disposed of the chemical
    b. Stormwater/Overland Transport: Described those facilities, stormwater basins or land use types where the chemical is known to be present in stormwater at significant levels. Cite factual information such as chemical concentrations, stormwater loading data and/or priority of source based on DEQ source control information.
    c. Wastewater: Describe those facilities where the chemical is known to be associated with wastewater discharges. Cite factual information to the extent possible to support the association of the chemical with the wastewater discharge (e.g., permit violations, documented spills or other documented information from DEQ files).
    d. Overwater Discharge: Cite factual information to the extent possible to support the association of the chemical with the overwater discharges (e.g., documented spills).
    e. Groundwater Discharge: Describe sites where groundwater plumes associated with the chemical are present. Present factual information such as chemical concentration in near shore groundwater wells and DEQ ranking of priority.
    f. Riverbank Erosion: Describe sites where the chemical has been detected in riverbank soils.
    g. Atmospheric Deposition: Describe what is known about atmospheric deposition. Cite data to the extent available
    h. Upriver (Watershed) Sources: Describe what is known about upriver (watershed) sources. Cite data including data from the downtown reach, upriver reach, and other data generated by DEQ, USGS and others.

3. Relationship of sources to distribution of chemical: Describe how the source information (including upriver/watershed sources) accounts for the distribution of contamination at the site. Focus on sediment distribution but also describe surface water, biota and transition zone water data. Discuss sources from the perspective of current and historical sources. Describe status of DEQ source control efforts (including watershed wide and downtown reach) to control current sources.

TAB 13

LOWER WILLAMETTE GROUP

Chairperson: Bob Wyatt, NW Natural
Treasurer: Fred Wolf, Legacy Site Services for Arkema

January 12, 2011

Chip Humphrey
U.S. Environmental Protection Agency, Region 10
805 SW Broadway, Suite 500
Portland, OR 97205

Re: December 21, 2010 EPA Letter on the Status of the Portland Harbor Feasibility Study; September 27, 2010 EPA Letter on the Benthic Risk Evaluation; and December 8, 2010 EPA Letter on General Responses to EPA Non-Directed RI, BHHRA and BERA Comments. Lower Willamette River, Portland Harbor Superfund Site, USEPA Docket No: CERCLA-10-2001-0240)

Dear Chip:

This letter provides the Lower Willamette Group (LWG) response to EPA's December 21, 2010, letter regarding the Feasibility Study (FS), and to EPA's September 27, 2010, and December 8, 2010, comment letters on the draft October 2009 Remedial Investigation (draft RI) and September 2009 draft risk assessments (Baseline Human Health Risk Assessment [BHHRA] and Baseline Ecological Risk Assessment [BERA]). We believe this letter provides a productive route for closure on EPA's nearly 1,000 comments on the draft RI, BHHRA, and BERA and, equally important, sets the stage for continued development of the draft FS as the next step toward an implementable Record of Decision.

Overview

The LWG's overriding goal remains to prepare a technically and legally sound Remedial Investigation/Feasibility Study (RI/FS) that fulfills the LWG's Administrative Settlement Agreement and Order on Consent (AOC), complies with the National Contingency Plan, and sets the foundation for selecting a sediment remedy that is protective of human health and the environment. The LWG has spent more than $80 million on the Portland Harbor Superfund Site study phase, and we want EPA to be able to transition to the cleanup phase as soon as possible.

In ten years the LWG has worked through all of the directives required by EPA without the need to invoke and complete dispute resolution. In all cases, we have been able to work through issues and differences, and we hope to continue our cooperative relationship as we prepare to deliver the FS. The LWG is committed to delivering a FS that is based on sound science, and helps EPA evaluate remedial options that are protective, implementable, and affordable for our region. To achieve this goal the June 2011 deadline for the draft FS submittal should be extended.

To prepare the FS, the LWG has been relying on feedback from EPA on the Draft RI and risk assessments submitted in fall 2009. In EPA's December 2009 comments on the RI and risk assessments, EPA said it thought the reports contained all the relevant data necessary to proceed with the FS. The LWG proceeded with work on FS-related tasks on that basis. Subsequently EPA provided nearly 1,000 comments to the LWG in July 2010, and followed with additional directive comments in September and December 2010 that require additional analyses and the incorporation of new data not collected by the LWG into the RI and risk assessments. EPA recently clarified that this direction also requires revisions to the FS database. This week EPA and LWG are still resolving the benthic toxicity model directive that will help define the areas requiring analysis in the FS. These new EPA directives impact FS-related analyses and the FS schedule.

This letter outlines a path forward to resolve the three remaining directives on the RI and risk assessments (dated December 8, 2010) as well as the directive on the benthic model (dated September 27, 2010) in order to facilitate completion of the draft FS. If EPA agrees with the proposed path the LWG will not dispute the directives.

To produce the FS, the RI and risk assessments must be brought to resolution. This letter outlines a path forward to resolve the three remaining directives on the RI and risk assessments (dated December 8, 2010) as well as the directive on the benthic model (dated September 27, 2010). If EPA agrees the LWG will not dispute the directives. Taking into account the substantial additional work remaining on the RI and risk assessments, delivery of a draft FS by June 15, 2011 is neither advisable nor feasible. While some work can be accomplished simultaneously, other work is by definition sequential and cannot be performed simultaneously. In this case, EPA's delivery of RI and risk assessment comments and directives affecting development of the FS as late as December 2010 means the LWG would be submitting a draft FS prior to submission of the revised RI and risk assessments. Doing so carries a significant risk of the FS being rushed, incomplete, and having limited value for EPA in developing the proposed plan. Per EPA's letter of December 21, 2010, we accept your offer to meet at your earliest convenience in order to discuss the overall process, including an appropriate schedule to bring these complex and interlocking deliverables to completion without sacrificing their quality.

Feasibility Study (EPA Letter of December 21, 2010)

In early 2009, EPA and LWG implemented an expedited FS development schedule whereby the FS was initiated prior to finalization of the baseline risk assessments. This approach was a divergence from the process outlined in the AOC but agreed to by the LWG and EPA in order to enable EPA to transition to cleanup decisions on a more expedited time frame.

The ability to maintain that expedited FS development schedule was critically dependent upon a number of conditions, including:

- No changes to the FS database;
- EPA providing comments on the draft risk assessments that could impact the FS development by end of December 2009;
- EPA providing comments on the benthic risk evaluation; and

- EPA providing feedback and buy-in on the Fate and Transport model calibration, all so that work on the FS could proceed without changes in the data that had to be considered or changes in the assumptions on which the FS was being developed.

EPA's Comments on the Draft Remedial Investigation:
EPA's December 8, 2010, comment letter directs the LWG to include additional data in the RI and RA database. EPA has clarified that this direction also requires that some of this new data must be included in the FS database. Changing the FS database results in changes to the schedule for completing the draft FS. For example, dozens of chemicals will have to be re-mapped which results in revisions to the areas and volumes of sediment to be considered in the FS. This in turn impacts the alternatives development and the comparative analysis of remedial alternatives.

EPA's Comments on the Draft Risk Assessments: On December 23, 2009, EPA provided preliminary comments on the draft BHHRA and draft BERA to identify key issues for consideration in the expedited FS, and to facilitate maintaining the expedited schedule. EPA indicated that it was not able to provide its benthic risk evaluation at that time, and that those comments should be provided to the LWG by spring 2010. On July 19, 2010, EPA provided detailed comments on the draft RI report, BHHRA, and BERA but again deferred its comments on the benthic approach presented in the draft BERA. At that time, EPA advised the LWG that it would provide comments on the benthic approach, including an alternate approach for evaluating benthic risk, later that summer. However, the July 19 comments on the draft risk assessments included directives to include new data sets (e.g., bird egg data and fish tissue data), new risk scenarios (e.g., combined child and adult scenarios), and new chemicals of concern (i.e., PBDE) and to incorporate additional sediment data not collected by the LWG into the FS database. Each of these directives has a direct impact on development of the draft FS.

EPA Feedback on the Benthic Risk Evaluation: EPA comments on the benthic risk evaluation and a predictive benthic toxicity logistic regression model (LRM) developed by NOAA were finally provided to the LWG on September 27, 2010. EPA and the LWG exchanged a great deal of information and met many times in late 2010 and early 2011 to resolve outstanding benthic evaluation issues, including errors in NOAA's LRM model. As recently as January 4, 2011, EPA was still providing critical information regarding NOAA's LRM that had the potential to fundamentally impact the outcome of the model and, therefore, the definition of the areas of benthic risk to be evaluated in the FS.

EPA Feedback and Buy-in on the Fate &Transport Model Calibration: Delays with EPA approval of calibration led to a much more compressed timeframe for modeling implementation and LWG review than was contemplated in the original plan to expedite FS development. Although the F&T model is state of the art, well calibrated, and supported by a robust data set, as of December 2010, the compressed time frame did not allow the LWG itself to review and understand key aspects of the F&T model.

Because so many building blocks for the expedited FS schedule were delayed, the LWG was not confident in November 2010 that the Alternatives Screening check-in scheduled for December

2010 would provide the appropriate range of realistic, implementable alternatives for the detailed evaluation of the draft FS. Some of the contributing factors including:

- the timeframe for EPA input on the risk assessments was extended;
- the LWG was required to put significant time and effort into resolving EPA's July RI and risk assessment comments;
- key RI and risk issues were not resolved by late Fall 2010; and
- a clear summary of EPA risk management considerations to support development of a full and appropriate set of alternatives to be carried into the detailed analysis in the FS was still outstanding.

It was clear to the LWG that the final resolution of these remaining key issues could result in significant changes to the Alternatives Screening analyses. Therefore, the LWG notified EPA on November 17, 2010, that it was best to scale back the scope of the December check-in in the absence of resolution of these key issues.

We disagree with the EPA's assertion that the LWG has not complied with the AOC because we were unable to provide a complete Alternatives Screening Analysis on December 14, 2010. A complete Alternative Screening Analysis cannot be presented without resolution of the issues described in this letter. The Alternative Screening Analysis is a step in the process where the data that has been collected is used to determine where risks to human and ecological health are located and how to start evaluating which cleanup alternatives might work to reduce those risks in the sediments and near shore areas of the Lower Willamette.

Because the RI and risk assessments, both logically and legally, form a significant part of the foundation for the FS, the LWG believes that EPA and the LWG must reach agreement on the substantive contents and conclusions of the RI and baseline risk assessments before the draft FS can be completed and submitted to EPA. With the approach outlined in this letter, the LWG will move forward with completing the risk assessments and use the results to develop recommended comprehensive risk management approaches for use in the FS. The effort to revise the RI and risk assessments and incorporate the risk assessment results into a risk management framework will likely take significant effort and time. Therefore, this has a significant impact on the FS schedule.

The LWG will deliver a draft FS that is consistent with the AOC, the NCP and guidance. We agree with EPA that the FS needs to be objective and transparent. We expect the FS to be approvable by EPA and to provide the basis for EPA's Proposed Plan and ROD. To achieve these goals, a re-evaluation of the draft FS deadline is necessary in the context of the schedule for the Proposed Plan and ROD. The LWG hopes to meet with EPA very soon to complete discussions regarding establishing a comprehensive schedule for completing the LWG's RI/FS and EPA's Proposed Plan and ROD.

Draft RI, BHHRA, and BERA (EPA Letter December 8, 2010)

The LWG has worked diligently with EPA to resolve EPA's July 19, 2010 comments (both directed and non-directed) on the draft RI, BHHRA, and BERA. The July 19 letter declined to provide comments on the BERA benthic risk evaluation; those comments were provided on September 27, 2010. LWG and EPA agreed to categorize all the comments into a list of key issues in order to streamline the process of resolving the comments. On September 15, 2010, following a number of meetings to discuss EPA's directive comments on the BHHRA and BERA, the LWG submitted to EPA a table of responses to the July 19 directed comments. On September 22, 2010, EPA's response letter indicated that, with clarifications, EPA and LWG were in agreement on the framework to address the July 19 directive comments. On November 18, 2010, following several meetings to discuss issues raised by the EPA non-directed comments, the LWG submitted to EPA a summary table of responses to the July 19 non-directed comments. EPA's response letter of December 8, 2010, provided confirmation that EPA and the LWG are in agreement on the vast majority of the issues raised by the comments. However, the December 8 letter directed the LWG to perform three additional tasks to complete the RI and BHHRA: (1) move the RI data lockdown date from June 2008 to July 19, 2010 and include specific data sets directed by EPA; (2) draft the conceptual site model to link both current and historical sources to in-water contamination; and (3) include EPA PBDE fish tissue data in the BHHRA. This letter describes how the LWG will comply with these three directed comments.

On a separate negotiation path, it was recognized by EPA and LWG that additional discussions were necessary to resolve the benthic risk evaluation (in particular, if and how to incorporate NOAA's Logistic Regression Model into the BERA). The established goal was to have the benthic risk evaluation issues resolved by December 1, 2010, with full EPA buy-in by mid-December, with outputs ready for LWG use by mid-January 2011. This letter also describes how the LWG will complete its evaluation of benthic risk for the BERA.

1. Data Lockdown

The LWG continues to maintain that the data utilized in the draft RI (i.e., June 2008 Data Lockdown) are adequate to finalize the RI and fully comply with the requirements of the AOC. Until it has evaluated the data, the LWG will not know whether the additional data EPA has asked it to consider meet the quality assurance/quality control requirements for inclusion in the RI as established in the Programmatic Work Plan and QAPP. Nonetheless, the LWG will not dispute EPA's directive to include particular data collected after the June 2008 lockdown date, but we do not agree with EPA that these additional data are necessary to finalize the RI. In addition, EPA has acknowledged that these additional data do not have to be incorporated into the risk assessments (except for the PBDE and bird egg data), because they will not alter the analyses or conclusions of the revised risk assessments.

In order to resolve the data lockdown issue, the LWG will comply with EPA's directive by including the additional data identified on Attachment A, which include the specific data sets listed in EPA's letter of December 8, 2010 and additional significant data sets identified by LWG as directed by the EPA letter, provided such data meet the RI QA/QC requirements and the

contemplated uses of the data are appropriate. The LWG continues to question the relevance of these data to the RI and maintains that this issue could have been best addressed per our previous agreement with EPA to include post-June 2008 data sets in the draft FS if they are deemed value-added to the FS analyses (e.g., demonstrated a significant difference in nature and extent of contamination in a particular portion of the study area).

As previously indicated to EPA, there will be schedule implications associated with including these data since the LWG must perform a quality control review of the data sets, incorporate the data into our electronic database, incorporate the data into our GIS program, and generate the EPA-directed text, tables, and figures, consistent with appropriate limitations on the use of the data.

Please confirm that EPA agrees that, with the inclusion of the data sets identified on Attachment A, the data set for the RI is complete, and EPA will not direct that additional data be included. If EPA does not agree, the LWG respectfully invokes dispute resolution on this issue for the reasons stated in this and prior correspondence.

2. Inclusion of PBDE Fish Tissue Data in the BHHRA

PBDE has not previously been identified as a contaminant of interest (COI) for the Portland Harbor site, and EPA's direction to include its PBDE fish tissue data in the RI and BHRRA is inconsistent with the EPA-approved Portland Harbor QAPP. In addition, EPA's PBDE data were not collected with the intent to include them in the Portland Harbor BHHRA; they are a limited data set and there are no co-located sediment data. Nonetheless, the LWG will comply with EPA's direction to perform additional risk assessment work to include PBDE fish tissue data in the revised BHHRA for informational purposes only. The LWG will need to perform the required QA/QC evaluation of this data in accordance with our approved QAPP to determine its adequacy and acceptability for such use. Per EPA's previous acknowledgement, PRGs for PBDE cannot be generated and therefore PBDE will not be carried forward into the draft FS.

Please confirm that EPA agrees that, with the inclusion of the PBDE data in the BHHRA, EPA will not direct that any additional data be evaluated in the BHHRA or the BERA.

3. Conceptual Site Model

EPA's December 8 letter directs the LWG to provide detailed information on potential current and historical sources of contamination to the Study Area. The LWG's obligation under the AOC is to

> "identify source areas that *are contributing* to contamination to the in-water portion of the Site. Although DEQ is primarily responsible for the control of upland contaminant sources to the Site, as part of the RI/FS, [the LWG] shall evaluate the distributions of sediment contaminants and, if appropriate (e.g. if the sediment data suggest the presence of an ongoing source), make recommendations to EPA and DEQ if the need for further investigation or control of sources is identified."

Statement of Work, §7.4 (emphasis added). The LWG met this obligation in its many submittals thus far that identify source areas that are contributing to in-water sediment contamination,

including Section 3 of the Programmatic Work Plan, Section 5 of the Round 2 Report and Section 4 of the Draft RI, each of which includes tables that compile source information.

There is no available comprehensive compilation of historical sources "that are contributing" and, although the above-cited information presented by the LWG identifies many specific sources of contamination, the LWG has made it clear that it is not an exhaustive list of current or historical sources of contamination. The Oregon Department of Environmental Quality (DEQ) is the lead agency tasked with implementing the on-going source identification and control efforts for the Portland Harbor Superfund Site (i.e, per the EPA/DEQ Joint Source Control Strategy Memorandum of Understanding, and as referenced in the EPA/LWG Administrative Order). The LWG understands that DEQ is not investigating or tabulating historical releases that are not considered on-going sources, and the LWG believes that it also does not have an obligation under the AOC to comprehensively research, compile and analyze such historical releases.

The most comprehensive source for historical release information is likely the EPA 104(e) responses. At EPA's request, LWG members have deferred submitting public records requests for this information to allow EPA time to process the information, and the LWG members have access to this information only as it is submitted in EPA-processed batches to the Portland Harbor allocation process. Therefore, the LWG does not have access to all of the non-LWG 104(e) responses. And, as EPA is certainly aware based on its review of the information, the volume of information received by EPA is so great that detailed review of the information, if the LWG had it all, would delay completion of the RI report by many months, if not a year or more, and any resulting LWG analysis would be highly contentious.

Nor does the LWG have any information beyond what has been compiled by DEQ as to the assessment and evaluation of upland contamination and contaminant migration pathways. The LWG has no access or authority to collect upland data, and it has no control over whether or under what standards such data are collected at all. The LWG's scope of work did not include evaluating upland data beyond the identification of sources required by SOW section 7.4, which the LWG has done. EPA previously agreed that, for purpose of providing the information on upland pathways necessary for the FS, DEQ and EPA would review and propose updates to the FS Source Tables. That process has been followed, and the LWG is currently reviewing the input that was provided by DEQ and EPA to those tables on November 23, 2010 for inclusion in the FS.

The LWG understands that EPA desires a broader discussion in the RI of upland contamination and contamination migration pathways. Based on the extension on the dispute deadline granted by EPA on this issue (i.e., to January 28, 2011), LWG will continue to discuss this with EPA in order to obtain clarification on EPA's direction.

Benthic Risk Evaluation (EPA Letter of September 27, 2010)

In response to EPA's September 27, 2010 comments on the Benthic Risk Evaluation, the LWG and EPA met several times in November and December 2010 to discuss the benthic approach, including whether to incorporate the use of NOAA's LRM model into the revised draft BERA. Based on that discussion, we believe that we have identified a mutually agreeable path forward on how benthic risk will be evaluated in the revised draft BERA. The elements of that path forward are set forward in Attachment B.

Please confirm that the approach described in Attachment B successfully resolves all directive or potentially directive EPA comments on the draft benthic BERA. If EPA does not agree that LWG's approach to complete the benthic risk assessment is sufficient to comply with EPA's directed comments, the LWG respectfully invokes dispute resolution on this issue for the reasons stated in this and prior communications.

Final Resolution of Contents of the RI and Risk Assessments

Having fully addressed EPA's July 19, September 27 and December 8, 2010 comments on the draft RI and risk assessments, the LWG understands that the final contents of the RI and risk assessments have been determined, and EPA will not direct the incorporation of additional data or evaluations in subsequent drafts of these documents.

Conclusion

The LWG is committed to completing the RI and risk assessments through to final approval, preparing a FS on a realistic and expedited schedule that ensures a high-quality deliverable, and working with EPA on an overall schedule and path to a final Record of Decision. In practice, the expedited FS schedule has proved very challenging to both the LWG and the Government teams. The LWG is willing to accept EPA's directives as outlined in this letter in order to expedite completion of the FS. The current June 15, 2011 deadline, however, was based on the assumption that the LWG would have a complete set of EPA comments on the RI and risk assessments in the summer of 2010 and that there would not be significant revisions to the RI and risk assessments. Due to the significant technical complexities involved in concluding the RI and risk assessments and the addition of new EPA directives into December 2010, the current schedule is no longer achievable. A draft FS by June 15, 2011 would put the draft FS at significant risk of being hastily developed and potentially result in a document that is inconsistent with the risk assessments and cannot be approved by EPA. Therefore, to the extent that EPA's December 21 letter contains a direction to submit the draft FS in June 2011, unless EPA agrees to work with the LWG on a revised FS schedule, the LWG has no alternative but to dispute that direction.

Per your December 21, letter, we accept your invitation to meet with you at your earliest convenience to discuss the overall process, including a complete project schedule through to a final Record of Decision. We will also continue to work cooperatively with EPA to jointly communicate with key stakeholders at the site to keep them informed about how we are moving

towards a FS that can successfully be used by EPA to craft the Proposed Plan and eventual Record of Decision.

Sincerely,

Bob Wyatt

cc: Confederated Tribes and Bands of the Yakama Nation
Confederated Tribes of the Grand Ronde Community of Oregon
Confederated Tribes of Siletz Indians of Oregon
Confederated Tribes of the Umatilla Indian Reservation
Confederated Tribes of the Warm Springs Reservation of Oregon
Nez Perce Tribe
Oregon Department of Fish & Wildlife
United States Fish & Wildlife
Oregon Department of Environmental Quality
LWG Legal
LWG Repository

Attachment A—

Data Sets to be Added to RI

1. T4 Abatement Phase 1 - Construction Phase 1 - Dredging and Capping*
2. Chevron Willbridge Terminal 2008/2009 Pre-dredge Sediment Characterization*
3. Ash Grove Cement Rivergate Plant Sediment Cores, Willamette River *
4. CLD Pacific Grain Post-dredge Sediment Data*
5. Glacier Northwest Cement Terminal Pre-dredge Characterization*
6. Goldendale Aluminum Company Pre-dredge Characterization*
7. City of Portland RM11E Sediment Data*
8. 2007/08 Maul Foster Alongi Zidell Sediment Data
9. 2009 Interim Construction Report, Revetment SCM at Arco Terminal 22T
10. EPA's PBDE data in LWG Sediment Grab Samples
11. EPA's 2009 PBDE Fish Tissue Data
12. EPA's Osprey Eggs Data
13. Willamette River FNC Post Office Bar Reach (RM2.2) Sediment Quality Evaluation
14. US Moorings RI 2008 Sediment Sampling
15. Triangle Park Riparian Soil, Final Removal Action Investigation Report
16. City of Portland Downtown Sediment Data, Phase 2
17. City of Portland RM 11 East Focused Sediment Characterization – Bank Soil and Debris Field
18. City of Portland RM 11 East Focused Sediment Characterization – Sediment Traps
19. PGE Downtown (RM 13.1-13.5) Sediment Data
20. PGM Downtown Sediment Data
21. Northwest Pipe & Casing, International Terminals Slip Sediment Data
22. Conoco Philips Pre-dredge Characterization
23. Chevron Pre-dredge Characterization
24. Cascade General/Vigor Pre-dredge Sediment Characterization

Note: The data sets marked with asterisk (*) have already been added to the project database for the draft FS.

Attachment B—

Resolution of EPA September 27, 2010 Comments on Benthic Risk Evaluation

1. The final bioassay hit classifications used to build the benthic toxicity models have been reconciled. These hit classifications differed in 27 out of 1,172 cases from the hit classifications used in the draft BERA. Twenty-five of the 27 differences were due to a change in data rounding procedures, requested by EPA. The other two changes were due to QC errors that have been corrected.

2. The LWG agrees to use the results from NOAA's new site-specific logistic regression model (LRM) in the revised draft BERA, with a P_{max} threshold for predicting Level 2 bioassay hits of 0.50 and a P_{max} threshold for predicting Level 3 hits of 0.59. The LWG has agreed to allow Jay Field (NOAA), as the principal developer of the new site-specific LRM, discretion to apply professional judgment in order to get a site-specific LRM that he considers to be most suitable for predicting benthic toxicity in Portland Harbor. Draft documentation for the new LRM was received from EPA on December 10, 2010. Windward reviewed the documentation and concluded that the documentation is sufficient as a draft. Windward will work with Jay Field (NOAA) to finalize the documentation for the revised BERA.

   As you know, an error was discovered in the new LRM on December 15. The LWG does not anticipate that other errors will be discovered, but we are not in a position to ensure that. If another error were discovered it would be necessary to stop work and reassess the decision to use the LRM.

3. EPA agrees to use the LWG's individual endpoint floating percentile models (FPMs) with balanced false positive and false negative rates as a condition of resolving the outstanding benthic issues. EPA has given the LWG, as the principal developer of the new FPMs, discretion to apply professional judgment in order to get site-specific FPMs that it considers to be most suitable for predicting benthic toxicity in Portland Harbor, contingent on the objective of balancing false positive and false negative rates. Output from other model runs that yield unbalanced false positive and false negative rates will be presented in an attachment, for the expressed purpose of documenting the work that was done to identify the FPMs with balanced false positive and false negative rates. Those other FPMs will not be used in the BERA. Draft documentation for the new FPMs was provided to EPA on December 1, 2010.

4. All four levels of benthic toxicity predictions will be presented in the BERA for each model (the LRM and the individual endpoint FPMs). EPA acknowledged that the Level 2 benthic toxicity predictions for the *Hyalella* biomass endpoint are unreliable, and instructed the LWG to report the false positive and false negative rates for that model (and the other models) along with the predictions. The LWG is allowed to objectively discuss the reliability of this endpoint in the risk characterization and to account for it in its risk management recommendations.

5. EPA and the LWG recognize that the sediment quality guidelines produced by any model (LRM, FPM or generic SQGs such as PECs or PELs) are intended to be used as a set – not individually. Therefore, the reliability of and uncertainties associated with the set of

chemical SQGs derived from each model will be presented and discussed for each set of SQGs and not for individual chemical SQGs within the set in the revised draft BERA.

6. The individual endpoint FPMs include SQGs for chemicals with insufficient data density or detection frequency to interpolate. Exceedances of those SQGs are to be mapped on a point-by-point basis.

7. Both the LRM and the FPMs include conventional parameters, but in different ways. The FPMs include SQGs for conventional parameters. The LRM uses conventional parameters to predict toxicity in combination with hazardous chemicals (e.g., organic carbon (OC)-normalized concentrations were used in the LRM for some chemicals, some chemicals' concentrations were multiplied by percent fines, and some chemicals' concentrations were both OC-normalized and multiplied by percent fines). The conventional SQG exceedances will be mapped and discussed as factors contributing to benthic toxicity in Portland Harbor. The implications of combining conventionals with hazardous substances will be examined as a source of uncertainty.

8. The generic SQGs that will be used moving ahead in the BERA are PECs and PELs (including mean quotients). This is based on EPA's verbal recommendation during our November-December 2010 meetings to resolve the benthic approach. TECs and TELs may still be used to define clean areas (as in the draft BERA). This represents a reduction in the number of generic SQG sets required to be used by EPA's BERA Problem Formulation.

   The PECs and PELs will be used to confirm that the site-specific LRM and FPMs are better than generic SQGs at predicting benthic toxicity in Portland Harbor, based on a comparison of false positive and false negative rates. Once that's been documented, the rest of the risk characterization will be based on the LRM and FPM SQGs.

9. EPA used false positive and false negative rates to evaluate benthic toxicity model reliability and reach resolution on the benthic approach to be used moving ahead in the BERA. This was in lieu of the other reliability statistics provided by EPA on September 29, 2010. In order to be consistent with the resolution, false positive and false negative rates will be focused on in lieu of the other reliability statistics moving ahead in the revised draft BERA, but all of the reliability statistics will be tabulated.

10. EPA and LWG agreed that benthic toxicity model validation is not feasible for Portland Harbor because the bioassay and chemistry data are all used to build and calibrate the models.

11. Moving into the FS, the LWG will use an updated version of the comprehensive benthic analysis that was presented to EPA on September 29, 2010 to define benthic AOPCs. The approach will be updated to use the final reconciled bioassay hit classifications and the benthic toxicity predictions from the revised draft BERA models (LRM and FPMs). The comprehensive benthic approach was designed to be consistent with EPA's April 21, 2010 guidelines for benthic analysis and is a weight-of-evidence approach. EPA's RPM reviewed the April 21 guidelines during the December 13 meeting and indicated that one of the guidelines – consider presence/absence of nearby sources – might not be adequately captured in the comprehensive benthic approach. After a brief discussion it was decided that the issue of whether presence/absence of nearby sources should affect

any particular benthic AOPCs would be addressed in EPA comments on work products that present benthic AOPCs.

12. The benthic approach as described by these elements was developed through the cooperative effort of EPA and the LWG and resolves and supersedes EPA's September 27, 2010 comments on the draft benthic BERA.

TAB 14

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10
1200 Sixth Avenue, Suite 900
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OFFICE OF
ENVIRONMENTAL CLEANUP

February 25, 2011

Mr. Jim McKenna
Co-Chairman, Lower Willamette Group
1519 SW Columbia, Suite A
Portland, Oregon 97201

Mr. Bob Wyatt
Northwest Natural & Chairman, Lower Willamette Group
220 Northwest Second Avenue
Portland, Oregon 97209

Re: Portland Harbor Superfund Site, Administrative Order on Consent for Remedial Investigation and Feasibility Study; Docket No. CERCLA-10-2001-0240
Schedule for Remedial Investigation (RI) and Feasibility Study (FS)

Dear Messrs. Mckenna and Wyatt:

On February 2, 2011, the Lower Willamette Group (LWG) requested a six month extension of the June 15, 2011 due date for the draft FS submittal. The letter also proposed a new schedule for delivery of a revised draft Remedial Investigation Report and revised draft Baseline Risk Assessment for Human Health and Ecology. We will address the schedule for each report separately, below.

This letter also provides EPA's response to the LWG's January 12, 2011 letter. That letter presented LWG's views on many of the same issues that were raised in its February 2, 2011 letter and described how the LWG will comply with the three directed comments in EPA's December 8, 2010 letter to: 1) move the RI data lockdown date from June 2008 to July 19, 2010; 2) draft the conceptual site model to link both current and historical sources to in-water contamination; and 3) include EPA PBDE fish tissue data in the BHHRA.

Baseline Human Health Risk Assessment (BHHRA)

In the February 2 letter, the LWG requested an extension date of June 15, 2011, to submit a revised draft BHHRA to EPA. EPA believes that this request is unreasonable and is directing the LWG to submit a revised draft BHHRA on May 2, 2011. EPA is also directing the LWG to provide the tables and calculations for the combined adult and child scenarios, evaluation of polybrominated biphenyl ethers (PBDEs), and breast milk scenarios by March 17, 2011 for EPA review and comment.

Basis for BHHRA Deadlines

1. On September 23, 2009, the LWG submitted a draft BHHRA to EPA.
2. In December 2009, EPA submitted preliminary comments to the LWG on the draft BHHRA that were determined to affect PRGs for development of a draft FS.
3. On July 19, 2010, EPA submitted a comprehensive comment set on the draft BHHRA and a revised draft was due within 90 days, October 14, 2010.
4. The only new exposure scenario that EPA required in the July 2010 comment set that affected the calculations in the draft BHHRA was combining the child and adult exposure scenarios. Although this was a new exposure scenario, the length of time the LWG has requested to revise the BHHRA is not warranted given the level of effort necessary to conduct the analysis of this scenario and incorporation into the BHHRA.
5. The LWG has been aware for several years that the inclusion of PBDEs in the revised draft BHHRA would be required. Inclusion of this information in the revised draft BHHRA does not warrant the requested schedule extension. Including PBDEs in the BHHRA was identified by EPA in December 2005 as a data gap. During development of Round 3B field sampling plans, EPA and the LWG agreed that EPA's Manchester Laboratory would perform the chemical analysis. The draft BHHRA presented an estimated maximum potential HQ of less than 1 for PBDEs using the maximum detected concentration for total PBDEs in the ODHS dataset (salmon, sturgeon and lamprey tissue) and the lowest RfD for any PBDE congener. EPA subsequently provided the results of the additional tissue analysis for carp and bass to the LWG on November 12, 2009. With the additional data analysis, EPA estimated that consuming fish contaminated with PBDEs resulted in hazard quotients ranging from 1 to 2. The LWG did not agree to include the PBDE data and evaluation in the BHHRA so on December 8, 2010, EPA directed the LWG to evaluate risks associated with PBDEs. EPA did not require the development of PRGs for PBDEs since tissue-sediment relationships have not been developed for PBDEs.
6. Including the breast feeding exposure scenario does not justify the requested schedule extension for submitting the BHHRA. EPA determined that this exposure should be included in the risk assessment in December 2005. EPA subsequently agreed with the LWG that this scenario would not be required for the draft BHHRA to allow EPA time to work with DEQ and EPA Headquarters and other regions on a methodology for evaluating this exposure scenario. A draft of DEQ guidance regarding this methodology was publicly available in May 2010 and finalized in October 2010. EPA informed the LWG that this methodology was to be used in revising the BHHRA in our July 2010 comments.
7. At the LWG's request, EPA agreed to extend the October 14, 2010 submittal deadline to engage in several meetings with the LWG regarding issues with comments on the draft BHHRA. The LWG provided a summary table showing resolution of the issues on November 17, 2010, and EPA advised the LWG of our determination that the vast majority of RI and Risk Assessment comments were resolved in our December 8, 2010 letter.

Baseline Ecological Risk Assessment (BERA)

In the February 2 letter, the LWG requested an extension date of July 27, 2011 to submit a revised draft BERA to EPA. EPA believes that this request is unreasonable and is directing the LWG to submit a revised draft BERA, including all associated models used to estimate risk, on July 5, 2011.

Basis for BERA Deadline

1. On September 2, 2009, the LWG submitted a draft BERA to EPA.
2. In December 2009, EPA submitted preliminary comments to the LWG on the draft BERA that were determined to affect PRGs for development of a draft FS.
3. On July 16, 2010, EPA submitted a comprehensive comment set on the draft BERA and required a revised draft BERA within 90 days, which was October 14, 2010.
4. The benthic risk evaluation was submitted separately from the draft BERA on November 13, 2009, and supporting information was provided January 20, 2010. EPA comments on the benthic risk evaluation, including an updated logistic regression model developed by Jay Field, were submitted separately to the LWG on September 27, 2010.
5. EPA agreed to extend the October 14, 2010 deadline at the LWG's request to engage in several meetings with the LWG regarding issues with the BERA comments and models. All significant issues regarding use of the LRM and EPAs comments were resolved in principle as of December 13, 2010. The benthic approach agreed to is documented in Attachment B to LWG's January 12, 2011 letter. EPA is in general agreement with the approach as described in Attachment B to the LWG's letter with some clarifications that are provided as an enclosure to this letter.

Remedial Investigation Report (RI)

In the February 2 letter, the LWG requested an extension date of September 28, 2011, to submit a revised draft RI to EPA. The LWG also expressed its desire not to have substantive or new comments provided by EPA on the revised draft. EPA cannot provide assurances that it will not make new comments or request revisions to the draft RI. However, one way that the likelihood of substantive new comments can be avoided is by submittal of the revised draft RI in phases to afford EPA the opportunity to review and comment, modify or direct changes to chapters of the revised draft RI prior to it being submitted in total form. Based on this review scenario and EPA's commitment to provide comments, modifications, or direction to the LWG within 30 days of submittal of each section (provided only one section is provided within a 30-day period; additional time will be required for EPA's review if multiple sections are provided), EPA agrees that the extension date of September 28, 2011, is reasonable and approved for submittal of the revised draft RI. EPA also agrees that, with the inclusion of the data sets identified in Attachment A to the LWG's January 12, 2011 letter, the data set for the RI is complete. EPA and LWG have also reached agreement on the path forward for the revision of the CSM directed comments, as documented in Gene Revelas' February 8, 2011 email.

EPA directs the LWG to submit a schedule commencing on March 21, 2011 and ending July 5, 2011 for submittal of the following preliminary revised sections, including all associated

tables, figures, maps, and appendices, of the revised draft RI by March 11, 2011 for EPA approval:

Section
Section 3: Current Environmental Setting
Section 4: Identification of Sources
Section 5: In-River Distribution of Contaminants
Section 6: Loading, Fate, and Transport for Select Indicator Contaminants
Section 7: Determination of Background Concentrations for Contaminants

Based on this schedule, the LWG shall provide the deliverables and should have ample time to resolve and incorporate EPA's comments, modifications or directions into the revised draft RI prior to a submittal date of September 28, 2011. If the LWG does not comply with this monthly submittal schedule, the entire revised RI Report will be due no later than August 1, 2011.

Development and Screening of Remedial Alternatives

Pursuant to the AOC (Section VII, Paragraph G) and the SOW (Section 9), the LWG was to provide under Task 7 a Development and Screening of Remedial Alternatives for the Portland Harbor Superfund Site. As noted in our December 21, 2010 letter, EPA agreed to check-in meetings in lieu of an alternatives screening document in the interest of expediting the project schedule. Per agreements with EPA, the LWG was to provide this deliverable, and additional information on FS tools, as a presentation, with supporting materials, in a check-in meeting on December 14, 2010. In our December 21, 2010 letter EPA notified the LWG that it had failed to meet this obligation under the AOC, for the reasons further described in that letter, because it had not provided the necessary content of the Alternatives Screening Check-in process. EPA also advised the LWG that in order to meet its obligations under the AOC the LWG must submit the alternative development and screening information that was not provided for the December 14, 2010 meeting. The LWG's February 2, 2010 letter did not respond to this issue or provide a submittal deadline specifically for an alternatives screening document. The LWG's proposed Portland Harbor RI/FS Schedule shows a line item for an FS Check-in with EPA on June 29, 2011, but it does not say that an alternatives screening would be submitted at this meeting, nor does a meeting alone meet the requirement for submittal of an alternatives screening deliverable.

As stated in our December 21 letter, the LWG is not in compliance with the AOC for failure to present the alternatives screening analysis in the December 14, 2010 meeting. EPA has not agreed to an extension to the December 14 deadline. In accordance with Section XIX., Paragraph 5.r., stipulated penalties are accruing on this late deliverable. The LWG should submit this deliverable as soon as possible, however, if the LWG submits the alternative screening analysis on or before April 1, 2011, EPA will use its discretion to waive imposition of stipulated penalties consistent with Section XIX, Paragraph 1. If the LWG refuses to submit a Development and Screening of Remedial Alternatives by April 12, 2011, EPA, in addition to assessing stipulated penalties may also take over the work or otherwise direct the LWG on the Alternatives for the FS.

As previously directed by EPA, the Alternatives Development and Screening must follow EPA's 1988 RI/FS guidance and 2005 Contaminated Sediment Remediation guidance and incorporate EPA's comments provided on December 18, 2009. To clarify EPA's expectations for this deliverable for Portland Harbor, the LWG is to first determine site-wide General Response Actions (GRAs), conduct a site-wide Technology Screen (TS) for the GRAs, and then assemble and screen site-wide Remedial Action Alternatives (RAAs). The LWG is then to evaluate each the site-wide GRAs, technologies, and alternatives for each of the AOPCs. EPA is not requiring the LWG to provide the results of the AOPC to SMA conversion as part of the alternatives screening deliverable; however, it is expected that the LWG will present the process for converting AOPCs to SMAs and provide examples using three (3) AOPCs at a meeting held on or before August 4, 2011 to ensure that EPA agrees with the methodology prior to the LWG submittal of a draft FS.

Basis for Alternatives Screen and Development Deadline

On November 17, 2009, the LWG presented examples of the Alternatives Development and Screening Evaluation. EPA provided comments on this presentation in a letter dated December 18, 2009. EPA also provided direction and guidance on the use of PRGs (April 2010) in the FS, CDF performance, standards (April 2010), approved the calibration of the QEAfate model (July 2010) and the mitigation framework (August 2010) which were identified by the LWG's consultants as critical path elements for the FS.

As stated in EPA's December 21, 2010, letter, the AOC, SOW, and original RI/FS Work Plan required the submittal of an alternatives screening document prior to the submittal of a draft FS. In place of this deliverable, EPA agreed to an alternatives screening check-in process with milestone dates that included two days of meetings: 1) December 7, 2010, to review the FS tools that would be used in the alternatives development, screening and evaluation; and 2) December 14, 2010, for presentation of the results of the alternatives development and screening evaluation. EPA agreed to these check-in meetings in lieu of submittal of a Development and Screening of Remedial Alternatives document in the interest of expediting the FS process and schedule, as desired by both parties.

The EPA and LWG jointly developed the structure and content of the meetings, which were documented and provided by the LWG on July 1, 2010 (*Draft Objectives, Agendas, and List of Topics to be Covered in Portland Harbor FS Alternatives Screening Check-in Process*). The LWG verified the purpose and content of the meetings during our project managers meeting on October 29, 2010, and the LWG's FS consultant indicated that they expected to provide advance meeting materials on November 18, 2010, for the FS Tools meeting and November 25, 2010, for the Alternatives Screening Check-in meeting. The LWG has had all of the necessary information to produce an alternatives screening analysis for well over a year. It is reasonable for the LWG provide this analysis immediately but no later than April 1, 2010.

Feasibility Study Report (FS)

In the February 2 letter, the LWG requested an extension date of December 14, 2011, to submit a draft FS to EPA. The LWG further states in its letter that this date is contingent upon EPA's conditional approval of the revised drafts of the RI, BHHRA, and BERA. EPA disagrees this linear approach is a necessity. The LWG previously did not think it was necessary either. However, we currently do not believe that the LWG would be able to meet the June 15, 2011 due date for the draft FS and EPA believes that the technical analysis for the FS would require more time that the remaining four (4) months. EPA therefore directs the LWG to produce a draft FS by November 15, 2011. Further, the LWG is to conduct a check-in meeting with EPA and partners on key FS elements, including RALs, as soon as possible, but no later than June 22, 2011. All documents for this check-in meeting shall be delivered to EPA at least 2 weeks prior to the scheduled meeting date.

As a reminder, it is LWG's responsibility to include all areas under early action evaluation in the draft Feasibility Study, including Terminal 4, Gasco/Siltronic, and Arkema. We expect that each LWG member working under an AOC is providing all information to the LWG for incorporation into the draft FS. The Harbor-wide FS must weigh alternatives wherever COCs are above acceptable risk levels. Specific information should also be solicited from each project including, but not limited to: the Terminal 4 final 60% design, Gasco/Siltronic EE/CA, and Arkema additional sediment core information. The early action work should help the LWG produce more robust alternatives analysis for these areas, and better cost estimates. The LWG should update this information as needed with the latest Harbor-wide context and process as necessary, for example, if dioxin/furans are of equal concern in weighing alternatives off of the Arkema Site. It should not be assumed that any of these early action processes will fully evaluate alternatives where contaminants may have been comingled downstream, which the Harbor-wide FS should again include wherever COCs are above acceptable risk levels.

Additionally, as we have discussed, it is EPA policy to enhance the environmental benefits of federal cleanup programs by promoting technologies and practices that are sustainable. Expectations for green cleanup and the policy itself are posted at: http://yosemite.epa.gov/R10/extaff.nsf/programs/greencleanups. Each remedial alternative should incorporate green remediation technologies. This should include consideration of green remediation factors for each alternative, including such factors as reporting and tracking specific quantities of materials reduced, reused, or recycled; carbon or greenhouse gas reductions; and water conserved or replenished. Use of these and other green remediation technologies will be standard unless a site-specific evaluation demonstrates impracticability or favors an alternative green approach. This policy does not fundamentally change how and why cleanup decisions are made, but calls for more sustainable methods of implementing cleanups. A comprehensive set of greener approaches to site cleanup may be found at www.clu-in.org/greenremediation and www.epa.gov/region09/cleanup-clean-air. Most emphatically, this policy is not intended to trade off environmental protectiveness for other benefits such as fewer carbon emissions. The FS should include an analysis of how efficiently each alternative can be implemented or how "green" it can be. The policy is not an invitation to state or argue the self-evident facts that doing less uses less energy or has a smaller carbon footprint, no action uses the least energy, or capping is less energy intensive than dredging.

Basis for Draft FS Deadline

For well over two years, EPA and the LWG have had an understanding to produce the draft FS concurrent with EPA's review of the draft RI and BRAs. Such concurrent development of an RI and FS is consistent with EPA RI/FS Guidance. Consequently, the EPA has worked with the LWG since early 2009 in scoping the FS and reaching agreements on key issues to allow the LWG to progress in development of the draft FS without finalizing the RI and BRAs. The EPA has put substantial resources into meeting with the LWG and reaching these agreements. The EPA worked with the LWG in early 2010 to develop an FS schedule which resulted in a draft deliverable due on June 15, 2011; this date was specified by EPA in a letter dated July 19, 2010. The LWG has already expended eight (8) months and has not even produced an Alternatives Development and Screening document or provided this information in a presentation. Both the AOC and the SOW do not require EPA approval of the RI or BRAs prior to development of a draft FS. Further, EPA's guidance discusses the parallel process of RI and FS development concurrently. EPA believes that the LWG has all the information necessary to produce a draft FS.

EPA understands that there are a lot of deliverables due this year; however, EPA believes that the LWG has ample time to develop these documents and further delays beyond those granted in this letter will not be accepted. EPA is concerned that the LWG's unwillingness to accept EPA's comments and desire to keep discussing the same issues they have with the comments in multiple meetings has only resulted in EPA having to direct the incorporation of information and schedule delays. Notwithstanding EPA's concerns, we still strongly advise the LWG to continue to coordinate its work on the draft RI, BRAs, and FS reports with EPA. EPA is willing to meet or provide additional guidance on specific issues on the overall process, as appropriate. In particular, EPA believes that continued discussions and exchange of key information will be beneficial in meeting our expectations for these deliverables.

If you have any questions regarding these matters, please contact Chip Humphrey at (503) 326-2678 or Kristine Koch at (206) 553-6705. All legal inquiries should be directed to Lori Cora at (206) 553-1115.

Sincerely,

for Chip Humphrey
Remedial Project Manager

Kristine Koch
Remedial Project Manager

Encl.

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TAB 15

LWG
LOWER WILLAMETTE GROUP

PORTLAND HARBOR RI/FS

DRAFT FINAL REMEDIAL INVESTIGATION REPORT

APPENDIX F

BASELINE HUMAN HEALTH RISK ASSESSMENT

DRAFT FINAL

DO NOT QUOTE OR CITE
This document is currently under review by US EPA and its federal, state, and tribal partners, and is subject to change in whole or in part.

May 2, 2011

Prepared for The Lower Willamette Group

Prepared by Kennedy/Jenks Consultants

RECOMMENDED FOR INCLUSION IN ADMINISTRATIVE RECORD

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LIST OF ACRONYMS

ACG	analytical concentration goal
ADAF	age-dependent adjustment factor
ALM	Adult Lead Methodology
AOPC	Area of Potential Concern
ATSDR	Agency for Toxic Substances and Disease Registry
AWQC	Ambient Water Quality Criteria
BEHP	Bis 2-ethylhexyl phthalate
BERA	baseline ecological risk assessment
BHHRA	baseline human health risk assessment
Cal EPA	California Environmental Protection Agency
CDC	Centers for Disease Control
CDI	chronic daily intake
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cm	centimeter
cm/hr	centimeters per hour
CNS	central nervous system~~COC chemical of concern~~
~~COI~~	~~chemical of interest~~
COI	~~chemical~~ contaminant[1] of interest
COPC	~~chemical~~ contaminant[1] of potential concern
CRITFC	Columbia River Inter-tribal Fish Commission
CSM	conceptual site model
CT	central tendency
DA_{event}	absorbed dose per event
DDD	dichlorodiphenyldichloroethane
DDE	dichlorodiphenyldichloroethylene
DDT	dichlorodiphenyltrichloroethane
delta-HCH	delta-hexachlorocyclohexane
DEQ	Oregon Department of Environmental Quality
DL	detection limit
DQO	data quality objective
E	east
EPA	United States Environmental Protection Agency
EPC	exposure point concentration
EPD	effective predictive domain
FS	feasibility study
g/day	grams per day
GI	gastrointestinal
GSI	Groundwater Solutions, Inc.
HEAST	Health Effects Assessment Summary Table

[1] Prior deliverables and some of the tables and figures attached to this document may use the term "Chemical of Interest" or "Chemical of Potential Concern", which as the same meaning as "Contaminant of Interest" or "Contaminant of Potential Concern", respectively, and refers to "contaminants" as defined in 42 USC 9601(33).

HHRA	human health risk assessment
HI	hazard index
HQ	hazard quotient
IEUBK	Integrated Exposure Uptake Biokinetic
IRAF	Infant Risk Adjustment Factor
IRIS	Integrated Risk Information System
ISA	initial study area
K_p	dermal permeability coefficient
l/day	liters per day
LADI	lifetime average daily intake
LOAEL	lowest observed adverse effects level
LWG	Lower Willamette Group
LWR	Lower Willamette River
µg/dl	microgram per deciliter
µg/kg	microgram per kilogram
µg/l	microgram per liter
MCL	Maximum Contaminant Level
MCPP	2-(4-Chloro-2-methylphenoxy)propanoic acid
mg/kg	milligram per kilogram
ml/day	milliliters per day
ml/hr	milliliters per hour
MRL	method reporting limit
NHANES	National Health and Nutrition Evaluation Survey
NLM	National Library of Medicine
OAR	Oregon Administrative Rules
ODFW	Oregon Department of Fish and Wildlife
ODHS	Oregon Department of Human Services
pg/g	picograms per gram
PAH	polycyclic aromatic hydrocarbon
PBDE	polybrominated diphenyl ether
PCB	polychlorinated biphenyl
PEF	potency equivalency factor
PPRTV	Provisional Peer Reviewed Toxicity Value
PRG	preliminary remediation goal
RBC	risk-based concentration
RfD	reference dose
RG	remediation goal
RI/FS	remedial investigation/feasibility study
RM	river mile
RME	reasonable maximum exposure
RSL	Regional Screening Level
SCRA	site characterization and risk assessment
SF	slope factor
STSC	Superfund Health Risk Technical Support Center

SVOC	semivolatile organic compound
TCDD	tetrachlorodibenzo-p-dioxin
TEF	toxic equivalency factor
TEQ	toxic equivalent
TZW	transition zone water
UCL	upper confidence limit
95% UCL/max	95% UCL or maximum
USDA	United States Department of Agriculture
VOC	volatile organic compound
W	west
WHO	World Health Organization
XAD	XAD-2 Infiltrex™ 300 system

GLOSSARY

Term	Definition
bioaccumulation	the accumulation of a substance in an organism
bioconcentration factor	the concentration of a chemical in the tissues of an organism divided by the concentration in water
central tendency	a measure of the middle or expected value of a dataset
~~chemical~~ contaminant of concern	the subset of ~~chemicals~~ contaminants[2] of potential concern with exposure concentrations that exceed EPA target risk levels
~~chemical~~ contaminant of interest	~~chemical~~ contaminant[2] detected in the Study Area for all exposure media (i.e., surface water, transition zone water, sediment, and tissue)
~~chemical~~ contaminant of potential concern	the subset of ~~chemicals~~ contaminants[2] of interest with maximum detected concentrations that are greater than screening levels
composite sample	an analytical sample created by mixing together two or more individual samples; tissue composite samples are composed of two or more individual organisms, and sediment composite samples are composed of two or more individual sediment grab samples
conceptual site model	a description of the links and relationships between chemical sources, routes of release or transport, exposure pathways, and the human receptors at a site
congener	a specific chemical within a group of structurally related chemicals (e.g., PCB congeners)
human health risk assessment	a process to evaluate the likelihood that adverse effects to human health might occur or are occurring as a result of exposure to one or more contaminants
dose	the quantity of a~~n~~ contaminant taken in or absorbed at any one time, expressed on a body weight-specific basis; units are generally expressed as mg/kg bw/day
empirical data	data quantified in a laboratory

[2] Prior deliverables and some of the tables and figures attached to this document may use the terms "chemical of concern", "chemical of interest", or "chemical of potential concern", which has the same meaning as "contaminant of concern", "contaminant of interest", or "contaminant of potential concern", respectively, and refers to "contaminants" as defined in 42 USC 9601(33).

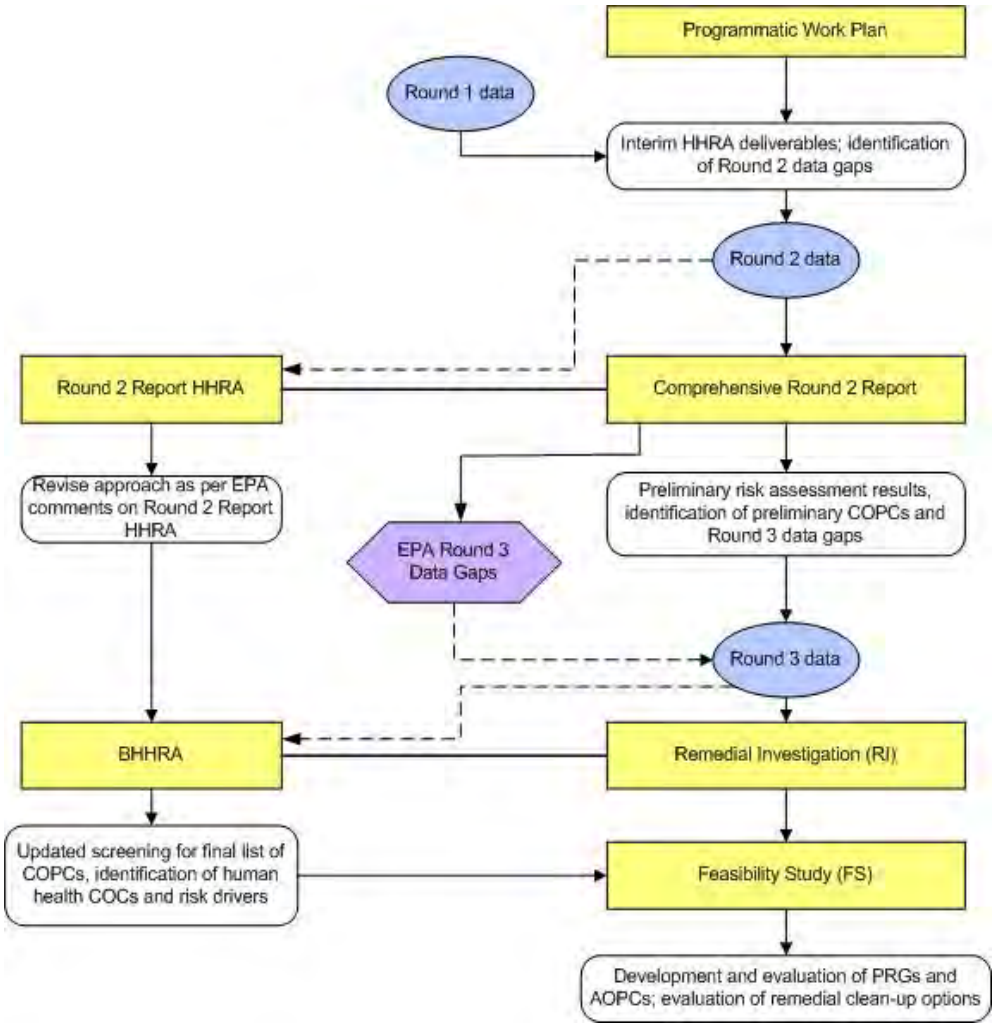
Term	Definition
exposure assessment	the part of a risk assessment that characterizes the chemical exposure of a receptor
exposure pathway	physical route by which a contaminant moves from a source to a human receptor
exposure point	the location or circumstances in which a human receptor is assumed to contact a contaminant
exposure point concentration	the value that represents the estimated concentration of a contaminant at the exposure point
exposure area	size of the area through~~out~~ which a receptor might come in contact with a~~n~~ contaminant as determined by human uses
hazard quotient	the quotient of the exposure level of a chemical divided by the toxicity value based on noncarcinogenic effects (i.e., reference dose)~~.~~
predicted data	data not quantified in a laboratory but estimated using a model
reasonable maximum exposure	the maximum exposure reasonably expected to occur in a population
receptor	The exposed individual relative to the exposure pathway considered~~.~~
risk	the likelihood that a specific human receptor experiences a particular adverse effect from exposure to contaminants from a hazardous waste site; the severity of risk increases if the severity of the adverse effect increases or if the chance of the adverse effect occurring increases. Specifically for carcinogenic effects, risk is estimated as the incremental probability of an individual developing cancer over a lifetime as a result of exposure to a potential carcinogen. Specifically for noncarcinogenic (systemic) effects, risk is not expressed as a probability but rather is evaluated by comparing an exposure level over a period of time to a reference dose derived for a similar exposure period.
risk characterization	a part of the risk assessment process in which exposure and effects data are integrated in order to evaluate the likelihood of associated adverse effects
slope factor	toxicity value for evaluating the probability of an individual developing cancer from exposure to contaminant levels over a lifetime

Term	Definition
Study Area	the portion of the Lower Willamette River that extends from River Mile 1.9 to River Mile 11.8
toxic equivalency factor	numerical values developed by the World Health Organization that quantify the toxicity of dioxin, furan, and dioxin-like PCB congeners relative to 2,3,7,8-tetrachlorodibenzodioxin
transition zone water	Pore water associated with the upper layer of the sediment column; may contain both groundwater and surface water
uncertainty	a component of risk resulting from imperfect knowledge of the degree of hazard or of its spatial and temporal distribution.
upper confidence limit on the mean	a ~~conservative~~ high-end statistical measure of central tendency
variability	a component of risk resulting from true heterogeneity in exposure variables or responses, such as dose-response differences within a population or differences in contaminant levels in the environment

EXECUTIVE SUMMARY

The baseline human health risk assessment (BHHRA) was conducted as part of the Remedial Investigation Report (RI Report) for the Portland Harbor Superfund Site (Site). ~~to identify chemicals and exposure pathways that may result in potential unacceptable risks and to focus on those that are predicted to have the highest contribution to the estimated risk at the Portland Harbor Superfund Site (Site), consistent with the requirements of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).~~ The BHHRA is an analysis of potential adverse health effects (current or future) caused by hazardous substance releases from a site in the absence of any actions to control or mitigate these releases. The results of the BHHRA are used to develop remedial action objectives and to assist in risk management decisions for the Site. Figure ES-1 presents an overview of how the development and production of the BHHRA fits in with the overall Remedial Investigation/Feasibility Study (RI/FS) process for the Portland Harbor Superfund ~~site~~Site.

Figure ES-1 Portland Harbor RI/FS Process and BHHRA



The general objective of the BHHRA ~~was~~ is to assess the potential risks to human health from exposure to site-related chemicals present in or entering into environmental media (i.e., water or sediment) or bioaccumulating in the food chain, to assist in determining the need for remedial action, to assist in providing a basis for determining concentrations of chemicals that can remain in place and still be protective of public health, and to assist in providing a basis for comparing the effectiveness of various remedial alternatives. Specifically, this included evaluating whether exposure to chemicals in sediment, surface water, groundwater seeps, or biota may result in unacceptable risks to human health.

The BHHRA followed the approach that was documented in the Programmatic Work Plan (Integral et al. 2004) and subsequent interim deliverables. It also reflects numerous discussions, directives, and agreements on risk assessment techniques for the Site with or from the United States Environmental Protection Agency (EPA), Oregon Department of Environmental Quality (DEQ), Oregon Department of Human Services (ODHS), and Native American Tribes. To minimize the chances of

underestimating risks, the BHHRA incorporated conservative~~,~~ (i.e. health-protective) assumptions into the identification of exposure scenarios, the estimates of exposure, and the use of toxicity values.

Industrial use of Portland Harbor and adjacent areas of the Lower Willamette River (LWR) has been extensive. Portland Harbor generally refers to a heavily industrialized reach of the LWR between river mile (RM) 0 and RM 11.8, the extent of the navigation channel. The approximate 10-mile portion of Portland Harbor from RM 1.9 to 11.8 is referred to as the Study Area, which is the focus of the BHHRA. Potential human uses of Portland Harbor were considered in identifying the exposure scenarios and exposure media for evaluation in the BHHRA.

ES.1 BHHRA DATASET

The BHHRA dataset includes ~~only~~ those ~~matrices relevant~~ data used for direct human health exposure pathways that were quantitatively evaluated in the risk characterization sections of the document: surface sediment (0 to 30.5 centimeter (cm) in depth), surface water, groundwater seep water, clam and crayfish tissue, and fish tissue. ~~Transition zone water (TZW) data were used in loading calculations to estimate surface water concentrations that were compared with surface water screening levels, but were not included in the risk characterization because there are no complete direct exposure pathways for humans to TZW.~~ Other matrices included in the site characterization and risk assessment (SCRA) dataset (e.g., subsurface sediment) were not evaluated in the BHHRA because they were not relevant to the exposure scenarios evaluated. Although the BHHRA focused on the Study Area, data from outside the Study Area, from downstream to RM 1.0, including Multnomah Channel, and upstream to RM 12.2, were also used to assess risk, per an agreement with EPA. The following summarizes the data used in the BHHRA by medium:

- Beach sediment: Composite beach sediment samples that were collected from designated human use areas within the Study Area were included in the BHHRA dataset.
- In-water sediment: In-water sediment (i.e., not beach sediment) samples that were collected from the top 30.5 cm in depth between the bank and the navigation channel were included in the BHHRA dataset.
- Surface water: All Round 2 and Round 3 surface water data collected within the Study Area and in Multnomah Channel were included in the BHHRA dataset.
- Groundwater seep: Data from Outfall 22B, which discharges in a potential human use area, were included in the BHHRA dataset. Samples collected from this outfall as part of a stormwater sampling event were excluded from the BHHRA groundwater seep dataset.

- Fish tissue: Composite samples, both whole body and fillet with skin (fillet without skin samples were analyzed for mercury only), of target resident fish species (smallmouth bass, brown bullhead, black crappie, and common carp) were included in the BHHRA dataset. Composite samples of adult Chinook salmon (whole body, fillet with skin, and fillet without skin), adult lamprey (whole body only), and sturgeon (fillet without skin only) were also included in the BHHRA dataset.
- Shellfish tissue: Field-collected composite samples of crayfish and clam tissue (depurated and undepurated) were included in the BHHRA dataset.

ES.2 BHHRA EXPOSURE SCENARIOS

The risk characterization in the BHHRA evaluated the following exposure scenarios, as provided in the approved Programmatic Work Plan and subsequent agreements with or directives from the EPA related to the BHHRA approach:

	Beach Sediment: Ingestion and dermal absorption	In-water Sediment: Ingestion and dermal absorption	Surface Water: Ingestion and dermal absorption	Groundwater Seeps Ingestion and dermal absorption	Fish/ Shellfish: Ingestion
Workers	○	○			
Transients	○		○	○	
Beach Users	○		○		
Fishers	○	○			○
Diver		○	○		

	Beach Sediment: Ingestion and dermal absorption	**In-water Sediment:** Ingestion and dermal absorption	**Surface Water:** Ingestion and dermal Absorption	**Groundwater Seeps:** Ingestion and dermal absorption	**Fish/ Shellfish:** Ingestion	**Infant Consumption of Human Milk**
Workers	●	●				●
Transients	●		●	●		
Beach Users	●		●			
Fishers	●	●			●	●
Divers		●	●			●
Domestic Users			●			

- Dockside worker — direct exposure to (i.e., ingestion of and dermal contact with) beach sediment, infant ingestion of human breast milk.
- In-water worker — direct exposure to in-water sediment, infant ingestion of human breast milk.
- Transient — direct exposure to beach sediment, surface water (for bathing and drinking water scenarios), and groundwater seeps.
- Adult and child recreational beach user — direct exposure to beach sediment and surface water (for swimming scenarios).
- Tribal fisher — direct exposure to beach sediment or in-water sediment, ~~and~~ fish consumption, and infant ingestion of human breast milk.
- Fisher — direct exposure to beach sediment or in-water sediment, fish consumption, ~~and~~ shellfish consumption, and infant ingestion of human breast milk.
- Diver — direct exposure to in-water sediment and surface water, infant ingestion of human breast milk.
- Domestic water user – direct exposure to untreated surface water hypothetically used as a drinking water source in the future.

Exposures to beach sediment were assessed per beach, and exposures to groundwater seeps were assessed per seep. Exposures to in-water sediment, surface water, and fish and shellfish tissue were assessed on both localized and Study Area-wide scales. Details of each exposure scenario and associated exposure parameters are provided in Section 3 of this BHHRA.

Of these scenarios, the following were evaluated at the direction of EPA: clam tissue ingestion, fish ingestion for single-species diets, exposure to in-water sediment and surface water by commercial divers, and hypothetical exposure to untreated surface water by a domestic user. ~~A hypothetical future resident was also included as an exposure scenario, as per direction by the EPA, to evaluate the domestic use of untreated surface water (ingestion and dermal contact),Potential future use of surface water as a drinking water source by residents was also included as an exposure scenario. even~~ Even though ~~there are no known or anticipated future uses of~~surface water in the ~~the~~ LWR within Portland Harbor is not currently used as a domestic water source, under OAR 340-041-0340 Table 340A, domestic water supply is a designated beneficial use of the Willamette River, with adequate pretreatment. Divers and clam consumption by fishers were not included in the original Programmatic Work Plan but were included in the BHHRA as directed by EPA. Asian clams (*Corbicula* sp.) are the only clam species that were found in the Study Area during sampling events and, in addition to crayfish, were evaluated for shellfish

consumption in the BHHRA.

Although hHarvest and possession of Asian clams is illegal in the State of Oregon, and although conversations with transients indicated shellfish (both crayfish and clams) may beare eaten during their limited time in an areaby them (Wagner 2004), there is no documentation of ongoing shellfish consumption by humans occurring in the Study Area. In addition, crayfish are commercially harvested in the Willamette River, although the extent of this harvest within the Portland Harbor Superfund sSite is not known.

Scenarios included in the BHHRA at the direction of EPA include:

- Exposure to untreated surface water as a domestic water source by a hypothetical future resident
- Clam tissue ingestion
- Exposure to in-water sediment and surface water by commercial divers

ES.3 BHHRA EXPOSURE ASSESSMENT

The exposure assessment incorporated the reasonable maximum exposure (RME) approach described by EPA (1989). The RME is intended to be a conservative exposure level that is still within the range of possible exposures. Consistent with EPA (1989), the exposure assessment also used central tendency (CT) values, which represent average exposures, for certain exposure assumptions. For some exposure scenarios, such as fish consumption, exposure assumptions were directed by EPA. However, for some exposure scenarios, such as fish consumption, the exposure assumptions were based on upper-bound (i.e., 90th, 95th, and 99th) percentiles only, at the direction of EPA. Exposure point concentrations (EPCs) were calculated for the 95% upper confidence limit on the arithmetic mean (95% UCL) and the arithmetic mean for each exposure area. In some exposure areas, the maximum concentration was used instead of the 95% UCL. Therefore, the EPCs are referred to as the 95% UCL/max and mean throughout the BHHRA.Exposure point concentrations (EPCs) were calculated for media and pathways that were evaluated quantitatively in this BHHRA. The EPCs used in this BHHRA incorporate CT and RME methods.

EPCs for sediment, surface water, and tissue were calculated for individual exposure areas and on a Study Area wideStudy Area-wide basis. The spatial scale of the individual exposure areas and the resulting data included in the calculation of those EPCs were predetermined through discussions with EPA based on assumptions about potential human uses as well as the species' home ranges in the case of tissue EPCs. Exposure areas were designated throughout the Study Area based on the predetermined spatial scales, regardless of the feasibility or practicality of use of the actual areas.

Assumptions about each population evaluated in the BHHRA were used to select exposure parameters to calculate the pathway-specific chemical intakes. Site-specific values are not available for all populations and pathways. Therefore, default values were used where site-specific values are not available. Where default values are not available, best professional judgment based on knowledge of human uses of the Study Area or requirements from EPA were used. Uncertainties that are inherent in exposure assessment are attributed to both variability in the population assessed and also the degree of knowledge associated with exposure assumptions. These uncertainties associated with the exposure assessment impact the risk estimates~~. (EPA (1989).Because many of the exposure scenarios that were evaluated in the BHHRA are highly variable and do not have standard default exposure factors, uncertainties associated with the exposure factors are anticipated to have significant impacts on the risk estimates.~~ (EPA 1989).

ES.4 BHHRA TOXICITY ASSESSMENT

Toxicity values provide a quantitative estimate of the potential for adverse effects resulting from exposure to a chemical. Cancer and noncancer toxicity values are used in human health risk assessments to quantify the likelihood of adverse effects occurring at different levels of exposure to a chemical. Toxicity values are often based on the results of animal studies, and the extrapolation of toxicological data from animal studies to humans can be one of the largest sources of uncertainty in a risk assessment. ~~Uncertainty or variability~~Modifying factors, which typically range from two to three orders of magnitude (100 to 1,000 times), are often used by EPA in deriving toxicity values for human health given the level of confidence~~uncertainties~~ in the toxicological data, the intra-species differences (i.e., animal to human), and the inter-species differences to account for sensitive human subpopulations. ~~As a result, actual risks within the Study Area could be lower than the potential risk estimates calculated in the BHHRA.~~

Some toxicity values are based on exposure to chemical mixtures and not to individual chemicals. This is because these chemicals are commonly present as mixtures in the environment, and the individual components of the mixtures have similar modes of toxicity (such as dioxins). The chemicals that were evaluated in the BHHRA for toxicity as mixtures include: chlordanes, dichlorodiphenyldichloroethane (DDD), dichlorodiphenyldichloroethylene (DDE), and dichlorodiphenyltrichloroethane (DDT); endosulfan; polychlorinated biphenyl (PCBs); and dioxins and furans.

ES.5 BHHRA RISK CHARACTERIZATION

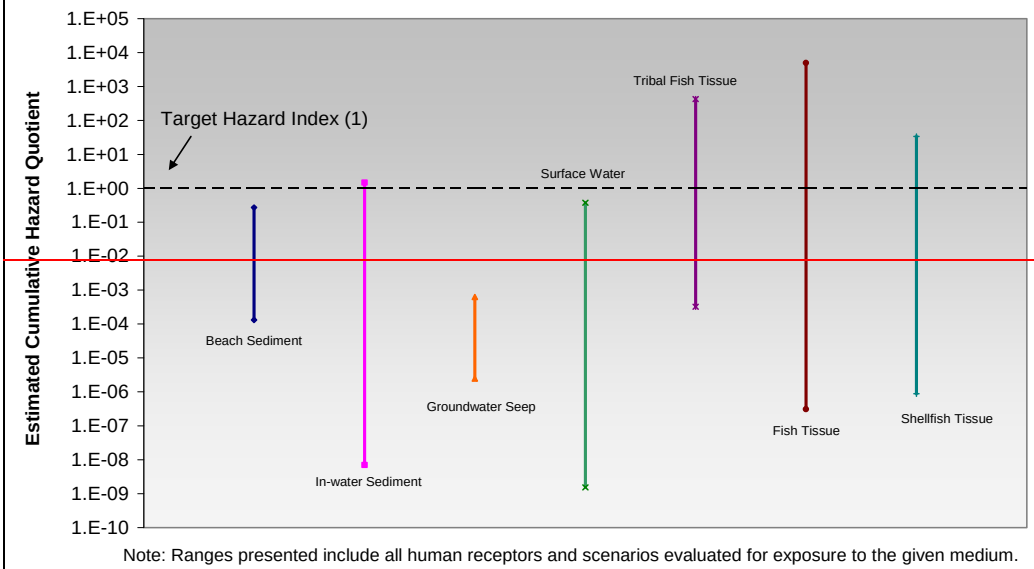
Consistent with DEQ (DEQ 2000a) and EPA guidance (EPA 1989), noncarcinogenic and carcinogenic effects were evaluated separately in the BHHRA. To characterize potential noncarcinogenic effects, comparisons were made between projected intakes

of substances and toxicity values. To characterize potential carcinogenic effects, projected intakes and chemical-specific, dose-response data were used to estimate the probability that an individual will develop cancer over a lifetime ~~of exposure~~.

Hazard quotients (HQs) were calculated for noncarcinogenic contaminants of potential concern (COPCs) to estimate the potential for noncarcinogenic effects. The HQs ~~with common toxicological endpoints~~ were then summed to yield cumulative hazard indices (HIs) for each exposure area and for the entire Study Area. Estimated HIs were compared to a target HI of 1. For exposure areas exceeding a cumulative HI of 1, endpoint-specific HIs were then calculated and compared to a target HI of 1, below which remedial action at a Superfund site is generally not warranted (EPA 1991a).

Table ES-1 shows the ranges of cancer~~s~~ risks and HIs for each receptor and medium. ~~As shown in Figure E-2, t~~The exposure pathway with the highest range of HI estimates is consumption of fish tissue. For the most part, exposure scenarios other than fish and shellfish consumption did not exceed a target HI of 1. The ranges of HI estimates are due to the evaluation of different exposure areas, RME and CT scenarios for sediment and water, and multiple ingestion rates and diets for tissue consumption. For example, the range of HI estimates for tissue~~, presented in Figure E-2 below,~~ encompass results for both adult and child consumers, results from three different ingestion rates for each receptor, and results from five different diet compositions.

Figure E-2
Ranges for 95% UCL or Maximum Exposure
Toxicity Endpoint-Specific Hazard Indexes, by Medium



Note: Ranges presented include all human receptors and scenarios evaluated for exposure to the given medium.

Potential cancer risks were calculated for carcinogenic COPCs. This calculated risk is expressed as the probability of an individual developing cancer over a lifetime as a result of exposure to the potential carcinogen, and is a ~~conservative,~~ health protective estimate of the incremental probability of excess individual lifetime cancer risk. Estimated total cancer risks (summed across all chemicals) were compared to a 1 x 10^{-4} to 1 x 10^{-6} risk range, which is the "target range" within which the EPA strives to manage risk as a part of the Superfund program (EPA 1991a). The DEQ ~~acceptable~~ target risk levels are 1 x 10^{-6} for individual carcinogens and 1 x 10^{-5} for total cancer risks.

As shown below in ~~Figure E-3~~Table ES-1, the exposure pathway with the highest range of cancer risk estimates is consumption of fish tissue. For the most part, exposure scenarios other than fish and shellfish consumption were within or below the target risk range of 1 x 10^{-4} to 1 x 10^{-6}. The ranges of cancer risk estimates are due to the evaluation of different exposure areas, RME and CT scenarios for sediment and water, and multiple ingestion rates and diets for tissue consumption. Round 1 fillet tissue samples were not analyzed for PCB, dioxin, or furan congeners. Therefore, the risks from consumption of black crappie and brown bullhead fillet tissue, which were only analyzed in Round 1, likely underestimate the actual risks. However, a range of risks was calculated for fish consumption scenarios, which included samples that were analyzed for congeners, so the lack of analysis of chemicals in certain samples should not impact the overall conclusions of this BHHRA.

Table ES-1. Ranges of Estimated Cumulative Excess Lifetime Cancer Risks and Hazard Indices for Portland Harbor Human Health Scenarios

		RME Scenarios				CT Scenarios			
		Estimated Cancer Risk		Cumulative Hazard Index		Estimated Cancer Risk		Cumulative Hazard Index	
Exposure Scenario	**Receptor**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**
Direct Exposure to Beach Sediment	Dockside Worker	5.E-07	**9.E-05**	2.E-03	7.E-02	4.E-08	**6.E-06**	5.E-04	1.E-02
	Transient	1.E-07	6.E-07	4.E-02	1.E-01	8.E-09	4.E-08	6.E-03	1.E-02
	Adult Recreational Beach User	5.E-07	**4.E-06**	8.E-03	3.E-02	2.E-08	2.E-07	2.E-03	6.E-03
	Child Recreational Beach User	**2.E-06**	**4.E-05**	8.E-02	4.E-01	2.E-07	**2.E-06**	1.E-02	5.E-02
	Combined Adult/Child Recreational Beach User	**2.E-06**	**5.E-05**	NA	NA	2.E-07	**2.E-06**	NA	NA
	Tribal Fisher	**2.E-06**	**2.E-05**	2.E-02	8.E-02	1.E-07	**2.E-06**	3.E-03	3.E-02
	Low-Frequency Fisher	4.E-07	**4.E-06**	7.E-03	3.E-02	1.E-08	1.E-07	8.E-04	3.E-02
	High-Frequency Fisher	5.E-07	**6.E-06**	1.E-02	5.E-02	2.E-08	3.E-07	2.E-03	3.E-02
	Breastfeeding Infant	7.E-09	1.E-06	1.E-02	1.E+00	5.E-10	9.E-08	2.E-03	2.E-01
Direct Exposure to Groundwater Seep	Transient	3.E-09	3.E-09	6.E-03	6.E-03	4.E-10	4.E-10	1.E-03	1.E-03
Direct Exposure to In-water Sediment	Diver in Dry Suit	3.E-08	**1.E-05**	2.E-04	2.E-01	NA	NA	NA	NA
	Diver in Wet Suit	9.E-08	**3.E-05**	7.E-04	6.E-01	3.E-09	6.E-07	6.E-05	1.E-02
	In-water Worker	7.E-08	**2.E-05**	1.E-03	1.E+00	5.E-09	4.E-07	2.E-04	6.E-02
	Tribal Fisher	1.E-06	**3.E-04**	3.E-03	**3.E+00**	6.E-08	**6.E-06**	3.E-04	9.E-02
	Low-Frequency Fisher	2.E-07	**6.E-05**	1.E-03	1.E+00	5.E-09	4.E-07	9.E-05	2.E-02
	High-Frequency Fisher	3.E-07	**8.E-05**	2.E-03	**2.E+00**	9.E-09	9.E-07	2.E-04	4.E-02
	Breastfeeding Infant	5.E-10	**3.E-04**	7.E-04	**5.E+00**	4.E-11	**3.E-06**	3.E-04	1.E-01
Direct Exposure to Surface Water	Diver in Dry Suit	1.E-08	**2.E-06**	6.E-05	2.E-03	NA	NA	NA	NA
	Diver in Wet Suit	1.E-08	**1.E-05**	8.E-05	6.E-03	8.E-10	5.E-07	1.E-05	7.E-04
	Transient	6.E-07	7.E-07	4.E-02	4.E-01	7.E-08	1.E-07	1.E-02	8.E-02
	Adult Recreational Beach User	2.E-08	2.E-08	1.E-04	1.E-04	2.E-09	2.E-09	3.E-05	3.E-05
	Child Recreational Beach User	4.E-08	5.E-08	1.E-03	1.E-03	8.E-09	9.E-09	2.E-04	2.E-04
	Combined Adult/Child Recreational Beach User	6.E-08	7.E-08	NA	NA	9.E-09	1.E-08	NA	NA
Surface Water as Hypothetical Drinking Water Source	Domestic User, Adult	**6.E-06**	**3.E-04**	3.E-02	7.E-01	1.E-06	**3.E-05**	2.E-02	3.E-01
	Domestic User, Child	**4.E-06**	**7.E-04**	1.E-01	**2.E+00**	**2.E-06**	**2.E-04**	5.E-02	8.E-01
	Domestic User, Combined Adult/Child	**9.E-06**	**3.E-04**	NA	NA	**3.E-06**	**8.E-05**	NA	NA

Table ES-1. Ranges of Estimated Cumulative Excess Lifetime Cancer Risks and Hazard Indices for Portland Harbor Human Health Scenarios

		RME Scenarios				CT Scenarios			
		Estimated Cancer Risk		Cumulative Hazard Index		Estimated Cancer Risk		Cumulative Hazard Index	
Exposure Scenario	**Receptor**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**
Direct Exposure to Beach Sediment	Dockside Worker	5.E-07	**9.E-05**	2.E-03	7.E-02	4.E-08	**6.E-06**	5.E-04	1.E-02
	Transient	1.E-07	6.E-07	4.E-02	1.E-01	8.E-09	4.E-08	6.E-03	1.E-02
	Adult Recreational Beach User	5.E-07	**4.E-06**	8.E-03	3.E-02	2.E-08	2.E-07	2.E-03	6.E-03
	Child Recreational Beach User	**2.E-06**	**4.E-05**	8.E-02	4.E-01	2.E-07	**2.E-06**	1.E-02	5.E-02
	Combined Adult/Child Recreational Beach User	**2.E-06**	**5.E-05**	NA	NA	2.E-07	**2.E-06**	NA	NA
	Tribal Fisher	**2.E-06**	**2.E-05**	2.E-02	8.E-02	1.E-07	**2.E-06**	3.E-03	3.E-02
	Low-Frequency Fisher	4.E-07	**4.E-06**	7.E-03	3.E-02	1.E-08	1.E-07	8.E-04	3.E-02
	High-Frequency Fisher	5.E-07	**6.E-06**	1.E-02	5.E-02	2.E-08	3.E-07	2.E-03	3.E-02
	Breastfeeding Infant	7.E-09	1.E-06	1.E-02	1.E+00	5.E-10	9.E-08	2.E-03	2.E-01
Direct Exposure to Groundwater Seep	Transient	3.E-09	3.E-09	6.E-03	6.E-03	4.E-10	4.E-10	1.E-03	1.E-03
Direct Exposure to In-water Sediment	Diver in Dry Suit	3.E-08	**1.E-05**	2.E-04	2.E-01	NA	NA	NA	NA
	Diver in Wet Suit	9.E-08	**3.E-05**	7.E-04	6.E-01	3.E-09	6.E-07	6.E-05	1.E-02
	In-water Worker	7.E-08	**2.E-05**	1.E-03	1.E+00	5.E-09	4.E-07	2.E-04	6.E-02
	Tribal Fisher	1.E-06	**3.E-04**	3.E-03	**3.E+00**	6.E-08	**6.E-06**	3.E-04	9.E-02
	Low-Frequency Fisher	2.E-07	**6.E-05**	1.E-03	1.E+00	5.E-09	4.E-07	9.E-05	2.E-02
	High-Frequency Fisher	3.E-07	**8.E-05**	2.E-03	**2.E+00**	9.E-09	9.E-07	2.E-04	4.E-02
	Breastfeeding Infant	5.E-10	**3.E-04**	7.E-04	**5.E+00**	4.E-11	**3.E-06**	3.E-04	1.E-01
Direct Exposure to Surface Water	Diver in Dry Suit	1.E-08	**2.E-06**	6.E-05	2.E-03	NA	NA	NA	NA
	Diver in Wet Suit	1.E-08	**1.E-05**	8.E-05	6.E-03	8.E-10	5.E-07	1.E-05	7.E-04
	Transient	6.E-07	7.E-07	4.E-02	4.E-01	7.E-08	1.E-07	1.E-02	8.E-02
	Adult Recreational Beach User	2.E-08	2.E-08	1.E-04	1.E-04	2.E-09	2.E-09	3.E-05	3.E-05
	Child Recreational Beach User	4.E-08	5.E-08	1.E-03	1.E-03	8.E-09	9.E-09	2.E-04	2.E-04
	Combined Adult/Child Recreational Beach User	6.E-08	7.E-08	NA	NA	9.E-09	1.E-08	NA	NA
Surface Water as Hypothetical Drinking Water Source	Domestic User, Adult	**6.E-06**	**3.E-04**	3.E-02	7.E-01	1.E-06	**3.E-05**	2.E-02	3.E-01
	Domestic User, Child	**4.E-06**	**7.E-04**	1.E-01	**2.E+00**	**2.E-06**	**2.E-04**	5.E-02	8.E-01
	Domestic User, Combined Adult/Child	**9.E-06**	**9.E-04**	NA	NA	**3.E-06**	**2.E-04**	NA	NA

Table ES-1 (continued). Ranges of Estimated Cumulative Excess Lifetime Cancer Risks and Hazard Indices for Portland Harbor Human Health Scenarios

		RME Scenarios				CT Scenarios			
		Estimated Cancer Risk		Cumulative Hazard Index		Estimated Cancer Risk		Cumulative Hazard Index	
Exposure Scenario	Receptor	Min	Max	Min	Max	Min	Max	Min	Max
Tribal Fish Ingestion	Tribal Adult Consumer	2.E-02	2.E-02	4.E+02	4.E+02	5.E-03	5.E-03	9.E+01	9.E+01
Multi-Species Diet	Tribal Child Consumer	3.E-03	3.E-03	8.E+02	8.E+02	8.E-04	8.E-04	2.E+02	2.E+02
Whole Body Tissue	Combined Tribal Adult/Child Consumer	2.E-02	2.E-02	NA	NA	5.E-03	5.E-03	NA	NA
Approximate number of meals per month: 23	Breastfeeding Infant	2.E-02	2.E-02	9.E+03	9.E+03	5.E-03	5.E-03	2.E+03	2.E+03
Tribal Fish Ingestion	Tribal Adult Consumer	1.E-02	1.E-02	3.E+02	3.E+02	2.E-03	2.E-03	5.E+01	5.E+01
Multi-Species Diet	Tribal Child Consumer	2.E-03	2.E-03	6.E+02	6.E+02	4.E-04	4.E-04	1.E+02	1.E+02
Fillet Tissue	Combined Tribal Adult/Child Consumer	1.E-02	1.E-02	NA	NA	3.E-03	3.E-03	NA	NA
Approximate number of meals per month: 23	Breastfeeding Infant	1.E-02	1.E-02	8.E+03	8.E+03	2.E-03	2.E-03	1.E+03	1.E+03
Fish Ingestion	Adult Consumer	7.E-05	6.E-02	2.E+00	3.E+03	7.E-05	2.E-02	2.E+00	1.E+03
Single-Species Diet	Child Consumer	3.E-05	2.E-02	4.E+00	5.E+03	3.E-05	8.E-03	4.E+00	2.E+03
Whole Body Tissue	Combined Adult/Child Consumer	9.E-05	7.E-02	NA	NA	8.E-05	2.E-02	NA	NA
Approximate number of meals per month: 2 - 19	Breastfeeding Infant	8.E-05	7.E-02	3.E+01	6.E+04	7.E-05	2.E-02	3.E+01	2.E+04
Fish Ingestion	Adult Consumer	7.E-06	4.E-02	5.E-01	2.E+03	7.E-06	1.E-02	5.E-01	7.E+02
Single-Species Diet	Child Consumer	3.E-06	1.E-02	1.E+00	4.E+03	3.E-06	5.E-03	9.E-01	1.E+03
Fillet Tissue	Combined Adult/Child Consumer	9.E-06	4.E-02	NA	NA	8.E-06	2.E-02	NA	NA
Approximate number of meals per month: 2 - 19	Breastfeeding Infant	6.E-06	2.E-02	7.E+00	5.E+04	6.E-06	2.E-02	7.E+00	2.E+03
Fish Ingestion	Adult Consumer	1.E-03	1.E-02	8.E+01	6.E+02	4.E-04	3.E-03	2.E+01	1.E+02
Multi-Species Diet	Child Consumer	6.E-04	5.E-03	1.E+02	1.E+03	1.E-04	1.E-03	3.E+01	3.E+02
Whole Body Tissue	Combined Adult/Child Consumer	2.E-03	1.E-02	NA	NA	4.E-04	4.E-03	NA	NA
Approximate number of meals per month: 2 - 19	Breastfeeding Infant	2.E-03	1.E-02	2.E+03	1.E+04	4.E-04	4.E-03	3.E+02	3.E+03
Fish Ingestion	Adult Consumer	1.E-03	9.E-03	6.E+01	5.E+02	2.E-04	1.E-03	9.E+00	7.E+01
Multi-Species Diet	Child Consumer	4.E-04	4.E-03	1.E+02	1.E+03	6.E-05	6.E-04	2.E+01	1.E+02
Fillet Tissue	Combined Adult/Child Consumer	1.E-03	1.E-02	NA	NA	2.E-04	2.E-03	NA	NA
Approximate number of meals per month: 2 - 19	Breastfeeding Infant	1.E-03	1.E-02	2.E+03	1.E+04	2.E-04	2.E-03	2.E+02	2.E+03
Shellfish Ingestion (clam or crayfish)	Adult Consumer	9.E-07	7.E-04	7.E-02	4.E+01	9.E-07	7.E-04	6.E-02	4.E+01
Approximate number of meals per month: 0.4 - 2.5	Breastfeeding Infant	1.E-10	7.E-04	5.E-04	8.E+02	1.E-10	7.E-04	4.E-04	8.E+02

Notes:

Values presented are for exposure areas assessed in the BHHRA that lie within the Study Area.

Bolded cells exceed the EPA target cancer risk level of 1×10^{-5} or the target hazard index of 1.

Highlighted cells exceed the EPA target cancer risk level of 1×10^{-4} or the target hazard index of 1.

For tissue ingestion, the RME scenario represents the 95 percent upper confidence limit/maximum exposure point concentration. The CT scenario represents the mean exposure point concentration.

The exposure medium shown for the breastfeeding infant represents the exposure medium for the adult.

Ranges for tissue ingestion include all consumption rates.

NA = Not applicable because a CT scenario was not evaluated or because hazard indices were not calculated for the combined adult/child scenario.

Hazard indices presented are the ranges for cumulative hazard indices per exposure area and exposure scenario. Endpoint-specific hazard indices were calculated for cumulative hazard indices greater than 1.

For tissue ingestion, number of meals per month is calculated based on an 8 ounce serving for adults a 3.4 ounce serving for children.

Table ES-1 (continued). Ranges of Estimated Cumulative Excess Lifetime Cancer Risks and Hazard Indices for Portland Harbor Human Health Scenarios

		RME Scenarios				CT Scenarios			
		Estimated Cancer Risk		Cumulative Hazard Index		Estimated Cancer Risk		Cumulative Hazard Index	
Exposure Scenario	**Receptor**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**
Tribal Fish Ingestion	Tribal Adult Consumer	**2.E-02**	**2.E-02**	**4.E+02**	**4.E+02**	**5.E-03**	**5.E-03**	**9.E+01**	**9.E+01**
Multi-Species Diet	Tribal Child Consumer	**3.E-03**	**3.E-03**	**8.E+02**	**8.E+02**	**8.E-04**	**8.E-04**	**2.E+02**	**2.E+02**
Whole Body Tissue	Combined Tribal Adult/Child Consumer	**2.E-02**	**2.E-02**	NA	NA	**5.E-03**	**5.E-03**	NA	NA
Approximate number of meals per month: 23	Breastfeeding Infant	**2.E-02**	**2.E-02**	**9.E+03**	**9.E+03**	**5.E-03**	**5.E-03**	**2.E+03**	**2.E+03**
Tribal Fish Ingestion	Tribal Adult Consumer	**1.E-02**	**1.E-02**	**3.E+02**	**3.E+02**	**2.E-03**	**2.E-03**	**5.E+01**	**5.E+01**
Multi-Species Diet	Tribal Child Consumer	**2.E-03**	**2.E-03**	**6.E+02**	**6.E+02**	**4.E-04**	**4.E-04**	**1.E+02**	**1.E+02**
Fillet Tissue	Combined Tribal Adult/Child Consumer	**1.E-02**	**1.E-02**	NA	NA	**3.E-03**	**3.E-03**	NA	NA
Approximate number of meals per month: 23	Breastfeeding Infant	**1.E-02**	**1.E-02**	**8.E+03**	**8.E+03**	**2.E-03**	**2.E-03**	**1.E+03**	**1.E+03**
Fish Ingestion	Adult Consumer	**7.E-05**	**6.E-02**	**2.E+00**	**3.E+03**	**7.E-05**	**2.E-02**	**2.E+00**	**1.E+03**
Single-Species Diet	Child Consumer	**3.E-05**	**2.E-02**	**4.E+00**	**5.E+03**	**3.E-05**	**8.E-03**	**4.E+00**	**2.E+03**
Whole Body Tissue	Combined Adult/Child Consumer	**9.E-05**	**7.E-02**	NA	NA	**8.E-05**	**2.E-02**	NA	NA
Approximate number of meals per month: 2 - 19	Breastfeeding Infant	**8.E-05**	**7.E-02**	**3.E+01**	**6.E+04**	**7.E-05**	**2.E-02**	**3.E+01**	**2.E+04**
Fish Ingestion	Adult Consumer	**7.E-06**	**4.E-02**	5.E-01	**2.E+03**	**7.E-06**	**1.E-02**	5.E-01	**7.E+02**
Single-Species Diet	Child Consumer	**3.E-06**	**1.E-02**	1.E+00	**4.E+03**	**3.E-06**	**5.E-03**	9.E-01	**1.E+03**
Fillet Tissue	Combined Adult/Child Consumer	**9.E-06**	**4.E-02**	NA	NA	**8.E-06**	**2.E-02**	NA	NA
Approximate number of meals per month: 2 - 19	Breastfeeding Infant	**6.E-06**	**2.E-02**	**7.E+00**	**5.E+04**	**6.E-06**	**2.E-02**	**7.E+00**	**2.E+03**
Fish Ingestion	Adult Consumer	**1.E-03**	**1.E-02**	**8.E+01**	**6.E+02**	**4.E-04**	**3.E-03**	**2.E+01**	**1.E+02**
Multi-Species Diet	Child Consumer	**6.E-04**	**5.E-03**	**1.E+02**	**1.E+03**	**1.E-04**	**1.E-03**	**3.E+01**	**3.E+02**
Whole Body Tissue	Combined Adult/Child Consumer	**2.E-03**	**1.E-02**	NA	NA	**4.E-04**	**4.E-03**	NA	NA
Approximate number of meals per month: 2 - 19	Breastfeeding Infant	**2.E-03**	**1.E-02**	**2.E+03**	**1.E+04**	**4.E-04**	**4.E-03**	**3.E+02**	**3.E+03**
Fish Ingestion	Adult Consumer	**1.E-03**	**9.E-03**	**6.E+01**	**5.E+02**	**2.E-04**	**1.E-03**	**9.E+00**	**7.E+01**
Multi-Species Diet	Child Consumer	**4.E-04**	**4.E-03**	**1.E+02**	**1.E+03**	**6.E-05**	**6.E-04**	**2.E+01**	**1.E+02**
Fillet Tissue	Combined Adult/Child Consumer	**1.E-03**	**1.E-02**	NA	NA	**2.E-04**	**2.E-03**	NA	NA
Approximate number of meals per month: 2 - 19	Breastfeeding Infant	**1.E-03**	**1.E-02**	**2.E+03**	**1.E+04**	**2.E-04**	**2.E-03**	**2.E+02**	**2.E+03**
Shellfish Ingestion (clam or crayfish)	Adult Consumer	9.E-07	**7.E-04**	7.E-02	**4.E+01**	9.E-07	**7.E-04**	6.E-02	**4.E+01**
Approximate number of meals per month: 0.4 - 2.5	Breastfeeding Infant	1.E-10	**7.E-04**	5.E-04	**8.E+02**	1.E-10	**7.E-04**	4.E-04	**8.E+02**

Notes:

Values presented are for exposure areas assessed in the BHHRA that lie within the Study Area.

Bolded cells exceed the EPA target cancer risk level of 1×10^{-6} or the target hazard index of 1.

Highlighted cells exceed the EPA target cancer risk level of 1×10^{-4} or the target hazard index of 1.

For tissue ingestion, the RME scenario represents the 95 percent upper confidence limit/maximum exposure point concentration. The CT scenario represents the mean exposure point concentration.

The exposure medium shown for the breastfeeding infant represents the exposure medium for the adult.

Ranges for tissue ingestion include all consumption rates.

NA = Not applicable because a CT scenario was not evaluated or because hazard indices were not calculated for the combined adult/child scenario.

Hazard indices presented are the ranges for cumulative hazard indices per exposure area and exposure scenario. Endpoint-specific hazard indices were calculated for cumulative hazard indices greater than 1.

For tissue ingestion, number of meals per month is calculated based on an 8 ounce serving for adults a 3.4 ounce serving for children.

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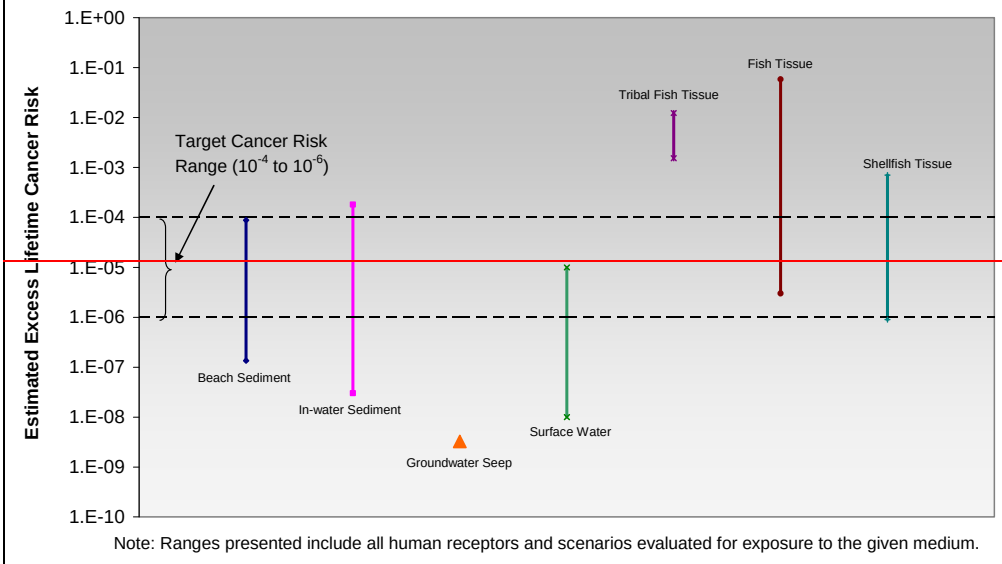
Figure E-3
Ranges for 95% UCL or Maximum Exposure
Cumulative Cancer Risk, by Medium



Note: Ranges presented include all human receptors and scenarios evaluated for exposure to the given medium.

~~F~~or both cancer risks and noncancer hazards, the maximum estimates are for fish consumption and represent the highest consumption rate, the 95% UCL or maximum tissue concentrations, and localized exposure areas. The following summarizes the assumptions associated with the highest risk estimates:

- **Fish ingestion rate.** The highest ingestion rates used in this BHHRA for adult tribal fishers and adult fishers ~~(~~are 175 g/day (CRITFC 1994) and 142 g/day (EPA 2002b), respectively~~) are~~. These are equivalent to 23 and 19 meals per month, respectively, based on an 8-ounce serving size, every month of the year exclusively of fish caught within the Study Area.
- **Exposure duration.** Fish consumption is assumed to occur at that same rate every month of every year for 30 years for adult fishers and 70 years for tribal fishers.

- **Whole body tissue.** Only whole body tissue (i.e., the entire fish) is consumed.
- **Single species.** For non-tribal fishers, only one species (i.e., common carp) is consumed.
- **Source of fish.** 100 percent of the fish consumed is caught/harvested from the same location.

In addition to the uncertainty associated with the exposure assumptions listed above, there are uncertainties associated with the cooking and preparation methods for fish consumption and background contributions ~~of chemicals of concern (COCs)~~ to the Study Area. Possible effects of cooking methods, which can reduce concentrations of lipophilic chemicals in fish tissue, were not considered. PCB concentrations have been shown to be reduced ~~up to 87 percent (Wilson et al. 1998)~~ with various cooking methods though due to the variability in the measured rates of reduction there is uncertainty in assigning a rate of reduction of PCBs associated with cooking and preparation methods. ~~In estimating the risks in this BHHRA, the conservative assumptions regarding fish consumption were multiplied together, which magnifies the conservatism in the risk estimates. The cumulative effects of the numerous conservative a~~Assumptions made during this BHHRA ~~are risk estimates that are potentially significantly higher than~~introduce uncertainty to the actual risks that may exist within the Study Area. The contribution of background sources ~~of COCs~~ is another important consideration. On a regional scale, fish consumption results in risk estimates exceeding cumulative risks of 10^{-4} or HIs of 1 based on fish tissue data collected from the Willamette and Columbia Rivers outside of the Study Area (EVS 2000, EPA 2002c). However, concentrations are higher at the Site than in the regional tissue.

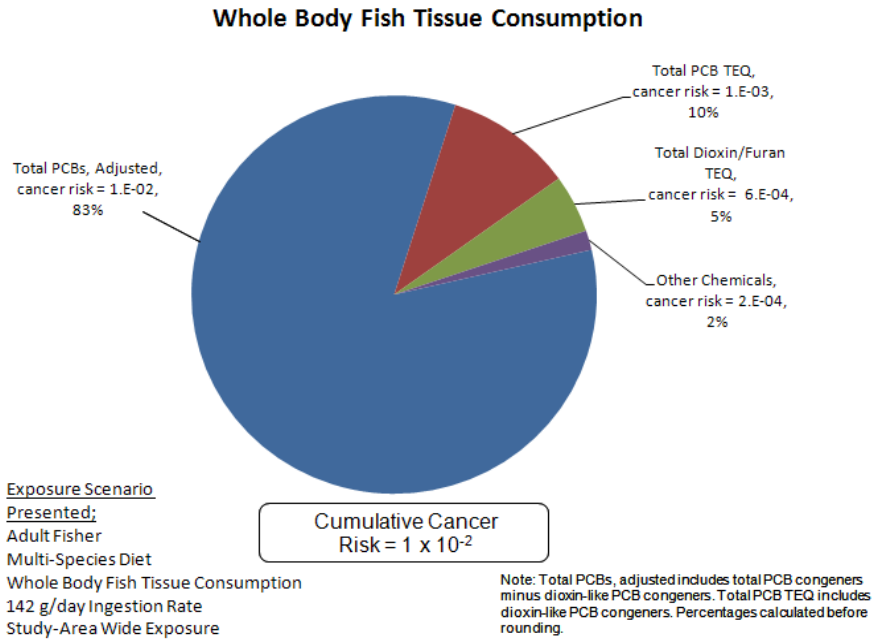
Chemicals were identified as ~~preliminary COCs chemicals~~contaminants potentially posing unacceptable risks[3] if they resulted in a cancer risk greater than the EPA point of departure of 1 x 10^{-6} or a HQ greater than 1 under any of the exposure scenarios for any of the exposure point concentrations evaluated in the BHHRA, regardless of the uncertainties. There were 28 chemicals identified as ~~preliminary COCschemicals~~contaminants potentially posing unacceptable risks for the exposure scenarios listed above. Only a subset of these ~~preliminary COCchemical~~contaminants were associated with cancer risks exceeding 1 x 10^{-4} or HQs exceeding 1, and an even smaller number of ~~COCs~~ contaminants ~~chemicals~~ contributed to most of the relative percentage of total risk. Of the 33 ~~chemicals~~contaminants identified as potentially posing unacceptable risks, four of the chemicals (alpha-, beta-, and gamma-hexachlorocyclohexane and heptachlor) were identified on the basis of N-qualified data only. The use of an "N" qualifier indicates that the identity of the analyte is not definitive. ~~Uncertainties associated with the~~

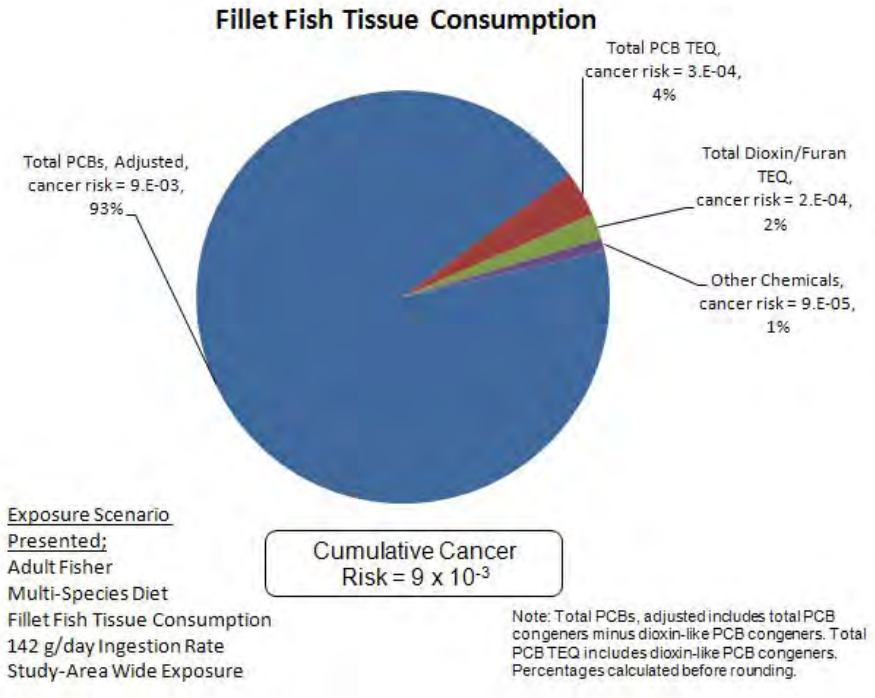
[3] Prior deliverables and some of the tables and figures attached to this document may use the term "Chemicals posing potentially unacceptable risks," which has the same meaning as "Contaminant posing potentially unacceptable risks" and refers to "contaminants" as defined in 42 USC 9601(33).

~~analytical data for individual chemicals were considered in the selection of the final COCs. Specifically, if chemicals were identified as preliminary COCs based only on the use of N-qualified data as EPCs, the chemicals were not identified as final COCs~~These four chemicals are not recommended for further evaluation of potential risks to human health. ~~There were 24 chemicals identified as final COCs for human health~~The remaining 29 contaminants ~~chemicals~~ identified as potentially posing unacceptable risks to human health are evaluated further in the Human Health Risk Management Recommendations.

As shown in Figure ES-~~4~~1, PCBs contribute the majority of the total cancer risk for the fish tissue consumption pathway (both whole body and fillet tissue) on a Study Area-wide exposure area basis, and are the primary contributor~~s~~ to risk under this exposure scenario.~~for the Study Area. risk driver~~ Dioxins and furans are the secondary ~~risk driver~~contributor to risk. PCBs contribute approximately 93 percent of the cumulative cancer risk, and ~~and~~ dioxins/furans contribute approximately ~~98~~ 5 percent of the cumulative cancer risk for Study Area-wide whole body fish tissue consumption~~ for the Study Area~~. ~~-~~For fillet tissue consumption, PCBs contribute approximately 97 percent of the cumulative cancer risk, and dioxins/furans contribute approximately 2 percent for Study Area-wide exposure. The remaining COPCs for Study Area-wide fish consumption account for less than 2 ~~.5~~ percent of the cumulative cancer risk. PCBs and dioxins/furans also resulted in the highest HQs for ~~the~~ Study Area~~--~~wide fish tissue consumption.

Figure ES-1. Relative Contribution of Individual Analytes to Cumulative Study Area-Wide Risk For The Non-Tribal Adult Fish Consumption Scenario, Whole Body and Fillet Tissue

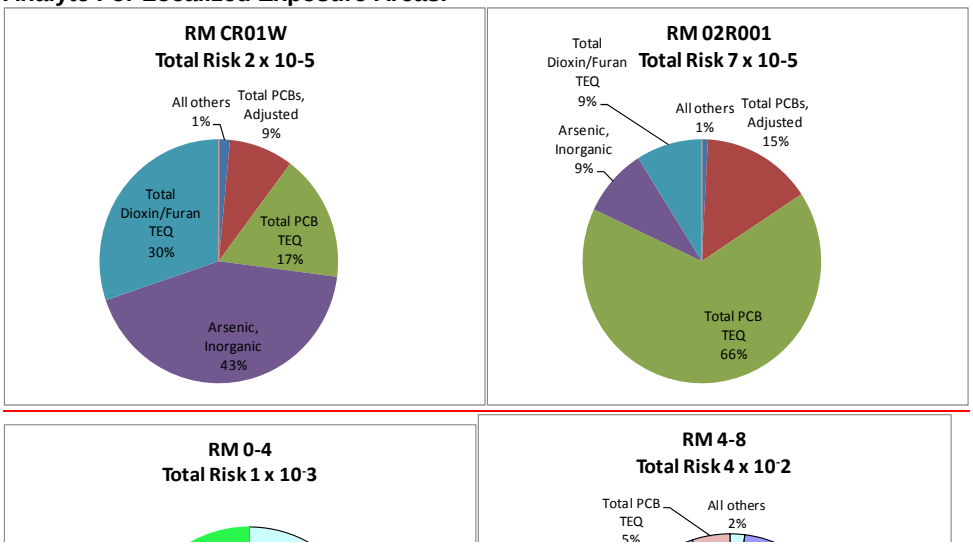



Fillet Fish Tissue Consumption
Total PCB TEQ, cancer risk = 3.E-04, 4%
Total Dioxin/Furan TEQ, cancer risk = 2.E-04, 2%
Other Chemicals, cancer risk = 9.E-05, 1%
Total PCBs, Adjusted, cancer risk = 9.E-03, 93%
Exposure Scenario Presented;
Adult Fisher
Multi-Species Diet
Fillet Fish Tissue Consumption
142 g/day Ingestion Rate
Study-Area Wide Exposure
Cumulative Cancer Risk = 9 x 10-3
Note: Total PCBs, adjusted includes total PCB congeners minus dioxin-like PCB congeners. Total PCB TEQ includes dioxin-like PCB congeners. Percentages calculated before rounding.

While tissue concentrations and risks are higher in Portland Harbor, in regional studies of fish tissue data from the Willamette and Columbia Rivers outside of the Study Area (EVS 2000, EPA 2002c) both PCBs and dioxins/furans also resulted in cancer risks greater than 1 x 10^{-4} and/or HQs greater than 1 for fish consumption using exposure assumptions similar to those in the BHHRA.

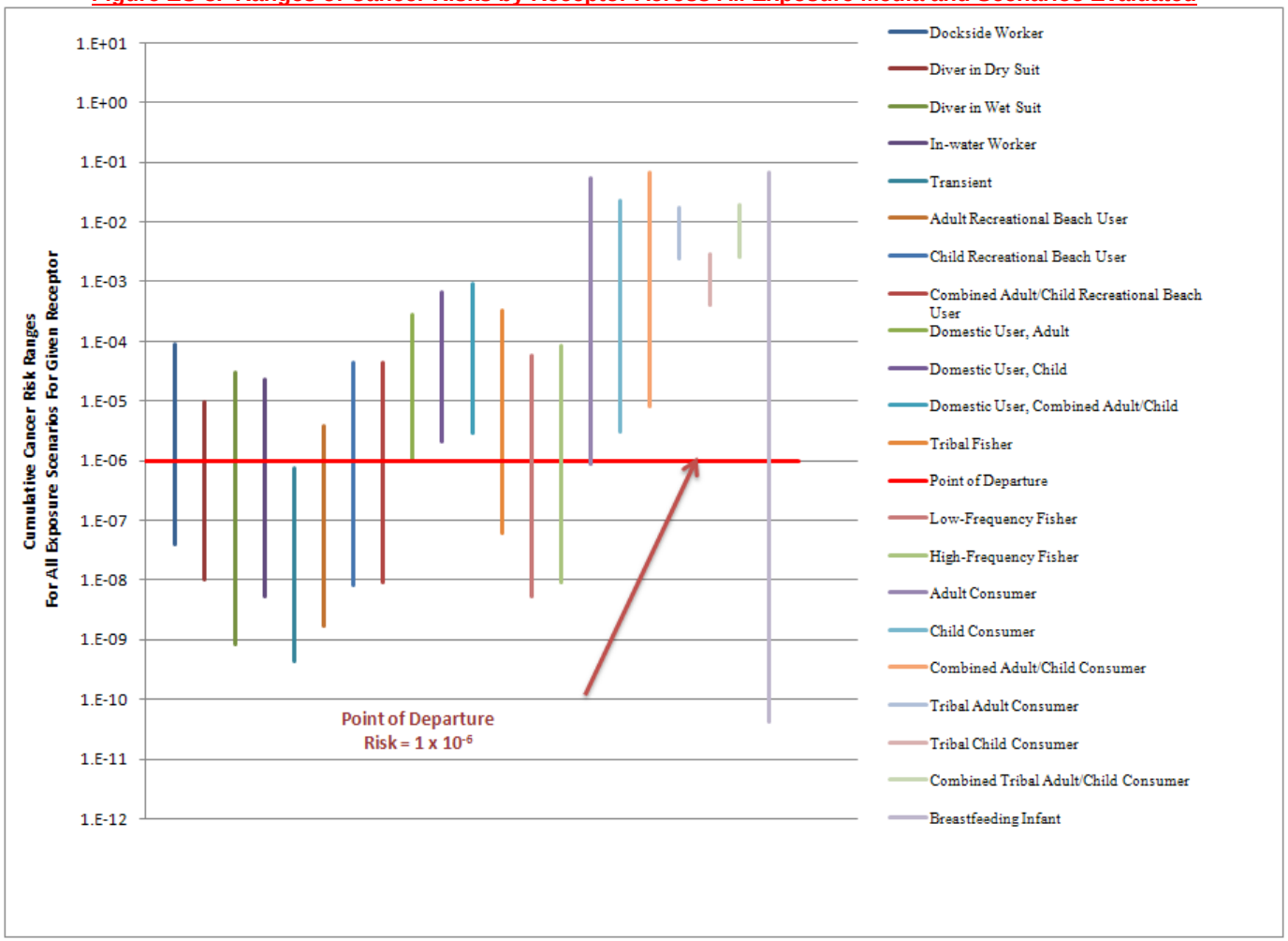
In some cases in the Portland Harbor, contaminants contributing most to cumulative risks differ between localized exposure areas. For example, Figure ES-2 shows the relative contribution of contaminants to cumulative cancer risks from ingestion of crayfish tissue by an adult fisher at two different localized exposure areas. In the pie chart on the left, which shows relative risks from consumption of crayfish at sampling station CR01W, arsenic is the primary contributor to cancer risk (42% of total risk), followed by total dioxin/furan TEQ (30% of total risk). The pie chart on the right shows relative risks from consumption of crayfish at sampling station RM 02R001, where ingestion of PCBs in shellfish tissue contributes to approximately 81% of total cancer risks (total adjusted PCBs plus total PCB TEQ), followed by an almost equal contribution from arsenic and total dioxin/furan TEQ (approximate 9% contribution to total risks by each contaminant)

Figure ES-2. Example of Differing Relative Contributions to Cumulative Risk by Analyte For Localized Exposure Areas.



A detailed breakdown of risks by exposure scenario, contaminant, and exposure area is provided in the figures and tables in Section 5 of this BHHRA. In addition, Figure ES-3 and ES-4 provide a visual representation of the ranges of cancer risks (ES-3) and noncancer hazards (ES-4) by receptor. Fish tissue consumers have the highest estimated cancer and noncancer risks.

Figure ES-3. Ranges of Cancer Risks by Receptor Across All Exposure Media and Scenarios Evaluated

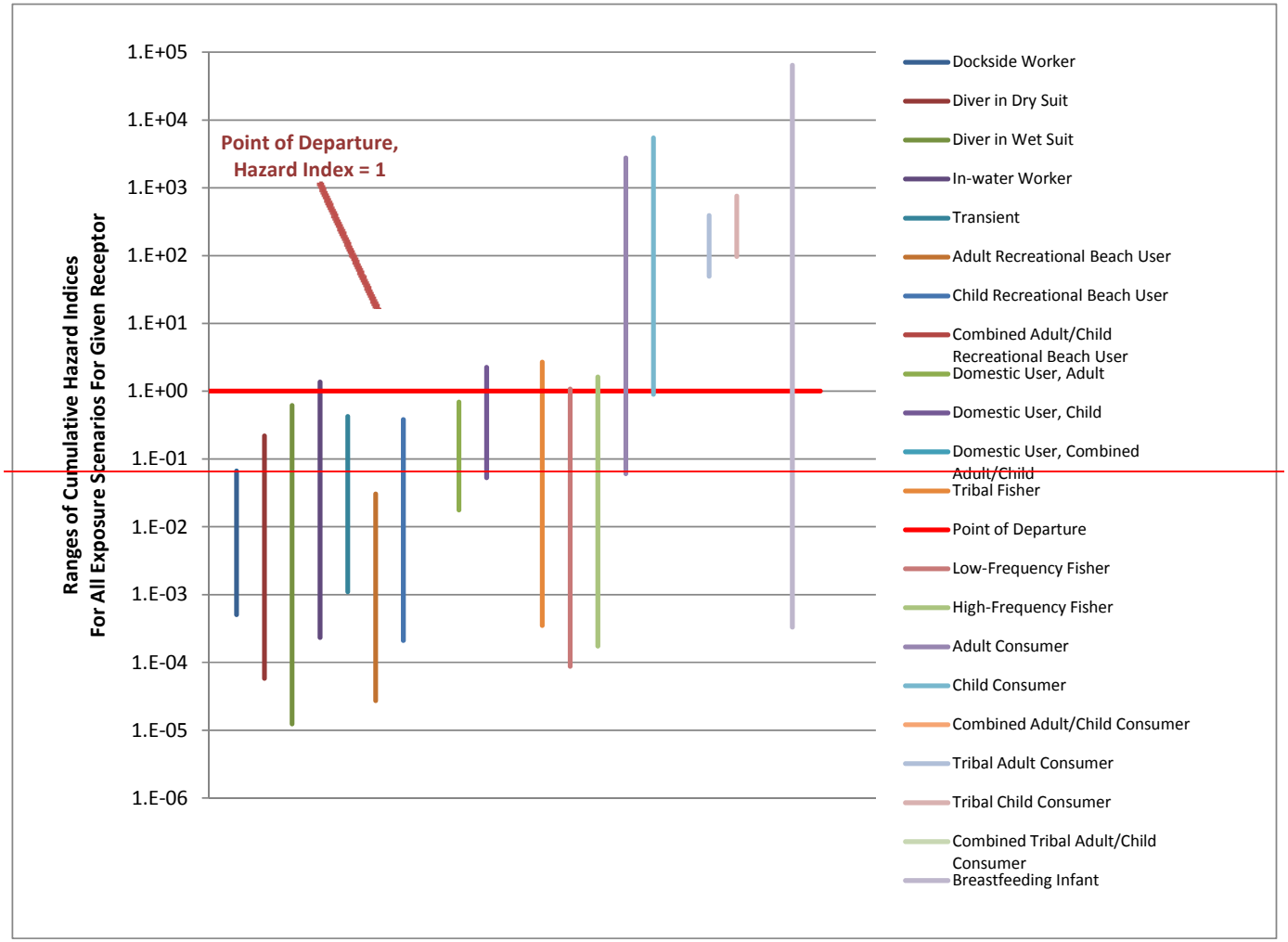


~~*In regional studies of fish tissue data from the Willamette and Columbia Rivers outside of the Study Area (EVS 2000, EPA 2002c)*~~

~~*both PCBs and dioxins/furans also resulted in cancer risks greater than 10^{-4} and/or HQs greater than 1 for fish consumption using exposure assumptions similar to those in the BHHRA.*~~

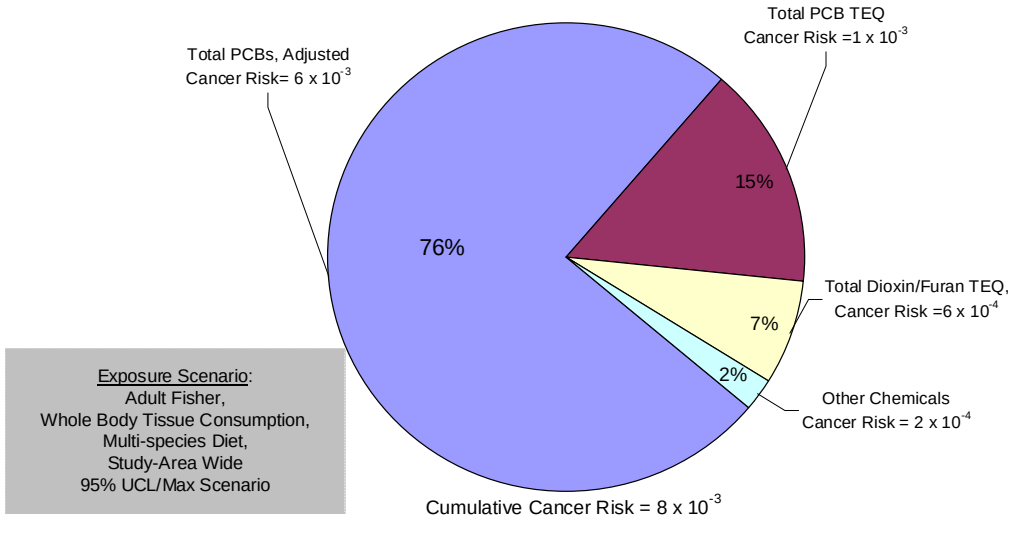
~~1.~~

Figure ES-4. Ranges of Cumulative Noncancer Hazard Indices by Receptor Across All Exposure Media and Scenarios Evaluated



o

Figure E-4
Relative Contribution of Individual Analytes to Cumulative Site-Wide Risk For Representative Fish Consumption Scenario



Note: Total PCBs, adjusted includes total PCB congeners minus dioxin-like PCB congeners. Total PCB TEQ includes dioxin-like PCB congeners.

o In addition to the quantitative evaluation of risks summarized above, the BHHRA included a screening evaluation of surface water and TZW data to evaluate the possible

~~contribution to potentially complete and significant exposure pathways. Specifically, surface water and TZW data were evaluated separately as a potential source of chemicals in biota that are consumed by humans, and TZW data were also evaluated as a potential source to untreated surface water that is hypothetically used as a domestic water source. The results of the screening evaluation of surface water and TZW data indicate that chemicals in these media may be contributing to the risks from consumption of biota.~~

~~o A bioaccumulation model was developed for Portland Harbor to determine the relative contribution of sediment and surface water concentrations in biota (Windward, 2009). Results of the model will be used to derive preliminary remediation goals, and the model will be incorporated into a more comprehensive fate and transport model for evaluation of the remedial alternatives in the FS. Under current conditions, the bioaccumulation model preliminarily determined that sediments are an important source of benthic invertebrate and fish tissue concentrations for the bioaccumulative compounds.~~

~~o However, it should be noted that risks from consumption of biota were evaluated in this BHHRA using empirical tissue data collected within the Study Area. The use of empirical tissue data to assess risks provides for greater confidence in calculated risk estimates than modeling tissue concentrations from sediment and/or water concentrations. The results of the screening evaluation of TZW data as a potential source to surface water used as a domestic water source indicate that TZW is not likely to contribute significantly to the overall risk from surface water exposures, even if untreated surface water was used as a domestic water source.~~

ES.6 SUMMARY OF BHHRA

The following presents the major findings of the BHHRA:

- Risks resulting from the consumption of fish or shellfish are generally orders of magnitude higher than risk resulting from direct contact with sediment, surface water, or seeps. Risks from fish and shellfish consumption exceed the EPA point of departure for cancer risk of 1×10^{-6}, as well as the target cancer risk range of 1×10^{-6} to 1×10^{-4} and target HI of 1. With the exception of two ½-mile river segments for the tribal fisher scenario and one location for the hypothetical use of untreated surface water as a drinking water source by a future resident, ~~direct contact with sediment, surface water, and seeps results~~ all of the direct contact scenarios result in risks within or below the EPA target cancer risk range of 1×10^{-6} to 1×10^{-4}. The direct contact scenarios also result in non-cancer hazards below the target HI of 1, with the exception of one ½-river mile segment for in-water sediment and one location for hypothetical use of untreated surface water as a drinking water source.

~~and below the target HI of 1. The evaluation of shellfish consumption was done at the direction of EPA~~

- ~~., and there is no information documenting whether shellfish consumption actually occurs on an ongoing basis within the Study Area. Therefore, fish~~

~~consumption is the exposure scenario that is considered the major risk driver for the Study Area.~~

- Fish consumption results in the highest risks of the scenarios evaluated in the BHHRA. PCBs are the primary contributor to risk~~risk driver~~ for fish consumption, and dioxins/furans are a secondary ~~risk driver~~contributor for fish consumption for exposure occurring over the full length of the Study Area. Other contaminants potentially posing unacceptable risks at a Study Area-wide or localized scale for at least one fish consumption exposure scenario include the following contaminants:
  - antimony
  - arsenic
  - lead
  - mercury
  - selenium
  - zinc
  - benzo(a)anthracene
  - benzo(a)pyrene
  - dibenzo(a,h)anthracene
  - total carcinogenic PAHs
  - bis(2-ethylhexy) phthalate
  - hexachlorobenzene
  - total PCBs and PCB TEQ
  - total dioxin TEQ
  - aldrin
  - dieldrin
  - heptachlor epoxide
  - total chlordane
  - total DDD
  - total DDE
  - total DDT
  - PBDEs

- Risks from PCBs based on consumption of fish within the Study Area exceed the EPA target risk range of 1×10^{-6} to 1×10^{-4}, with a maximum estimated risk of ~~6~~ 7 x 10^{-2} (combined adult and child receptor). The maximum cumulative hazard index from fish consumption is 5,000 (child receptor), primarily from exposure to PCBs in whole body tissue. The maximum cumulative hazard index from consumption of fillet fish tissue is 4,000 (child receptor), also primarily from exposure to PCBs.

- The body of information available regarding fish consumption rates, both nationally and regionally, indicates that the fish ingestion rates used in the BHHRA address a range of exposures that might occur for consumers of locally caught fish in Portland Harbor, including high fish consuming populations. ~~The uncertainties associated with the tissue consumption scenarios should be considered when using~~

~~the results of the BHHRA in risk management decisions. The fish tissue consumption risks in the BHHRA incorporate assumptions that may under-estimate, or more likely over-estimate the actual risks.~~

- Concentrations of bioaccumulative chemicals are higher at the Site than in regional tissue. However, ~~O~~on a regional basis, risks from exposure to bioaccumulative chemicals in tissue exceed EPA target risk levels. For example, the PCB concentrations detected in resident fish from the Willamette and Columbia Rivers are approximately 20 to 100 times higher than the EPA target fish tissue concentration, when adjusted for the ingestion rates used in this BHHRA and based on a target risk level of 1×10^{-6}. Regional efforts are underway to reduce fish tissue concentrations. Sources contributing to regional tissue concentrations are unknown.

- The contribution of background sources of ~~COCs~~ contaminants potentially posing unacceptable risks is an important consideration in risk management decisions. For example, arsenic concentrations in beach sediment contribute approximately 50% of cumulative risk from exposure to this medium for the highest-risk scenarios, yet arsenic concentrations detected in beach sediment within the Study Area are comparable to Oregon DEQ-established background levels.

1.0 INTRODUCTION

This Baseline Human Health Risk Assessment (BHHRA) presents the Lower Willamette Group's (LWG's) evaluation of risks to human health for the Portland Harbor Superfund Site (Site) in Portland, Oregon. This BHHRA is intended to provide an assessment of human health risks for the Site and to support risk management decisions for the Site.

Portland Harbor encompasses the authorized navigation channel in the Lower Willamette River (LWR) in Portland, Oregon, from the confluence with the Columbia to about River Mile (RM) 11.8. Portland Harbor has been the focus of numerous environmental investigations completed by the LWG and various other governmental and private entities. Major LWG data collection efforts occurred during three sampling rounds in the Remedial Investigation/Feasibility Study (RI/FS) Study Area (RM 1.9 to 11.8) to characterize the physical system of the river and to assess the nature and extent of contamination in sediment, surface water, transition zone water, stormwater, and biota. This BHHRA incorporates the results of these environmental investigations and builds from the initial Human Health Risk Assessment (HHRA) performed as part of the Portland Harbor RI/FS Comprehensive Round 2 Site Characterization Summary and Data Gaps Analysis Report (Round 2 Report) (Integral et. al. 2007).

The LWG has worked with the United States Environmental Protection Agency (EPA) to develop the methods and assumptions used in this BHHRA. At the direction of EPA, this BHHRA incorporates ~~conservative~~ assumptions to provide a health protective assessment of risks associated with contaminants present at the Site, which is consistent with EPA guidance on risk assessment (1989). For many of the exposure scenarios evaluated in this BHHRA, upper-bound literature values are used to quantify exposure due to the lack of site-specific exposure information. In some cases, the maximum detected concentrations are used to quantify long-term exposures~~. While the use of maximum detected concentrations provides a health protective approach~~, ~~it~~ which may not~~-~~ be representative of ~~conditions~~ ongoing exposures in the Study Area. Therefore, the results of the BHHRA have a margin of conservatism built into the risk conclusions consistent with EPA guidance (1989). ~~The conservative assumptions about exposure and toxicity also affect the preliminary remediation goals (PRGs) and early activities in the Feasibility Study (FS).~~

This BHHRA is being conducted as part of the Remedial Investigation Report (RI Report) to evaluate potential adverse health effects caused by hazardous substance releases at the Site, consistent with the requirements of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The BHHRA will be used to support the development of contaminant ~~chemical~~ thresholds to be used as preliminary remediation goals (PRGs) for sediment. The BHHRA PRGs are provided along with PRGs developed under the baseline ecological risk assessment (BERA) for the Site. The PRGs will provide

preliminary estimates of the long-terms goals to be achieved by any cleanup actions in Portland Harbor. During the feasibility study (FS) process, the PRGs will be refined based on background sediment quality, technical feasibility, and other risk management considerations. EPA will identify the final remediation goals (RGs) for the site in the Record of Decision, following completion of the FS.

1.1 OBJECTIVES

The general objective of a HHRA is to assess the potential risks to human health from exposure to chemicals present in or entering into environmental media (i.e., water or sediment) or bioaccumulating in the food chain. The overall objective of this BHHRA for the Site is to evaluate whether exposure to contaminants in sediment, surface water, groundwater seeps, or biota may result in unacceptable risks to human health. To achieve the overall objective, the following are specific objectives of this BHHRA:

- Identify ~~chemicals~~ contaminants of potential concern (COPCs)[4] for human health
- Identify potential exposure pathways to populations who may contact COPCs
- Characterize potentially exposed populations and estimate the extent of their exposure to COPCs
- Quantitatively characterize the noncarcinogenic and carcinogenic risks to the populations resulting from potential exposure to COPCs and identify ~~chemicals~~ contaminants ~~of concern (COCs)~~potentially posing unacceptable risks~~.~~
- Characterize uncertainties associated with this risk assessment
- Identify the ~~COCs that will~~ contaminants and pathways that contribute the majority of the risk~~be the focus of risk management decisions for the Site~~.

1.2 APPROACH

This BHHRA follows the approach that was documented in the Programmatic Work Plan (Integral et al. 2004) and subsequent interim deliverables. It also reflects numerous discussions and agreements on appropriate risk assessment techniques for the Site among interested parties, including the EPA, Oregon Department of Environmental Quality (DEQ), Oregon Department of Human Services (ODHS), and Native American Tribes.

[4] Prior deliverables and some of the tables and figures attached to this document may use the term "Chemicals of potential concern," which has the same meaning as "Contaminants of potential concern" and refers to "contaminants" as defined in 42 USC 9601(33).

Most of the exposure scenarios, including potential exposure pathways and potentially exposed populations, were originally identified in the Programmatic Work Plan. Most of the assumptions used to estimate the extent of exposure for these scenarios were also identified in the Programmatic Work Plan. Additional assumptions for estimating the extent of exposure were provided in the Exposure Point Concentration Calculation Approach and Summary of Exposure Factors Technical Memorandum (Kennedy/Jenks Consultants 2006) and the Human Health Toxicity Values Interim Deliverable (Kennedy/Jenks Consultants 2004a). Exposure scenarios that were not included in the Programmatic Work Plan were evaluated in this BHHRA based on direction from EPA. Specific agreements with and direction from EPA related to the approach for this BHHRA are documented in Attachment F1.

The approach of this BHHRA is based on EPA (1989, 1991b, 2001a, 2004, 2005a) and ~~Region 10~~ EPA Region 10 (2000a) guidance~~, except where further health protective assumptions were used at the request or direction of EPA~~ and direction from EPA. The approach is also consistent with DEQ guidance for HHRAs (DEQ 2000a, 2010).

1.3 SITE BACKGROUND

The LWR extends from the Willamette's convergence with the Columbia River at river mile (RM) 0 upstream to the Willamette Falls at RM 26. Portland Harbor generally refers to a heavily industrialized reach of the LWR between RM 0 and RM 11.8, the extent of the navigation channel. Additional information on the environmental setting of Portland Harbor, including historical and current land use, regional geology and hydrogeology, surface water hydrology, the in-water physical system, habitat, and human access and use is provided in Section 3 of the RI Report. The approximate 10-mile portion of Portland Harbor from RM 1.9 to 11.8 is referred to as the Study Area (Map 1-1). Because the Site boundaries have not yet been defined[5], this BHHRA focused on the Study Area.

Portland Harbor and the Willamette River have served as a major industrial water corridor for more than a century. Industrial use of the Study Area and adjacent areas has been extensive. The majority of the Study Area is currently zoned for industrial land use and is designated as an "Industrial Sanctuary" (City of Portland 2006a). Much of the shoreline in the Study Area includes steeply sloped banks covered with riprap or constructed bulkheads, with human-made structures such as piers and wharves over the water in various locations. A comprehensive update of Portland's Willamette Greenway Plan and related land use policies and zoning (The River Plan) is underway, addressing all of the Willamette riverfront in Portland (City of Portland 2006b). ~~The North Reach of the River Plan (River Plan/North Reach), which includes Portland Harbor, was adopted on April 15, 2010. The River Plan is a plan for land along the Willamette River and generally includes all land within~~

[5] The Site boundaries will be defined by EPA in the Record of Decision for the Site.

~~approximately ¼ mile of the river. The River Plan/North Reach addresses economic prosperity, watershed health, access, riverfront communities, and working with stakeholders (City of Portland 2010). The overall objective for the River Plan/North Reach is to "continue to provide Oregon with access to global markets and support the region's economy as a West Coast distribution hub and heavy industrial area. Environmental cleanup, recreational access, and watershed health actions will contribute to the harbor's long-term vitality." (City of Portland 2010) The plan will continue to support industrial uses within Portland Harbor while at the same time looks to increase public access to the river. As a result, recreational use within the Study Area may increase at certain locations in the future.~~ The Willamette Greenway Plan addresses the quality of the natural and human environment along the Willamette River and generally includes all land adjacent to the river, public lands near the river, and land necessary for conservation of significant riparian habitat. (The Willamette Greenway Plan, adopted by City Council November 5, 1987, Ordinance 160237.) The Greenway Plan is intended to "protect, conserve, enhance, and maintain the natural, scenic, historical, economic, and recreational qualities of lands along Portland's rivers." (Portland City Code Chapter 33.440). The Plan supports industrial uses within Portland Harbor while at the same time looks to increase public access to the river. As a result, recreational use within the Study Area may increase at certain locations in the future.

~~The plan update may affect land use practices in Portland Harbor, but it will not affect the "Industrial Sanctuary" designation.~~

There are numerous potential human uses of Portland Harbor. Worker activities occur at the industrial and commercial facilities in the Study Area. However, due to the sparse beach areas and high docks associated with most of the facilities, worker exposure to the in-water portion of the Study Area may be limited in shoreline areas. Commercial diving activities also occur in the LWR.

In addition, the LWR provides many natural areas and recreational opportunities, both within the river itself and along the riverbanks. Within the Study Area, Cathedral Park, located under the St. Johns Bridge, includes a sandy beach area and a public boat ramp and is used for water skiing, occasional swimming, and waterfront recreation. Recreational beach use also may occur within Willamette Cove, which is a riverfront natural area, in Swan Island Lagoon, and on the southern end of Sauvie Island, which is within the Study Area. Swan Island Lagoon includes a public boat ramp. Additional LWR recreational beach areas exist on the northern end of Sauvie Island and in Kelley Point Park, both of which are outside of the Study Area.

Fishing is conducted throughout the LWR basin and within the Study Area, both by boaters and from locations along the banks. The LWR also provides a ceremonial and subsistence fishery for Pacific lamprey (particularly at Willamette Falls) and

spring Chinook salmon for Native American ~~tribes~~Tribes. Many areas in the LWR are also important currently for cultural and spiritual uses by local Native Americans.

Transients have been observed along the LWR, including some locations within the Study Area. The observation of tents and makeshift dwellings during RI sampling events confirms that transients were living along some riverbank areas. Transients are expected to continue to utilize this area in the future.

The RI/FS being completed for the Site is designed to be an iterative process that addresses the relationships among the factors that may affect chemical distribution, risk estimates, and remedy selection. Three rounds of field investigations have been completed as part of the RI/FS. Round 1 was conducted in 2002 and focused primarily on chemical concentrations in fish and shellfish tissue and in beach sediment. Round 2 was conducted in 2004 and 2005 and focused on chemical concentrations in sediment cores, in-water surface sediment, surface water, transition zone water, and additional shellfish tissue and beach sediment. Round 3 was conducted in 2006 and 2007 and focused on chemical concentrations in additional surface water, sediment, and fish and shellfish tissue. These Round 1, Round 2, and Round 3 sampling efforts, while initially focused on RM 3.5 to 9.2, which is the Administrative Order on Consent-defined initial study area (ISA), extended well beyond the ISA to RM 0 downstream and to RM 19 upstream.

1.4 ORGANIZATION

In accordance with guidance from EPA (1989), which is consistent with DEQ guidance (2000a, 2010), the BHHRA incorporates the four steps of the baseline risk assessment process: data collection and evaluation, exposure assessment, toxicity assessment, and risk characterization (which includes an uncertainty assessment).

This BHHRA is organized as follows:

- Section 2, Data Evaluation – This section evaluates the available data for the Study Area and identifies the COPCs for further evaluation in the BHHRA.
- Section 3, Exposure Assessment – This section presents potentially complete routes of exposure and potential receptor populations for further evaluation in the BHHRA, which are summarized in the conceptual site model (CSM).
- Section 4, Toxicity Assessment – This section evaluates the potential hazard and toxicity of the COPCs selected for quantitative evaluation in this BHHRA.
- Section 5, Risk Characterization – This section presents the cancer risks and noncancer hazards and identifies the ~~COCschemicals~~contaminants potentially posing unacceptable risks to human health.

- ~~Section 6, Screening of Surface and Transition Zone Water Data – This section presents an evaluation of surface water and transition zone water (TZW) data relative to screening levels and the results of the risk characterization presented in Section 5. This evaluation was conducted separately from the risk characterization, consistent with agreements with EPA.~~
- ~~Section 7~~Section ~~6~~6, Uncertainty Analysis – This section discusses the uncertainties that are inherent in performing a HHRA, and the uncertainties specific to this BHHRA.
- Section ~~8~~7, Summary – This section summarizes the findings of this BHHRA and identifies chemicals and pathways that contribute the majority of the risk ~~and identifies risk drivers; that is, those COCs with the highest contribution to estimated risks~~ within the Study Area.
- Section ~~9~~8, Conclusions – This section provides the conclusions for this BHHRA.
- Section ~~10~~9, References – This section lists the references used in this BHHRA.

2.0 DATA EVALUATION

Data collection and evaluation included the gathering and analysis of data relevant to human exposures and the identification of those contaminants that are the focus of this BHHRA. Data needs for the BHHRA were identified through the data quality objective (DQO) process described in Section 7 of the Programmatic Work Plan (Integral et al. 2004).

This section presents the data that were used in this BHHRA and the results of the selection of COPCs in sediment, water, and tissue. The LWG sampling events and non-LWG sampling events included in the site characterization and risk assessment (SCRA) dataset are described in detail in Section 2.0 of the RI Report. The BHHRA dataset used in this risk analysis and described in this section is a subset of data from the sampling events that comprised the SCRA dataset as of September 2008. Additional information on the BHHRA dataset and details on the use of the data in the BHHRA are provided in Attachment F2. In addition, a risk evaluation of potential exposures to polybrominated diphenyl ethers (PBDEs) in in-water sediment, fish tissue, and shellfish tissue was performed at the direction of EPA using a subset of data from the sampling events that comprised the SCRA dataset as of February 2011. The data for the PBDE analysis are discussed in Attachment F3, and the PBDE risk assessment used the general data evaluation methodology discussed in this section.

2.1 AVAILABLE DATA

The risk characterization BHHRA dataset includes only those matrices relevant for direct human health exposure pathways that were quantitatively evaluated: surface sediment (0 to 30.5 centimeter (cm) in depth), clam and crayfish tissue, fish tissue, surface water and groundwater seeps. ~~TZW data were used in loading calculations to estimate surface water concentrations that were compared with surface water screening levels, as presented in Section 6, but were not included in the risk characterization because there are no complete direct exposure pathways for humans to TZW.~~ Other matrices included in the SCRA dataset (e.g., subsurface sediment) were not evaluated in the BHHRA because they were not relevant to the exposure scenarios evaluated (see Section 3). Although the BHHRA focused on the Study Area, data from outside the Study Area, from downstream to RM 1.0, including Multnomah Channel, and upstream to RM 12.2, were also used to assess risk, per an agreement with EPA. The BHHRA dataset is divided into samples within the Study Area and outside of the Study Area, and summarized by matrix in Tables 2-1 and 2-2. The dataset is described briefly in the following subsections, and described in more detail in Section 2.0 of the RI Report.

2.1.1 Beach Sediment

Areas where potential exposure to beach sediment could occur were identified and designated as human use areas in the Programmatic Work Plan. Human use areas were designated based on current conditions. Beaches are relatively dynamic environments; if beach conditions change in the future, additional risk evaluation of the human use areas may be required. Composite sediment samples were collected during Round 1 from each beach that had been designated as a potential human use area within the ISA. Additional human use areas within the Study Area but downstream of the ISA were sampled during Round 2 as part of the sampling of shorebird habitat. All of the Round 1 beach samples and the six Round 2 beach samples that were collected from potential human use areas located downstream of the ISA were included in the BHHRA dataset. The designated potential human use areas and associated beach sediment samples are shown in Map 2-1. Table 2-3 presents a summary of the beach composite sediment samples included in the BHHRA dataset.

2.1.2 In-Water Sediment

In-water surface sediment chemistry data in the BHHRA dataset include LWG collected data (from Rounds 1, 2, and 3) and non-LWG collected data. Tables 2-3 and 2-4 present a summary of the surface sediment samples both within the Study Area and outside of the Study Area that are included in the BHHRA dataset. All non-LWG data included in the BHHRA dataset (see Section 2.0 of the RI Report) met the data quality requirements for risk evaluation (Category 1/QA2), as agreed to between LWG, EPA, and EPA's partners in the Programmatic Work Plan (Integral et al. 2004).

All in-water surface sediment data included in the BHHRA dataset were collected from the top 30.5 cm in depth, outside of the navigation channel of the river. Samples from within the Study Area were located throughout its entire length (RM 1.9 to RM 11.8), and samples outside of the Study Area extended downstream to RM 1.0, including Multnomah Channel, and upstream to RM 12.2. Surface sediment samples that were collected from areas that have been characterized in the SCRA as capped or dredged were not included in the BHHRA dataset because these samples are no longer representative of the current conditions in the Study Area. A more detailed description of the in-water sediment dataset used in this BHHRA is provided in Attachment F2; a description of samples that have been characterized as capped or dredged in the SCRA is provided in Appendix A of the RI Report.

2.1.3 Surface Water

Surface water data were collected by the LWG during Rounds 2 and 3, as described in Appendix A of the RI Report. All Round 2 and Round 3 surface water data between RM 1.9 and 11.8, as well as samples collected from

Multnomah Channel, were included in the BHHRA dataset. The use of the surface water dataset in evaluating different human exposure scenarios is discussed in subsequent sections and in Attachment F2. Surface water sampling was performed in seven separate events between 2004 and 2007 to capture the seasonal water flow conditions on the LWR. Tables 2-5 and 2-6 present a summary of the surface water samples included in the BHHRA dataset from within and outside of the Study Area.

Amongst all seven sampling events, 37 surface water locations were sampled between RM 1.9 and RM 11.8, and were included in the BHHRA dataset. Surface water samples in the BHHRA dataset were collected from 32 single point stations and 5 transect locations (at RM 2.0, Multnomah Channel, RM 3.9, RM 6.3, and RM 11). Surface water samples were collected with either a peristaltic pump or an XAD-2 Infiltrex™ 300 system (XAD). Single point samples included near-bottom and near-surface samples, as well as vertically integrated water column samples. Transect samples included horizontally integrated near-bottom and near-surface samples, cross-sectional equal discharge increment samples (i.e., samples horizontally integrated across the entire width of the river into a single sample for either near-surface or near-bottom horizontally integrated samples), and vertically integrated samples from the east, west, and middle sections of a transect on the river. Additional information on the surface water sampling methods is available in Section 5.3 of the RI Report.

2.1.4 Groundwater Seep

A seep reconnaissance survey was conducted during Round 1 to document readily identifiable groundwater seeps along approximately 17 miles of riverbank from RM 2 to 10.5 (GSI 2003). Twelve potential groundwater seeps were observed at or near a potential human use beach area. Of these, only three sites were identified where it was likely for upland ~~chemicals~~ contaminants of interest (COIs)[6] to reach groundwater seeps or other surface expressions of groundwater discharging to human use beaches (GSI 2003): City of Portland storm sewer Outfall 22B, Willbridge, and McCormick and Baxter (at Willamette Cove).

Of the three potential groundwater seep areas, only the Outfall 22B discharge was evaluated in this BHHRA. At this location, groundwater infiltrates into the outfall pipe, which subsequently discharges to a beach. The beach where Outfall 22B discharges was identified as a potential transient use area, so exposure to the groundwater seep in that beach by transients is considered a potentially complete pathway. The groundwater seep identified at Willbridge is in a beach restricted to industrial use, and exposure to groundwater seeps is considered an incomplete pathway for workers. The groundwater seep identified during the seep survey (GSI

[6] Prior deliverables and some of the tables and figures attached to this document may use the term "Chemicals of interest," which has the same meaning as "Contaminants of interest" and refers to "contaminants" as defined in 42 USC 9601(33).

2003) in Willamette Cove, downgradient of the McCormick and Baxter Superfund Site, was capped during remedial activities in 2004.

The stormwater pipeline that discharges at Outfall 22B provides a conduit for surface discharge of groundwater containing COIs that infiltrates into the pipe upland of the beach. Samples of the discharge at Outfall 22B have periodically been collected for analysis, both during stormwater events and outside of stormwater events. In order to represent potential exposure from the groundwater seep, samples taken during stormwater events were not included in the BHHRA dataset. The data from Outfall 22B met the data quality requirements for risk evaluation (Category 1/QA2), and the results of this sampling were included in the SCRA database. Samples taken since 2002 were used in the BHHRA. Table 2-5 presents a summary of the samples from Outfall 22B that were included in the BHHRA dataset. The BHHRA Outfall 22B dataset is further described in Attachment F2. The sampling events for this data are described in Appendix A of the RI Report.

2.1.5 Fish Tissue

Target fish species for human consumption were identified in the Programmatic Work Plan (Integral et al. 2004). Resident fish samples were collected during Rounds 1 and 3 by the LWG. In addition, adult white sturgeon (*Acipenser transmontanus*), adult spring Chinook salmon (*Oncorhynchus tshawytscha*), and adult Pacific lamprey (*Lampetra tridentate*) were collected in the summer of 2003 through a cooperative effort of the ODHS, Agency for Toxic Substances and Disease Registry (ATSDR), Oregon Department of Fish and Wildlife (ODFW), the City of Portland and EPA Region 10. (This sampling effort is referred to as the "ODHS Study" in the rest of this BHHRA). Table 2-7 presents a summary of the fish tissue samples included in the BHHRA dataset.

2.1.5.1 Resident Fish Tissue

Smallmouth bass (*Micropterus dolomieui*), black crappie (*Pomoxis nigromaculatus)*, common carp (*Cyprinus carpio carpio),* and brown bullhead (*Ameiurus nebulosus*) were the resident fish species collected and analyzed to support the BHHRA. The sampling design was based on the reported home ranges of the target fish, so the sampling approach differed based on species. For Round 1 data collection, the tissue compositing scheme for each sample was reviewed and approved by EPA in November and December 2002 prior to laboratory analysis. For Round 3 data collection, the tissue compositing scheme for each sample was reviewed and approved by EPA in October 2007 prior to laboratory analysis.

During Round 1, smallmouth bass samples were collected from eight locations between RM 2 and 9, each corresponding to approximately one river mile. Smallmouth bass were collected and composited based on river mile locations due to their small home range relative to the other fish collected during Round 1. Three whole body replicate composite samples were collected at three of the eight river mile

locations. At each of the remaining five river mile locations, one whole body composite sample and one fillet composite sample were collected. All Round 1 results from within the Study Area were included in the BHHRA dataset.

During Round 3, smallmouth bass were collected from 18 stations between RM 2 and 12, each corresponding to approximately one river mile, and either the west or east portion of the river. One composite sample was collected from each station, for which fillet tissue and remainder tissue (body without fillet) were analyzed separately. All Round 3 results were included in the BHHRA dataset.

During Round 1, black crappie, common carp, and brown bullhead samples were collected and composited for two fishing zones, each approximately three river miles in length (RM 3-6 and RM 6-9). Three whole body and three fillet replicate composite samples were collected at each of the two fishing zones for common carp and brown bullhead. Two whole body and two fillet replicate composite samples were collected within each of the fishing zones for black crappie. All Round 1 results from within the Study Area were included in the BHHRA dataset.

During Round 3, common carp samples were collected for three fishing zones, each approximately four river miles in length (RM 0-4, RM 4-8, and RM 8-12). Three common carp composite samples were collected from each fishing zone and analyzed separately as fillet tissue and remainder tissue. All Round 3 results were included in the BHHRA dataset.

For smallmouth bass, black crappie, and common carp, all fillet samples were analyzed as fillet with skin, except for the analysis of mercury, which was performed using fillet without skin. For brown bullhead, all fillet samples were analyzed as fillet without skin.

2.1.5.2 Salmon, Lamprey, and Sturgeon

The tissue data collected during the ODHS Study were the only non-LWG fish tissue data of acceptable data quality for risk evaluation (Category 1/QA2). Although these data were not collected as part of the RI, they were evaluated by the LWG and used in this BHHRA.

The adult Chinook salmon samples were collected at the Clackamas fish hatchery. Whole body, fillet with skin, and fillet without skin composite samples were analyzed. Each composite sample included three individual fish. Five whole body composite samples, including one split, three fillet with skin, and three fillet without skin composite samples were analyzed. The fillet without skin composite samples were only analyzed for dioxin, furan, and polychlorinated biphenyl (PCB) congeners and mercury.

The adult Pacific lamprey samples were collected at the Willamette Falls. Only whole body composite samples were analyzed. Each composite sample included 30 individual fish. Four whole body composite samples were analyzed.

The adult sturgeon samples were collected between RM 3.5 and 9.2. Only fillet without skin samples were analyzed. Each sample was an individual fish. Six fillet samples, including one split, were analyzed.

2.1.6 Shellfish Tissue

Shellfish tissue in the BHHRA dataset included field-collected samples for crayfish and clam (*Corbicula* sp.) tissue. Crayfish samples were collected during Rounds 1 and 3 and clam samples were collected during Rounds 1, 2, and 3. Although data from laboratory bioaccumulation samples were also available from Round 2, these data were not used because field-collected tissue samples provide for a more direct evaluation of potential human exposure than laboratory bioaccumulation samples. No field-collected, non-LWG shellfish tissue data of acceptable data quality for risk evaluation (Category 1/QA2) were identified. Tables 2-7 and 2-8 present a summary of the shellfish tissue samples included in the BHHRA dataset, from both inside and outside the Study Area, respectively.

For crayfish, samples were collected from 24 stations during Round 1. The Round 1 crayfish stations were selected based on habitat areas. Crayfish were collected from 9 stations during Round 3. The Round 3 crayfish stations were based on data needs identified by the EPA and habitat areas. Crayfish were collected and composited from individual stations commensurate with their limited home ranges. Only whole body composite samples were collected for crayfish. During Round 1, two replicate composite samples were collected at three of the 24 stations. At each of the remaining stations, a single composite sample was collected. During Round 3, a single composite sample was collected at each station.

For clams, samples were collected from 3 stations during Round 1, 33 stations during Round 2, and 10 stations during Round 3. Clams were collected and composited from individual stations that were selected based on habitat areas and biomass availability. A single composite sample was collected at each station in Rounds 1 and 2. In Round 3, two composite samples were collected from each of five stations, and a single composite sample was collected from each of the remaining five stations. Depuration is a common method for cleansing shellfish that is often done prior to human consumption to eliminate the sediment present in the gastrointestinal (GI) tract of the shellfish. The Round 1 and Round 2 field-collected clams were not depurated prior to analysis, and the data therefore may over predict human health risks from this exposure pathway for consumers that do depurate clams prior to consumption. In Round 3, five samples were depurated prior to analysis (depurated samples were from stations where two samples were

collected; one sample from each Round 3 station was not depurated). Additional discussion of the potential effects of depuration on human health risks is included in ~~Section 7~~Section 6. All LWG field-collected clam samples were included in the BHHRA dataset.

~~2.1.7 Transition Zone Water~~

~~TZW data consist of pore water samples that were collected by the LWG during Rounds 2 and 3. TZW sampling was performed between October 3 and December 2, 2005, to capture the relatively higher groundwater discharge to the LWR. In addition, non-LWG data from the Siltronic Supplemental In-River transition zone water sampling, which was performed in May and June of 2005, met the acceptable data quality for risk evaluation (Category 1/QA2). All shallow (0 to 38 cm) TZW data, both filtered and unfiltered, were included in the BHHRA dataset for purposes of the screening evaluation presented in Section 6. Table 2-9 presents a summary of the shallow TZW samples included in the BHHRA dataset.~~

~~The LWG TZW sampling locations were selected to focus primarily on the zones of possible groundwater plume discharge, based on the Round 2 groundwater pathway assessment pilot study discharge mapping effort conducted from August 1 to September 9, 2005 (Integral 2006). Nine high-priority Category A sites, defined as sites with a confirmed or reasonable likelihood for discharge of upland groundwater COIs to Portland Harbor, were selected as TZW locations and sampled within the Study Area. TZW samples were collected from the following nine sites: Kinder Morgan Linnton Terminal, ARCO Terminal 22T, ExxonMobil Oil Terminal, Gasco, Siltronic, Rhone-Poulenc, Arkema (acid plant and chlorate plant areas), Willbridge Bulk Fuels Terminal, and Gunderson. LWG TZW samples were collected with either a Trident® probe or small-volume peeper.~~

2.2 USE OF DATA

Prior to using the data in the BHHRA, data reduction was conducted consistent with the Guidelines for Data Reporting, Data Averaging, and Treatment of Non-Detected Values for the Round 1 Database (Kennedy/Jenks Consultants et al. 2004), the Exposure Point Concentration Calculation Approach and Summary of Exposure Factors (Kennedy/Jenks Consultants 2006), and Proposed Data Use Rules and Data Integration for Baseline Human Health Risk Assessment (BHHRA), submitted to EPA in a May 28, 2008 email communication with EPA. Data reduction and data use rules applied to the combining of surface water data collected by different methods, the handling of non-detects, the summing of chemical groups, and the calculation of exposure point concentrations (EPCs). These rules are described in detail in Attachment F2.

2.3 CHEMICAL SCREENING CRITERIA

EPA guidance (1989) recommends considering criteria to limit the number of chemicals that are included in a quantitative risk assessment while also ensuring that all contaminants~~chemicals~~ that may contribute significantly to the overall risk are addressed. According to EPA guidance, the screening procedure is used to focus quantitative risk assessment efforts on contaminants ~~chemicals~~ that could be of concern under health-protective exposure assumptions. For purposes of the BHHRA, the only screening criterion used to select COPCs was a comparison with risk-based concentrations, as described in the Programmatic Work Plan (Integral et al. 2004). ~~Frequency of detection was not used as a screening criterion per an agreement with EPA.~~ The risk-based concentrations used to select COPCs are described below for the respective BHHRA media. When specified below, COPCs were selected for a medium based on a subset of data determined to represent exposure to a specific human population. Potentially exposed human populations are discussed as part of the exposure assessment in Section 3, and include but are not limited to: transients, divers, recreational beach users, and fishers.

2.3.1 Sediment

Sediment data were quantitatively evaluated in the BHHRA for direct exposure scenarios. As a health-protective initial approach, the current EPA Regional Screening Levels (RSLs) for soil (EPA ~~2009a~~2010a) were used as the basis for screening values for sediment. For chemicals that do not have EPA RSLs, EPA RSLs for surrogate chemicals with similar chemical structures were used if available (e.g., pyrene for phenanthrene). As required by EPA Region 10 (see e-mail from Dana Davoli to Laura Kennedy, October 17, 2008, in Attachment F1), for trichloroethylene, the geometric mid-point of the slope factor range from EPA 2001 (0.089 per mg/kg-day) was used for evaluating cancer risks for both inhalation and oral exposures. This value was also used to calculate an acceptable soil screening level of 7.7 mg/kg.~~As required by EPA Region 10 (EPA 2007a), the EPA Region 6 Human Health Medium-Specific Screening Levels for trichloroethylene (EPA 2008a), rather than the EPA RSLs, were used in this BHHRA.~~

For carcinogenic chemicals, the EPA RSLs were used as the screening values. For noncarcinogenic chemicals, the EPA RSLs were divided by 10 to account for potential cumulative effects from multiple chemicals, as required by EPA Region 10 (2007a), and these modified RSLs were used as the screening values~~, with the exception of EPA RSLs noted as being based on "max" or "sat". For the EPA RSLs noted as being based on "max" or "sat", the expanded tables were referenced to compare the integrated risk-based soil concentrations to the EPA RSLs listed in the primary screening table. The concentration used was the lower of the concentrations of the EPA RSL listed in the primary screening table and the~~

~~integrated risk-based concentration divided by 10.~~ . For chemicals that exhibit both carcinogenic and noncarcinogenic effects, the lower screening value was used for selecting COPCs.

EPA RSLs have been developed for both residential and industrial exposure scenarios for soil. Residential soil EPA RSLs are based on exposure assumptions of 350 days per year. For cancer endpoints, the residential EPA RSLs are calculated using an age-adjusted soil ingestion factor that takes into account the difference in daily soil ingestion rates, body weight, and exposure duration for children from 1 to 6 years old and others from 7 to 31 years old (total exposure over 30 years). For noncancer endpoints, the residential EPA RSLs are calculated using exposure factors for children from 1 to 6 years old and chronic toxicity criteria. Industrial soil EPA RSLs are based on exposure assumptions of 250 days per year for 25 years. Both residential and industrial EPA RSLs are based on a target cancer risk of 1×10^{-6} for carcinogenic chemicals or a hazard quotient of 1 for noncarcinogenic chemicals. Dividing EPA RSLs for noncarcinogenic chemicals by 10 is equivalent to using a hazard quotient of 0.1. Because the potential exposure to sediments that may occur is anticipated to be less than the exposure that was assumed to occur with soil in developing the EPA RSLs, the soil RSLs represent conservative screening values for protection of human health. Because uses of Portland Harbor include both recreational and industrial activities, COPCs were selected using both residential and industrial EPA RSLs, consistent with the EPA comments on the Round 2 Comprehensive Report provided on January 15, 2008 (EPA 2008b).

For beach sediment, residential soil EPA RSLs were used to select COPCs in areas where exposures could occur during recreational, transient, or fishing activities. In areas where occupational exposures could occur, COPCs were selected using industrial soil EPA RSLs. The designated potential uses for beaches in the Study Area are presented in Map 2-1.

The extent of direct contact (i.e., ingestion and dermal contact) with in-water sediment that could occur under site-specific exposure scenarios would be significantly less than with upland soil or beach sediment. Therefore, COPCs for in-water sediment were identified using only the industrial soil EPA RSLs.

2.3.2 Surface Water and Groundwater Seep

Surface water and groundwater seep data were quantitatively evaluated in the BHHRA for direct exposure scenarios. A discussion of potential sources of contaminants to surface water is provided in the RI. As a health-protective initial approach, EPA RSLs for residential tapwater (EPA ~~2009a~~2010a) were used as the screening values for surface water and the groundwater seep to select COPCs for direct exposure scenarios. For chemicals that do not have EPA RSLs, EPA RSLs for surrogate chemicals with similar chemical structures were used if available (e.g.,

pyrene for phenanthrene). As required by EPA Region 10 (EPA 2007a), the EPA Region 6 Human Health Medium-Specific Screening Levels for trichloroethylene (EPA 2008a), rather than the EPA RSLs, were used in this BHHRA. For carcinogenic chemicals, the EPA RSLs were used as the screening values. For noncarcinogenic chemicals, the EPA RSL was divided by 10 to account for potential cumulative effects from multiple chemicals, and this modified EPA RSL was used as the screening value, as required by EPA Region 10.

Residential tapwater EPA RSLs are based on domestic use of water, including ingestion, and represent conservative screening values for direct contact scenarios where water may not be used for domestic purposes, such as surface water contact during beach recreation. EPA RSLs are based on a target cancer risk of 1×10^{-6} for carcinogenic chemicals or a hazard quotient of 1 for noncarcinogenic chemicals. Dividing EPA RSLs for noncarcinogenic chemicals by 10 is equivalent to using a hazard quotient of 0.1.

2.3.3 Tissue

EPA Region 10 has not accepted any criteria for screening tissue from Portland Harbor; therefore, per an agreement with EPA, risk-based concentrations were not used for screening the tissue data, and all chemicals detected in fish and shellfish in the BHHRA dataset were selected as COPCs for tissue.

2.3.4 Hypothetical Future Exposure to Untreated Surface Water fFor Domestic Use

Even though no current or future uses of the LWR within Portland Harbor as a domestic water source have been identified, under OAR 340-041-0340 Table 340A, domestic water supply is a designated beneficial use of the Willamette River, with adequate pretreatment. Because the Willamette River is capable of serving as a potential drinking water source, the expectation is that this resource will be protected to achieve such use with adequate pretreatment. Although surface water within the Study Area is not currently used as a domestic water source, nor are there future plans for domestic water use within the Study Area, surface water data were quantitatively evaluated in the BHHRA as a hypothetical future domestic water source at the direction of EPA (see Section 2.4.5 below). The same criteria and screening values used for data to assess direct contact with surface water and the groundwater seep were used to select COPCs for surface water as a hypothetical future domestic water source. As with the surface water and groundwater seep screening, the noncarcinogen RSLs were divided by 10 to account for potential multiplicative effects, and the modified RSLs were used as the screening values.

In addition to the EPA RSLs, EPA maximum contaminant levels (MCLs) for drinking water (EPA 2003a) were used as screening criteria for the selection of COPCs for the hypothetical future use of untreated surface water for domestic purposes. If the

maximum detected concentration for a contaminant ~~chemical~~ in the dataset selected to represent hypothetical exposure to untreated surface water for domestic use exceeded either the EPA RSL or the EPA MCL, the contaminant ~~chemical~~ was selected as a COPC for this scenario.

2.4 IDENTIFICATION OF ~~CHEMICALS~~ CONTAMINANTS OF POTENTIAL CONCERN

COPCs for human health were selected according to the approach described in the Programmatic Work Plan (Integral et al. 2004) using the screening criteria described in Section 2.3 and were quantitatively evaluated in this BHHRA. The process used to select the COPCs for quantitative evaluation in this BHHRA is described in the following subsections.

~~Also, surface water and transition zone water data were compared with additional screening criteria but were not quantitatively evaluated in this BHHRA for the scenarios associated with the screening criteria, per an agreement with EPA. The screening evaluation of surface water and transition zone water is described in Section 6.~~

2.4.1 Sediment

Humans can be exposed to both beach sediment and in-water sediment. Because the exposure scenarios for beach versus in-water sediment are different, COPCs were selected for both beach and in-water sediment exposures.

2.4.1.1 Beach Sediment

Beach sediment data were evaluated in the BHHRA for potential risks to human health through direct contact. The selection of COPCs for beach sediment evaluated sediment data from potential human use areas where direct contact with human receptors could occur (only reasonably accessible beach sediments, such as those with access from contiguous upland areas or by boat). The locations of the beach sediment data evaluated in the BHHRA are shown in Map 2-1.

For contaminants that were detected in beach sediment, the detected concentrations were compared to risk-based screening levels described in Section 2.3.1. The maximum detected concentration of each contaminant ~~chemical~~ from all samples collected in recreational, transient, or fishing beach areas was compared to the screening level based on the residential soil EPA RSL. The maximum detected concentration of each ~~chemical~~ contaminant from all samples collected in industrial beach areas was compared to the screening level based on the industrial soil EPA RSL. If the maximum detected concentration of a ~~chemical~~ contaminant was greater than the screening level, that ~~chemical~~ contaminant was selected as a COPC for beach sediment. The contaminants ~~chemicals~~ selected as COPCs for beach sediment and the rationale for selection are presented in Tables 2-~~10~~ 9 and 2-~~11~~10.

ContaminantsChemicals selected as COPCs for beach sediment were quantitatively evaluated in this BHHRA. ContaminantsChemicals with maximum detected concentrations less than the screening values were not selected as COPCs and were not evaluated further in this BHHRA for direct contact with beach sediment.

2.4.1.2 In-Water Sediment

In-water sediment data were evaluated in the BHHRA for potential risks to human health through direct contact and not based on the potential for bioaccumulation. The potential for bioaccumulation is evaluated separately in this BHHRA as part of the fish and shellfish tissue assessments. The selection of COPCs for in-water sediment evaluated all surface sediment data in the BHHRA dataset within the Study Area, excluding the navigation channel and beach composite samples. The sample locations of the in-water sediment data evaluated in the BHHRA are shown in Map 2-2.

For chemicals that were detected in in-water sediment, the maximum detected concentration of each chemical from surface sediment samples was compared to the screening level based on the industrial soil EPA RSL, as described in Section 2.3.1. If the maximum detected concentration of a chemical contaminant was greater than the screening level, that chemical was selected as a COPC for in-water sediment. The contaminants chemicals selected as COPCs for in-water sediment and the rationale for selection are presented in Table 2-1211.

Contaminants Chemicals selected as COPCs for in-water sediment were quantitatively evaluated in this BHHRA. Chemicals with maximum detected concentrations less than the EPA RSLs were not selected as COPCs and were not evaluated further in this BHHRA for direct contact with in-water sediment.

2.4.2 Surface Water

Direct contact with surface water was evaluated in the BHHRA for potential risks to human health. The selection of COPCs for quantitative evaluation in the BHHRA in surface water was based only on potential for direct human contact and not based on the potential for bioaccumulation. The potential for bioaccumulation is evaluated separately in this BHHRA as part of the fish and shellfish tissue assessments. Surface water data gathered during the RI were used to identify the COPCs in surface water for quantitative evaluation in the BHHRA. Because the exposure scenarios for divers are different from those of transients and beach users, COPCs were selected separately for both divers and transient/beach user exposures. For divers, COPCs were selected from all available surface water samples taken within the Study Area, as described in Section 2.1.3. Near-bottom and near-surface sample results, as well as vertically integrated transect results, were combined according to the rules described in Attachment F2 prior to selecting COPCs. For transients and beach users, COPCs were selected from surface water samples taken from areas where direct contact with transient or beach users could occur, including both single point

sampling stations where vertically integrated samples were collected and transect samples. This included one sample from Swan Island Lagoon. A summary of samples used for each surface water COPC screening is provided in Table 2-~~13~~12. In addition, the sample locations of the surface water data evaluated for transients and recreational beach user exposure scenarios are shown in Map 2-3. The sample locations of the surface water data evaluated for diver exposures are shown in Map 2-4.

For chemicals that were detected in each surface water dataset, the detected concentrations were compared to screening values based on the residential tapwater RSLs. If the maximum detected concentration of a ~~chemical~~ contaminant in surface water was greater than the screening value, that ~~chemical~~ contaminant was selected as a COPC for surface water and was quantitatively evaluated in the BHHRA. Chemicals that were detected only at concentrations less than the RSLs were not selected as COPCs for quantitative evaluation. The contaminants ~~chemicals~~ selected as COPCs for surface water and the rationale for selection are presented in Table 2-~~14~~ 13 for divers, and Table 2-~~15~~ 14 for transients and beach users.

2.4.3 Groundwater Seep

Direct contact with the groundwater seep at Outfall 22B, shown in Map 2-5, was evaluated in the BHHRA for potential risks to human health. The selection of COPCs for quantitative evaluation in the BHHRA was based only on potential for direct human contact with the groundwater seep, and not based on the potential for bioaccumulation.

For chemicals that were detected in the groundwater seep, the detected concentrations were compared to screening values based on the residential tapwater EPA RSLs. If the maximum detected concentration of a contaminant ~~chemical~~ in the groundwater seep was greater than the screening value, that contaminant ~~chemical~~ was selected as a COPC for the groundwater seep and was quantitatively evaluated in the BHHRA. Chemicals that were detected only at concentrations less than the EPA RSLs were not selected as COPCs for quantitative evaluation. The contaminants ~~chemicals~~ selected as COPCs for the groundwater seep and the rationale for selection are presented in Table 2-~~16~~15.

2.4.4 Fish and Shellfish Tissue

Fish and shellfish tissue were evaluated in the BHHRA for potential risks to human health through ingestion. Because EPA Region 10 has not accepted any criteria for screening tissue from Portland Harbor, all chemicals detected in fish and shellfish tissue in the BHHRA dataset were considered to be COPCs and evaluated further in the BHHRA. Map 2-6 shows the general location of all fish for a particular composite of the smallmouth bass and common carp tissue data evaluated for ingestion scenarios in this BHHRA. Samples for brown bullhead and black crappie

were each composited for RM 3-6 and RM 6-9, and are not shown on a map. The sample locations of the shellfish tissue data (both crayfish and clam) evaluated for ingestion scenarios are shown in Map 2-7. Shellfish were also composited over areas representing their assumed home range, and the sample locations on Map 2-7 represent the general spatial distribution of composited samples. The contaminants ~~chemicals~~ detected in each individual species were selected as COPCs only for ingestion of that species. For the multi-species diet scenarios (discussed in Section 3), analytes detected in any of the target resident fish species (see Section 2.1.5) were selected as COPCs. Since no screening took place to determine COPCs for tissue, the tissue COPCs are presented in the exposure point concentration summary tables, discussed in Section 3.

2.4.5 Hypothetical Future Exposure to Untreated Surface Water ~~For~~ for Domestic Use

There is no known current or anticipated future use of surface water within the Study Area for a drinking water supply. Even though no current or future uses of the LWR within Portland Harbor as a domestic water source have been identified, under OAR 340-041-0340 Table 340A, domestic water supply is a designated beneficial use of the Willamette River, with adequate pretreatment. Because the Willamette River is capable of serving as a potential drinking water source, the expectation is that this resource will be protected to achieve such use with adequate pretreatment. Potential sources of contaminants to surface water are discussed in the RI. ~~Even in the unlikely event that surface water in the Study Area were to be used for a domestic water supply, which includes drinking and bathing, such use would be subject to requirements for adequate pretreatment in accordance with the Safe Drinking Water Act, and Oregon rules. However, for this BHHRA, EPA required assessment of domestic uses of untreated surface water from the Study Area.~~Because future use of the LWR as a domestic water supply would require adequate pretreatment, the evaluation of untreated surface water as a drinking water source is designated a hypothetical scenario. The inclusion of the assessment of domestic use of untreated surface water from the Study Area was done at the direction of EPA.

Surface water as a hypothetical future domestic water source was evaluated in the BHHRA for potential risks to human health. The selection of COPCs for quantitative evaluation in the BHHRA in surface water was based only on potential for hypothetical contact from domestic uses, and not based on the potential for bioaccumulation. The potential for bioaccumulation is evaluated separately in this BHHRA as part of the fish and shellfish tissue assessments. Surface water data gathered during the RI were used to identify the COPCs for quantitative evaluation in the BHHRA. ~~Vertically integrated and combined transect samples collected by the LWG within the Study Area were used to select COPCs for hypothetical future domestic water exposure.~~ At the direction of EPA, results from surface water samples collected near-bottom and near-surface within the water column were combined according to the rules described in Attachment F2. The combined near-

bottom and near-surface samples, vertically integrated single point samples, and vertically integrated transect samples were used to select the COPCs. These samples are presented in Table 2-~~13~~12, and shown in Map 2-8. Filter and column data collected from samples collected by XAD were combined before selection of COPCs, according to the rules described in Attachment F2. No further data reduction was performed on the hypothetical future domestic water dataset prior to COPC selection.

For chemicals that were detected in this dataset, the detected concentrations were compared to screening values based on the RSLs for tap water and on EPA MCLs for drinking water (EPA 2003a). If the maximum detected concentration of a contaminant ~~chemical~~ in surface water was greater than either of the screening values, that ~~chemical~~ contaminant was selected as a COPC for surface water and was quantitatively evaluated in the BHHRA. Chemicals that were detected only at concentrations less than both screening values were not selected as COPCs for quantitative evaluation. The maximum detected concentration did not exceed the MCL for any chemical (Table 2-~~17~~16). Maximum concentrations exceeded other RSLs [~~(~~e.g., tap water screening levels for arsenic and 2-(4-Chloro-2-methylphenoxy)propanoic acid (MCPP)~~]~~). The contaminants ~~chemicals~~ selected as COPCs for surface water as a hypothetical domestic water source, and the rationale for selection, are presented in Table 2-~~17~~16.

3.0 EXPOSURE ASSESSMENT

The objectives of the exposure assessment are to identify potential exposure pathways for individuals who may come in contact with COPCs at the Study Area, to characterize potentially exposed populations, and to estimate the extent of exposure.

The exposure assessment in this BHHRA followed EPA guidance and incorporated the reasonable maximum exposure (RME) methods recommended by EPA. As stated in EPA guidance (EPA 1989), the RME is a conservative exposure level that is still within the range of possible exposures. The exposure assessment also used average values, which represent central tendency (CT) exposures, for some exposure scenarios. According to EPA (1989), an exposure assessment includes four primary tasks:

- Identify potentially exposed human populations that may come in contact with the COPC. This requires knowledge of (and/or making reasonable assumptions regarding) both current and future populations.
- Identify relevant exposure pathways for human populations by which potentially exposed populations may contact environmental media containing COPCs.
- Estimate EPCs at the points of potential human contact for all identified COPCs.
- Estimate daily intakes for exposure routes and potentially exposed populations. The daily intakes are derived using the EPCs and assumptions regarding such variables as exposure duration, consumption rates, skin absorption factors, and other parameters that describe human activities.

The exposure assumptions and methods for each task included in the exposure assessment are discussed below.

3.1 IDENTIFICATION OF POTENTIALLY EXPOSED HUMAN POPULATIONS

Potentially exposed and hypothetically exposed populations were identified based on consideration of current, future, and hypothetical future uses of the Study Area and EPA (1989) guidance. A pathway analysis for the Study Area is detailed in the Portland Harbor RI/FS Programmatic Work Plan (Integral 2004). The human populations identified below represent those populations that are anticipated to be maximally-exposed to contaminants ~~chemicals~~ within the Study Area under current and reasonably foreseeable or hypothetical future conditions. The evaluation performed for the selected populations is considered to be protective of other potentially exposed populations that are not evaluated quantitatively in this BHHRA. The populations for current, future, and hypothetical future uses of the Study Area include the following:

- Dockside worker
- In-water worker
- Transient
- Diver
- Recreational beach user
- Non-tribal Fisher
- Tribal fisher
- ~~Hypothetical d~~Domestic water user

The above populations were identified based on human activities that are known to occur within the Study Area, as described in the Programmatic Work Plan, or were required by EPA for evaluation in this BHHRA. Divers, clam consumption by fishers, and ~~hypothetical~~ domestic water user were included in this BHHRA as required by EPA. Infant consumption of human milk was included as a complete exposure pathway for all adult receptor populations that were assessed quantitatively for bioaccumulative chemicals (i.e., PCBs, dioxin/furans, and DDX), as required by EPA.

Potential risks were quantified for each of the receptor populations; however, certain individuals may participate in activities resulting in potential exposures under more than one category (e.g., recreational beach users may also be fishers). Potentially overlapping exposures are discussed in Section 3.3.7 of this BHHRA.

This BHHRA focused on potential exposures occurring within and immediately upstream and downstream of the Study Area in quantifying potential risks to humans.

Except for the hypothetical future exposure to untreated surface water for domestic water users, the exposure assessment assumes that future land and water use will be the same as current land use; therefore, the risks characterized are based only on current use. If land or water use changes in the future, exposures and risk may also change.

3.2 IDENTIFICATION OF EXPOSURE PATHWAYS

Exposure pathways are defined as the physical ways in which chemicals may enter the human body (e.g., ingestion, inhalation, dermal absorption). A complete exposure pathway consists of the following four elements:

- A source of chemical release
- A release or transport mechanism (or media in cases involving media transfer)

- An exposure point (a point of potential human contact with the contaminated exposure medium)
- An exposure route (e.g., ingestion, dermal contact) at the exposure point.

If any of the above elements is missing, the pathway is considered incomplete and exposure does not occur.

As discussed in Sections 4, 5, and 6 of the RI Report, the affected media within the Study Area are sediment, water, and biota. Current and historical industrial activities and processes within, upstream and downstream of the Study Area may have led to chemical releases from either point or nonpoint sources to the Study Area. In addition to these releases, discharges to the river from outfalls and groundwater may be potential ~~chemical~~ contaminant sources to the Study Area. Finally, releases that occur upstream and downstream of the Study Area and global, regional, and local emissions resulting in atmospheric deposition may be potential sources to the Study Area. These potential sources and release mechanisms are discussed in greater detail in Section 4 of the RI Report.

Chemicals in sediment and water may be accumulated by organisms in the water column or associated with the sediments. Edible fish and shellfish species feeding on these organisms and living within the Study Area may accumulate chemicals in their tissues through dietary exposures and direct exposure to sediment and water. The potential exposure pathways to human populations at the Study Area include:

- Ingestion of and dermal contact with beach sediment
- Ingestion of and dermal contact with in-water sediment
- Ingestion of and dermal contact with surface water
- Ingestion of and dermal contact with groundwater seep
- Ingestion of fish and shellfish~~.~~
- Infant consumption of human milk.

Section 3.~~2.1~~3 provides a more detailed discussion of potential exposures for the Study Area under current, reasonably foreseeable and hypothetical future conditions, and presents the rationale for including or eliminating pathways from quantitative evaluation. The identified receptors, exposure routes, and exposure pathways, and the rationale for selection are also summarized in Table 3-1.

3.2.1 Definition and Significance of Exposure Pathways

Exposure pathways are designated in one of the following four ways:

Potentially Complete: There is a source or release from a source, an exposure point where contact can occur, and an exposure route by which contact can occur. Pathways considered potentially complete are quantitatively evaluated in this BHHRA.

Potentially Complete and Insignificant: There is a source or release from a source, an exposure point where contact can occur, and an exposure route by which contact can occur; however, the pathway is considered a negligible contributor to the overall risk. Pathways considered potentially complete and insignificant were not evaluated further in this BHHRA.

Incomplete: There is no source or release from a source, no exposure point where contact can occur, or no exposure route by which contact can occur for the given receptor. Pathways considered potentially incomplete were not evaluated further in this BHHRA.

Potentially complete pathway, but evaluated under a different receptor category: These pathways may be complete for individuals in this receptor category due to overlapping exposure scenarios (e.g., some in-water workers may also be fishers), but are not evaluated for the identified receptor category because the pathways are not considered relevant for that receptor. These pathways are evaluated under different receptor categories where the pathways are considered potentially complete and significant. Overlapping exposures that may occur for the different receptor categories are discussed further in Section 3.3.7 of this BHHRA.

3.2.2 Conceptual Site Model

The conceptual site model (CSM) for human exposures based on the current understanding of the Study Area and requirements from EPA is presented in Figure 3-1. The CSM graphically depicts possible sources of COPCs based on current information, possible COPC-affected media, mechanisms of COPC transfer between media, and the processes through which human receptors may be exposed to chemicals. Additional information on potential sources of COPCs is provided in Section 5 of the RI Report. Potentially complete exposure pathways were identified in the Programmatic Work Plan or based on subsequent requirements from EPA. In-water workers exposure to river sediment, transients exposure to shoreline seeps, divers exposure to surface water and in-water sediment, infant exposure via consumption of human milk for all receptors with bioaccumulative COPCs, and hypothetical future exposures of ~~residents~~ domestic water users to surface water were included as potentially complete pathways per requirements from EPA. Pathways that are potentially or hypothetically complete and may result in significant exposure, or for which significance is unknown, were evaluated quantitatively in this BHHRA, per direction from EPA. Pathways included at the direction of EPA include clam consumption, exposure to surface water and in-water sediment by a commercial

diver, and hypothetical exposure to untreated surface water ~~as domestic water source~~ by a ~~hypothetical future resident~~domestic water user.

3.3 EXPOSURE SCENARIOS

The following sections provide a detailed discussion of the exposure scenarios that are quantitatively evaluated in this BHHRA. The following exposure scenarios were identified based on exposures that may generically occur throughout the Study Area and do not consider site-specific conditions that may limit exposure at a given location.

3.3.1 Direct Exposure to Beach Sediment

Ingestion of and dermal contact with beach sediment could occur within natural river beach areas used by human populations within the Study Area. These areas were identified as human use areas in the Programmatic Work Plan based on current and future uses within the Study Area. Human use areas were further classified based on the type of exposures that could occur at these beaches including recreational, fishers, tribal fishers, transient, or dockside worker use areas. These classifications are described in greater detail below. The human use areas in the Study Area and their associated classifications are shown in Map 2-1.

3.3.1.1 Dockside Workers

Dockside workers include industrial and commercial workers at facilities adjacent to the river who conduct specific activities within natural river beach areas, such as unloading ships or barges from the beach itself or conducting occasional maintenance activities from the water's edge. The actual activities that occur within natural river beach areas are site-specific and generally occur only very infrequently. Although exposure is anticipated to be infrequent, workers conducting activities within natural river beach areas may contact beach sediment within riverfront industrial and commercial sites at the Study Area. Exposure for a given worker would occur only within the defined dockside worker use area adjacent to the facility of that worker.

3.3.1.2 Transients

During past site tours, tents and makeshift dwellings were observed as evidence that individuals were occupying some riverbank areas. While the tents and makeshift dwellings were typically observed above the actual beach areas, transients may contact beach sediment within transient use areas, which are beach areas that are not active industrial sites and are not otherwise restricted from access. Although transients are anticipated to move throughout the Study Area, some may spend a majority of their time at relatively few of the possible areas. Exposure for a given transient ~~would~~ was evaluated in this BHHRA on the basis of ~~likely occur only within~~ a single transient use area, although it is possible that transients move from one transient use area to others within or outside the Study Area. This BHHRA presented

an evaluation of individual use areas not only because transients may inhabit single beach areas, but also because such an evaluation provides a range of possible risks for individuals that either move frequently or remain at a single location.

3.3.1.3 Recreational Beach Users

Both adults and children participate in recreational activities in beach areas within the Study Area. Areas currently used for recreational beach activities, as well as other areas in the Study Area where sporadic beach use may occur were identified as recreational use areas. Recreational beach users may contact beach sediment within recreational use areas at the Study Area. Some recreational beach users may primarily use a specific recreational use area while other recreational beach users may use various recreational use areas throughout and outside the Study Area.

3.3.1.4 Tribal Fishers

The LWR provides a ceremonial and subsistence fishery for Native American tribes. The extent to which tribal members fish within the Study Area, as well as the extent to which that fishing occurs from beach areas and the degree of sediment exposure that might occur while fishing are unknown. However, exposure assumptions provided by EPA were used to evaluate beach sediment exposure by tribal fishers.

3.3.1.5 Non-tribal Fishers

Fishers who fish from the water's edge within natural river beach areas could have direct exposure to beach sediment. In theory, fishing could occur at any beach area without restricted access. Therefore, all non-dockside worker use areas (i.e., all transient and recreational use areas) were considered potential human use areas where fishers could be exposed to beach sediment. Some fishers may primarily use a specific beach area for fishing activities while other fishers may use beach areas throughout and outside the Study Area.

For beach sediment exposure, two different fisher scenarios were included in this BHHRA to evaluate differences in the frequency of fishing activities. High-frequency fishers were assumed to fish recreationally, and at more frequent intervals than the low-frequency fisher (exposure frequency of 156 days per year for high frequency fishers compared to 104 days per year for low-frequency fishers). The extent to which fishing from beach areas actually occurs is unknown, as is the degree of sediment exposure that might occur while fishing.

3.3.1.6 Potentially Complete and Insignificant Exposure Pathways

This BHHRA did not identify any potentially complete and insignificant exposure pathways for beach sediment exposure.

3.3.1.7 Incomplete Exposure Pathways

Beach sediment exposures are considered incomplete exposure pathways for both in-water workers and divers based on the defined activities of these receptor populations in this BHHRA. In-water workers are those workers who conduct over water activities and thus are not directly exposed to beach sediments. Dockside workers are the worker population for which beach sediments exposures are considered potentially complete and were evaluated in this BHHRA. Divers conduct activities in the river that do not result in beach sediment exposures. The hypothetical future domestic water use scenario evaluates use of surface water for domestic water supply and thus beach sediment exposures were considered incomplete exposure pathways for this receptor population.

3.3.2 Direct Exposure to In-Water Sediment

Ingestion of and dermal contact with in-water sediment could occur through over-water activities (i.e., activities conducted from a boat or other vessel) that result in bringing sediment to the river's surface where exposure would be possible. Unlike the beach sediment exposure scenarios that are restricted to specific beach areas, potential exposure to in-water sediment could occur anywhere that over-water activities occur. As a result, direct exposure to in-water sediment was evaluated throughout the Study Area. At the direction of the EPA, exposure to in-water sediment by divers is also evaluated in this BHHRA.

3.3.2.1 In-Water Workers

While this population is referred to as "in-water" workers, these workers are not actually in the water. Rather, in-water workers are those workers who conduct over-water activities such as maintenance dredging and repair of in-water structures. Exposure to in-water sediment could occur while performing these specific activities, although most maintenance dredging activities are mechanical and are unlikely to result in significant sediment contact. Although likely occurring less frequently than mechanical dredging activities, other activities such as maintenance and cleaning of equipment or in off-loading sediments to disposal sites may result in a greater exposure potential.

3.3.2.2 Divers

In the Study Area, the majority of divers are expected to be commercial divers. To evaluate diver exposures, two different exposure scenarios are included in this BHHRA, one assuming that a wet suit is worn during diving and one assuming that a dry suit is worn during diving. The diver exposure scenarios were directed by EPA in a memorandum regarding the *Proposed Commercial Diver Exposure Scenario for the Portland Harbor Risk Assessment* (EPA 2008c). Both the wet suit and dry suit diver exposure scenarios assume that the diver is exposed to sediment through inadvertent ingestion of sediment and dermal exposure to sediment. As EPA stated in its approach, the use of a dry suit is expected to limit diver exposure, so it is assumed

that the wet suit diver has more dermal exposure to sediment than the dry suit diver. Based on communications with commercial diving companies in the Portland area (Hutton 2008, Johns 2008, and Burch 2008), the standard of practice for commercial divers is the use of dry suits and helmets when diving in the LWR. However, based on the directive of the EPA, the wet suit diver scenario is also included in this BHHRA.

3.3.2.3 Tribal Fishers

The LWR provides a ceremonial and subsistence fishery for Native American tribes. The extent to which tribal members fish within the Study Area, as well as the extent to which that fishing occurs from boats or piers and the degree of sediment exposure that might occur while fishing are unknown. However, exposure assumptions provided by EPA were used to evaluate in-water sediment exposure by tribal fishers.

3.3.2.4 Non-tribal Fishers

Fishers who fish from boats or piers could be theoretically exposed to in-water sediment on anchors, hooks, or crayfish pots. For in-water sediment exposure, two different fisher scenarios were included in this BHHRA to evaluate differences in the frequency of fishing activities: high-frequency fishers and low-frequency fishers. The extent to which fishing actually occurs under these two scenarios is unknown, as is the degree of sediment exposure that might occur while fishing. However, exposure assumptions provided by EPA were used to evaluate in-water sediment exposure by fishers.

3.3.2.5 Potentially Complete and Insignificant Exposure Pathways

Recreational beach users could contact in-water sediment while swimming. However, any exposure to in-water sediment is expected to be minimal and the exposure would occur under water, so it cannot be quantitatively evaluated using EPA exposure models. In-water sediment exposures were considered potentially complete and insignificant exposure pathways for recreational beach users and were not quantitatively evaluated in this BHHRA.

3.3.2.6 Incomplete Exposure Pathways

In-water sediment exposures were considered incomplete exposure pathways for dockside workers and transients based on the defined activities of these receptor populations in this BHHRA. Dockside workers are those workers who conduct specific activities within natural river beach areas and thus are not directly exposed to in-water sediments. In-water workers are the worker population for which in-water sediments exposures are considered potentially complete and were evaluated in this BHHRA. Transients who conduct specific activities while occupying natural river beach areas are unlikely to contact in-water sediment. The hypothetical future domestic water use scenario evaluates use of surface water for domestic water supply

and thus in-water sediment exposures are considered incomplete exposure pathways for this receptor population.

3.3.3 Direct Exposure to Surface Water

Direct exposure to surface water could potentially occur for many of the populations evaluated in this BHHRA. Two populations expected to potentially have the most frequent contact with surface water are transients and recreational beach users. At the direction of the EPA, exposure to surface water by divers and the hypothetical future use of untreated surface water as a domestic water source are also evaluated in this BHHRA.

3.3.3.1 Transients

Transients may have dermal contact with surface water during swimming, bathing or other activities, such as washing of clothing or equipment. In theory, transients may also use river water as a drinking water source. Exposure to surface water by transients would likely occur within transient use areas.

3.3.3.2 Divers

As described in Section 3.3.2.2, two different diver exposure scenarios are included in this BHHRA. The two exposure scenarios for divers differentiate between the use of either a wet suit or dry suit, as directed by the EPA (2008c). Both the wet suit and dry suit diver exposure scenarios assume that the diver is exposed to surface water through inadvertent ingestion of surface water and dermal exposure to surface water. As EPA stated in its approach, the use of a dry suit is expected to limit diver exposure, so a diver using a wet suit is assumed to have more dermal exposure to surface water.

3.3.3.3 Recreational Beach Users

The LWR is used by both adults and children for boating, water skiing, swimming, and other water activities that result in exposure to surface water. Of these activities, exposure to surface water would occur to the greatest extent while swimming in the river. Swimming would likely occur primarily within recreational beach areas.

3.3.3.4 ~~Hypothetical Future~~ Domestic Water User

As mentioned in Section 2.4.5, there is no known ~~or anticipated future~~current use of surface water within the Study Area for a domestic water supply. ~~Due to a requirement by EPA~~However, because domestic water use is a designated beneficial use of the Willamette River following adequate pretreatment, ~~river water ,~~ the ~~hypothetical~~ use of untreated river water ~~-~~ as a domestic water source was assessed as a hypothetical future pathway for both adult and child residents, at the direction of EPA~~., resulting in exposures through ingestion and dermal contact~~. In this scenario, exposure to untreated surface water could hypothetically occur from ingestion and

dermal contact throughout the Study Area. At the direction of the EPA, volatilization of chemicals from untreated surface water to indoor air through household uses was identified as a potentially complete exposure pathway for hypothetical future domestic water use.

3.3.3.5 Potentially Complete and Insignificant Exposure Pathways

Surface water exposures through dermal absorption and ingestion were considered potentially complete and insignificant exposure pathways for dockside workers, in-water workers, tribal fishers, and fishers. It is unlikely that both dockside and in-water populations would have direct contact with surface water through industrial activities. It is also unlikely that tribal fishers and fishers would have significant direct contact with surface water through fishing activities. Any exposures to surface water by the dockside workers, in-water workers, tribal fishers, or fishers would be minimal; therefore, surface water exposures were considered potentially completed and insignificant exposure pathways for these receptor populations.

Volatilization of chemicals from surface water to outdoor air is unlikely to result in a significant exposure considering the amount of mixing with ambient air that would occur. Given the low levels of chemicals in outdoor air from volatilization from surface water, surface water exposures through inhalation of volatiles was considered a potentially complete and insignificant exposure pathway for all receptor populations who conduct outdoor activities.

3.3.3.6 Incomplete Exposure Pathways

This BHHRA did not identify any incomplete exposure pathways for surface water exposures.

3.3.4 Direct Exposure to Groundwater Seeps

Direct contact with groundwater would occur only within human use areas where groundwater comes to the surface (i.e., seeps) on the beach above the water line and is only considered a potentially complete exposure pathway for transients and recreational beach users. As described in Section 2.1.4, there was only one groundwater seep identified during the seep reconnaissance survey that has not been remediated and is located in a recreational or transient use area. That seep, which is the potential groundwater discharge from Outfall 22B, occurs within a potential transient use area. Therefore, only transients were evaluated for exposure to groundwater seeps in this BHHRA.

3.3.4.1 Transients

Transients may have direct contact with groundwater seeps, within riverfront beach areas that have been identified as transient use areas. While contact with seep water would be unintentional, dermal contact with or incidental ingestion of seep water may occur.

3.3.4.2 Potentially Complete and Insignificant Exposure Pathways

This BHHRA did not identify any potentially complete and insignificant exposure pathways for direct exposure to groundwater seeps.

3.3.4.3 Incomplete Exposure Pathways

Direct exposure to groundwater seeps were considered incomplete exposure pathways for all receptor populations who do not conduct activities at beaches where groundwater discharges above the water line. As discussed above, only one groundwater seep was identified, which is within a transient use area. Therefore, direct exposure to groundwater seeps is considered an incomplete exposure pathway for dockside and in-water workers, recreational beach users, tribal fishers, fishers, and divers. The hypothetical future domestic water use scenario evaluates use of surface water for domestic water supply and thus groundwater seep exposures were considered incomplete exposure pathways for this receptor population.

3.3.5 Fish Consumption

Certain chemicals may bioaccumulate in fish tissue, and human populations that consume fish may be exposed to COPCs bioaccumulating in the fish tissue. Fish may be caught throughout the Study Area. While the populations evaluated in this BHHRA are described as "fishers", the fish consumption evaluation in this BHHRA includes people who consume fish caught within the Study Area, not just those who catch the fish.

3.3.5.1 Non-tribal Fishers

A year-round recreational fishery exists within the Study Area. Current information suggests that spring Chinook salmon, steelhead, Coho salmon, shad, crappie, bass, and white sturgeon are the fish species preferred by local recreational fishers (DEQ 2000b, Hartman 2002, and Steele 2002). In addition to recreational fishing, the investigation by the Oregonian newspaper and the limited surveys conducted on other portions of the Willamette River indicate that immigrants from Eastern Europe and Asia, African-Americans, and Hispanics are most likely to be catching and eating fish from the lower Willamette (ATSDR 2002). These preliminary surveys also indicate that the most commonly consumed species are carp, bullhead catfish, and smallmouth bass (ATSDR 2002). However, other species may also be consumed. Conversations were conducted with transients about their consumption of fish or shellfish from the Willamette River as part of a project by the Linnton Community Center (Wagner 2004). Transients reported consuming a large variety of fish, and several transients said they ate whatever they could catch themselves or get from other fishers. However, the frequency and amount of consumption was not reported, and many of the transients indicated they were in the area temporarily. Site-specific information is not available for fish consumption rates for specific species, so a range of ~~high-end~~ ingestion rates and various diets were evaluated in this BHHRA for both adult and child consumers.

3.3.5.2 Tribal Fishers

Four (Yakama, Umatilla, Nez Perce, and Warm Springs) of the six Native American tribes involved in the Portland Harbor RI/FS participated in a fish consumption survey that was conducted on the reservations of the participating tribes and completed in 1994 (Columbia River Inter-tribal Fish Commission (CRITFC) 1994). The results of the survey ~~suggest~~ show that tribal members surveyed generally have higher fish ingestion rates than the general public. Fish species, especially salmon and Pacific lamprey, are an important food source as well as an integral part of the tribes' cultural, economic, and spiritual heritage. Ingestion of fish by both adult and child tribal members was evaluated in this BHHRA.

3.3.5.3 Potentially Complete but Evaluated Under a Different Receptor Category

Fish could be consumed by dockside workers, in-water workers, recreational beach users, and divers; however, fish consumption by these receptor populations is evaluated under the fisher receptor category. Long-term, ongoing fish consumption by transients would not occur; therefore, the fisher receptor category would be protective of fish consumption by transients.

3.3.5.4 Incomplete Exposure Pathways

The hypothetical future domestic water use scenario evaluates use of surface water for domestic water supply and thus fish consumption was considered an incomplete exposure pathway for this receptor population.

3.3.6 Shellfish Consumption

Like fish, shellfish may bioaccumulate certain chemicals in their tissue. Populations that consume shellfish may be exposed to COPCs that accumulate in the shellfish tissue. In the Programmatic Work Plan, crayfish was identified as the species to use to evaluate shellfish consumption. Additionally, as required by EPA, consumption of clams is also evaluated in this BHHRA. Harvest and possession of Asian clams, which is the clam species that was found in the LWR during sampling events, is illegal in the State of Oregon because Asian clams are on the prohibited species list of the ODFW rules regarding the importation, possession, confinement, transportation and sale of nonnative wildlife (OAR 635–056–0050).

3.3.6.1 Fishers

In theory, shellfish consumption could occur throughout the Study Area wherever shellfish are found. However, it is not known to what extent shellfish consumption occurs~~, as there is no documentation of ongoing shellfish consumption by humans occurring in the Study Area~~.

The Linnton Community Center project (Wagner 2004) reported that some transients reported eating clams and crayfish; however, many of the individuals indicated that

they were in the area temporarily, move from location to location frequently, or have variable diets based on what is easily available. The Superfund Health Investigation and Education (SHINE) program in the Oregon Department of Human Services (DHS) stated that is unknown whether or not crayfish are harvested commercially within Portland Harbor (ATSDR 2006). ~~In addition,~~ ODFW has records for crayfish collection in the Columbia and Willamette Rivers, but these records do not indicate whether the collection actually occurs within the Study Area. Based on ODFW's data for 2005 to 2007, no commercial crayfish landings were reported for the Willamette River in Multnomah County. DHS had previously received information from ODFW indicating that an average of 4300 pounds of crayfish were harvested commercially from the portion of the Willamette River within Multnomah County each of the five years from 1997-2001. In addition to this historical commercial crayfish harvesting, DHS occasionally receives calls from citizens who are interested in harvesting crayfish from local waters who are interested in fish advisory information. According to a member of the Oregon Bass and Panfish club, crayfish traps are placed in the Portland Harbor Superfund Site boundaries and collected for bait and possibly consumption (ATSDR 2006). Even if collection does occur within the Study Area, it is not known whether those crayfish are consumed by humans or used as bait.

Because site-specific information is not available for shellfish consumption, a range of ingestion rates was evaluated in this BHHRA for adult shellfish consumers.

3.3.6.2 Potentially Complete but Evaluated Under a Different Receptor Category

Shellfish could potentially be consumed by dockside workers, in-water workers, recreational beach users, and divers; however, shellfish consumption by these receptor populations is evaluated under the adult shellfish consumer receptor category. Long-term, ongoing shellfish consumption by transients would not occur; therefore, the adult shellfish consumer receptor category would be protective of shellfish consumption by transients.

3.3.6.3 Incomplete Exposure Pathways

The hypothetical future domestic water use scenario evaluates use of surface water for domestic water supply and thus shellfish consumption was considered an incomplete exposure pathway for this receptor population.

3.3.7 Potentially Overlapping Exposure Scenarios

Exposure can potentially occur under more than one scenario for an individual. Examples of these overlapping scenarios include: an in-water worker who is also a high-frequency fisher and recreational beach user, a transient who is also a fisher, a tribal fisher who is also a recreational beach user, and others. The potentially overlapping scenarios are indicated in Figure 3-1. It is likely that one or more of the exposure scenarios potentially affecting an individual will pose a much higher level

of risk than the other scenario(s), such that combining the effects of the scenarios will not influence risk management decisions for the Study Area. Risks from potentially overlapping scenarios are discussed in Section 5 of this BHHRA.

3.4 CALCULATION OF EXPOSURE POINT CONCENTRATIONS

EPCs were calculated for media and pathways that were evaluated quantitatively in this BHHRA. The process to estimate EPCs for tissue and beach sediment was previously described in the Programmatic Work Plan, and the Round 1 tissue EPCs were previously presented in *Round 1 Tissue Exposure Point Concentrations* (Kennedy/Jenks Consultants 2004b) and *Salmon, Lamprey, and Sturgeon Tissue Exposure Point Concentrations for Oregon Department of Human Services* (Kennedy/Jenks Consultants 2004c), both of which were approved by EPA. The process for deriving EPCs for in-water sediment, surface water, and groundwater seeps was previously described in *Exposure Point Concentration Calculation Approach and Summary of Exposure Factors* (Kennedy/Jenks Consultants 2006), which was approved by EPA.

~~The EPCs used in this BHHRA incorporate CT and RME methods, consistent with EPA guidance. Because the RME scenarios in this BHHRA use either the maximum detected concentration or the 95% upper confidence limit (95% UCL) on the arithmetic mean as the EPC for an exposure area, this BHHRA uses the term "95% UCL/max" to reference RME EPCs, and "mean" to reference CT EPCs.~~EPCs were calculated for the 95% upper confidence limit on the arithmetic mean (95% UCL) and the arithmetic mean for each exposure area. In some exposure areas, the maximum concentration was used instead of the 95% UCL. Therefore, the EPCs are referred to as the 95% UCL/max and mean throughout this BHHRA.

Prior to calculating EPCs for sediment, surface water, tissue, and groundwater seeps, data were reduced, as needed, to address reporting of multiple results for the same constituent in the same sample and to reduce laboratory duplicates and field splits of samples to derive one value for use. Data reductions performed within the SCRA database followed the rules described in *Guidelines for Data Reporting, Data Averaging, and Treatment of Non-Detected Values for the Round 1 Database Technical Memorandum* (Kennedy/Jenks Consultants et al. 2004). Additional data reductions and data use rules specific to the BHHRA were approved by EPA and are detailed in Attachment F2.

Chemicals that were not detected at concentrations above the detection limit were designated as non-detects. Non-detects may represent concentrations that are zero, or may represent concentrations greater than zero but less than the detection limit. For purposes of calculating mean EPCs, non-detected values were used in the calculations at one half their detection limit. For both mean and 95% UCL/max EPCs, non-detects whose detection limit was greater than the maximum detected concentration for an exposure area were removed from the dataset prior to calculation of the EPCs.

For the purposes of calculating 95% UCL/max EPCs, the following rules were applied to datasets for tissue (based on species and tissue type), sediment, surface water, and the groundwater seep:

1. If a chemical was not detected in any sample for a given medium within the Study Area, it was assumed to not be present, so an EPC was not calculated for that chemical in that medium

2. If a chemical was detected at least once within the Study Area in samples for a given medium, the non-detect concentrations were used in the EPC calculations in accordance with the methods used in the software ProUCL Version 4.00.02 (EPA 2007b). ProUCL software output for the 95% UCLs calculated in this BHHRA are provided in Attachment ~~F3~~F4.

In risk characterization, some toxicity values are based on exposure to chemical mixtures and not to individual chemicals. The risks from these chemicals, which were identified in *Human Health Toxicity Values Interim Deliverable* (Kennedy/Jenks Consultants 2004a), were evaluated for the combined exposure to the chemicals and not on an individual chemical basis. For chemicals that were evaluated as mixtures in the BHHRA, the concentrations of the individual isomers or congeners that comprise the mixtures were summed to calculate the EPCs for the mixtures, as described in Attachment F2. The chemicals evaluated as mixtures are described in Attachment F2 as well, and include: PCBs, endosulfans, chlordanes, DDTs, DDDs, DDEs, and 2,3,7,8-TCDD TEQs.

~~3~~3.4.1 Beach Sediment

Sediment data collected from human use areas during Round 1 and 2 were used to estimate the EPCs for beach sediment. There were no additional beach sediment data collected from human use areas for Round 3. Within the Study Area, EPCs were estimated for exposure areas based on the types of populations potentially exposed. Since potentially complete exposure pathways for sediment involve direct contact with beach sediments, only beach sediment data were used in estimating EPCs for direct exposure pathways.

One composite sample was collected from each beach area. Therefore, the results from the composite sample were used for both the 95% UCL/max and the mean EPCs for that beach. The process to estimate EPCs for each receptor population is described below.

3.4.1.1 Dockside Workers

Dockside workers could potentially be exposed to beach sediment in dockside worker use areas, which are shown in Map 2-1. Beach sediment data from these areas were used to estimate the EPCs for dockside workers. For dockside workers, the exposure area is considered to be the industrial site (i.e., facility within a property boundary)

where the worker is employed. To estimate an EPC for each industrial site, beach sediment data from the composite sample collected from the beach associated with that industrial site were used. If the beach area extends across multiple industrial sites, the same EPC was used to evaluate exposure of dockside workers at each of the adjacent industrial sites. Beach sediment EPCs for exposures of dockside workers are presented in Table 3-2.

3.4.1.2 Transients

Transients could potentially be exposed to beach sediment in transient use areas, which are shown in Map 2-1. ~~Although t~~Transients ~~are anticipated to~~may move throughout the Study Area, while some may spend a majority of their time at only one of the identified areas. Therefore, EPCs for transients were ~~conservatively~~ estimated for each beach area within the transient use areas to represent a range of possibilities for transients residing in the Study Area. Beach sediment EPCs for exposures by transients are presented in Table 3-3.

3.4.1.3 Recreational Beach Users

Recreational beach users could potentially be exposed to beach sediment in recreational use areas, which are shown in Map 2-1. Beach sediment data from these areas were used to estimate the EPCs for recreational beach users. For recreational beach users, the exposure area is considered to be one river beach area, which represents a conservative assumption for the BHHRA because the beach user could be exposed to multiple recreational beach areas within and outside of the Study Area during the exposure time period. EPCs were estimated for individual beaches within the recreational beach use areas. Beach sediment EPCs for exposures by recreational beach users are presented in Table 3-3.

3.4.1.4 Fishers

Fishing could occur from beaches with unrestricted access~~es~~, which are the potential transient and/or recreational use areas. Beach sediment data from these areas were used to estimate the EPCs for non-tribal and tribal fishers, as shown on Map 2-1. ~~For fishers, the exposure area is considered to be one river beach area, which represents a conservative assumption for the BHHRA because the f~~Fishers are likely to ~~could~~ fish from multiple beach areas within and outside of the Study Area during the exposure time period. The exposure area for fishers was considered to be one individual beach in order to provide a range of risk estimates for individual beaches within the Study Area. EPCs were estimated for individual beaches within the recreational and transient use areas and are the same as the EPCs for transients and recreational beach users. Beach sediment EPCs for exposures by fishers are presented in Table 3-3.

3.4.2 In-Water Sediment

In-water sediment data of appropriate data quality collected within the Study Area were used to estimate EPCs for in-water sediment. Direct contact would only occur

with near-shore surface sediment, so only surface sediment data (less than 30.5 cm in depth) collected outside of the navigation channel were used in estimating the EPCs.

If a ~~chemical~~ contaminant was detected at least once in surface sediment within the Study Area, an EPC was calculated for that ~~chemical~~contaminant, and any non-detect concentrations were included in the EPC calculations in accordance with the ProUCL Version 4.00.02 guidance (EPA 2007b). In-water sediment EPCs were estimated for in-water workers, fishers, and divers and are presented in Table 3-4.

3.4.2.1 In-Water Workers

For in-water workers, exposure could occur anywhere within the Study Area that docks or pilings are being constructed or where other in-water activities are occurring (such as maintenance dredging of private slips or berths). While these activities would not necessarily be restricted to a given area, exposure would most likely be localized to in-water sediment adjacent to facilities where these activities occur. Most of these activities would be between the shore and the navigation channel. As a result, sediment samples in near-shore (i.e., excluding the central navigation channel) half-river mile segments along both sides of the river were used to develop in-water sediment EPCs. In addition to calculating EPCs for exposure within the Study Area, EPCs were also calculated for the downstream reach of the river from RM 1.0 – 1.9, the downtown reach of the river from RM 11.8 – 12.2, and for samples within Multnomah Channel, per an agreement with EPA.

In accordance with EPA guidance (1989), the 95% UCL was used for the 95% UCL/max EPC for in-water workers for exposure areas with at least 5 detected concentrations for a given analyte. For analytes with less than 5 detected concentrations, the maximum detected concentration for that exposure area was used as the 95% UCL/max EPC. Uncertainties associated with estimating EPCs for small datasets (i.e., less than 10 detected concentrations) and in using the maximum detected concentration as the EPC are discussed in ~~Section 7~~Section 66. The arithmetic mean of detected concentrations was used for the mean EPC. The 95% UCLs were calculated for each dataset following EPA guidance (EPA 2002a and EPA 2007b). ProUCL version 4.00.02 (EPA 2007b) was used to test datasets for normal, lognormal, or gamma distributions and to calculate the 95% UCLs. Data were tested first for normality, then for gamma distributions, and finally for lognormal distributions, as recommended by ProUCL guidance (EPA 2007b). If the data did not exhibit a discernable distribution, a non-parametric approach (e.g., Chebyshev) was used to generate a UCL. The 95% UCLs were calculated using the method recommended by ProUCL guidance (EPA 2007b) for the data distribution, sample size, and skewness. In-water sediment EPCs for exposures by in-water workers are presented in Table
3-4.

3.4.2.2 Fishers

Fishers include adult non-tribal and tribal fishers. The fisher scenario is based on long-term exposure. For repeated exposures over an entire lifetime, direct contact with in-water sediment would occur over a very wide area. Even though exposure would occur over a wide area, in-water sediment EPCs for the fisher were derived on a half-mile segment on each side of the river, as was done for the in-water workers, as requested by EPA in its comments, dated February 24, 2005 on draft *Exposure Point Concentration Calculation Approach and Summary of Exposure Factors*. Deriving exposure areas based on a half-mile segment on each side of the river provides a range of possibilities for risk management and for risk communication to fishers making fishing location choices. In addition to calculating EPCs for exposure within the Study Area, EPCs were also calculated for the downstream reach of the river from RM 1.0 – 1.9, the downtown reach of the river from RM 11.8 – 12.2, and for samples within Multnomah Channel, per an agreement with EPA. Both the mean and 95% UCL/max EPCs were calculated as described for the in-water worker EPCs. In-water sediment EPCs for exposures to fishers are presented in Table 3-4.

3.4.2.3 Divers

Commercial divers could conduct diving activities anywhere within the Study Area, though exposure would most likely be to in-water sediment adjacent to facilities where commercial diving is required for purposes such as marine construction, underwater inspections, and routine operation and maintenance. It is assumed that all other diving done by a diver is done outside of the Study Area. Therefore, in-water sediment EPCs for the diver were derived for half-mile segments on each side of the river, as was done for the in-water workers, and as directed by EPA in the memorandum dated September 15, 2008 (EPA 2008c). In addition to calculating EPCs for exposure within the Study Area, EPCs were also calculated for the downstream reach of the river from RM 1.0 – 1.9, the downtown reach of the river from RM 11.8 – 12.2, and for samples within Multnomah Channel, per an agreement with EPA. Both the 95% UCL/max and mean EPCs were calculated as described for the in-water worker EPCs. In-water sediment EPCs for exposures to divers are presented in Table 3-4.

3.4.3 Surface Water

Surface water data of appropriate data quality collected within the Study Area were used to estimate EPCs. Both integrated and non-integrated water column surface water samples were collected within the Study Area and were used in estimating the surface water EPCs. The specific samples used to estimate EPCs for each receptor were dependent upon the exposures of that receptor to surface water within the Study Area. A summary of surface water samples used to calculate EPCs for each receptor is provided in Table 3-5. Surface water EPCs were estimated for transient, recreational beach user, diver, and hypothetical future domestic water user exposure scenarios.

3.4.3.1 Transients

Transient exposures to surface water could occur throughout the year at transient use areas within the Study Area. As a result, data from all seven of the completed seasonal sampling events were used in estimating the surface water EPCs for transients. Data from the four transect stations within the Study Area were used to estimate surface water EPCs for exposures at transient use areas throughout the Study Area. Results of near-bottom and near-surface horizontally integrated transect samples from the same sample location and sampling event were combined prior to calculation of EPCs, as were vertically integrated transect samples from the east, middle, and west portions of the river. Rules for combining transect samples are described in Attachment F2. Surface water samples were also collected at Willamette Cove, which is a quiescent transient use area that may not be adequately characterized by the transect samples. Year-round data from this surface water sample location were used to estimate surface water EPCs for exposures in Willamette Cove. Surface water EPCs for exposures by transients are presented in Table 3-6.

Given that transients can live along many parts of the river, EPCs were calculated for each transect, as well as for the combination of all four transects. In addition to calculating EPCs for exposure within the Study Area, EPCs were calculated for one transect station outside of the Study Area, at Multnomah Channel. For the 95% UCL/max EPC, the 95% UCL was used for the EPC for exposure areas with at least 5 detected concentrations for a given analyte. For analytes with less than 5 detected concentrations in a given exposure area, the maximum detected concentration was used as the EPC. Uncertainties associated with estimating EPCs for small datasets (i.e., less than 10 detected concentrations) and in using the maximum detected concentration as the EPC are discussed in ~~Section 7~~Section ~~6~~6. The 95% UCLs were calculated as described for in-water sediment. The arithmetic mean of the detected concentrations for each exposure area was used for the mean EPC.

3.4.3.2 Recreational Beach Users

Recreational beach user exposures to surface water could occur during summer months at recreational use areas within the Study Area. The only summer sampling event for recreational use areas occurred in July 2005. As a result, only data from the low-water sampling event in July 2005 were used in estimating the surface water EPCs for recreational beach users. The uncertainty associated with using data from only the low-water summer sampling event is discussed further in ~~Section 7~~Section ~~6~~6. Data collected from recreational beaches in July 2005 included three transect locations and three single-point locations (Cathedral Park, Willamette Cove, and Swan Island Lagoon). Data from the three transect stations were used to estimate surface water EPCs for exposures at non-quiescent recreational beach use areas throughout the Study Area, and data from single-point surface water samples were used to estimate EPCs for exposure at quiescent recreation beach areas. Because only one sample was collected from each quiescent area during low-water periods, the results for the single sample were used as both the 95% UCL/max EPC and the mean

EPCs for each area. Only three transect samples were collected in July 2005 during the low-water period, so the maximum concentrations were used as the 95% UCL/max EPCs and the arithmetic mean of detected concentrations were used as the mean EPCs. Surface water EPCs for exposures by recreational beach users are presented in Table 3-7.

3.4.3.3 Divers

Diver exposures to surface water could occur throughout the year at all areas within the Study Area. Therefore, for divers, all of the surface water data collected in the Study Area, including both transect data and data collected from single point stations, were used to estimate EPCs. In addition to calculating EPCs for exposure within the Study Area, EPCs were calculated for one transect station outside of the Study Area, at Multnomah Channel. Transect data were used to estimate EPCs for diver exposures as described for transient exposures (Section 3.4.3.1). Surface water data available as single point samples from Round 2 in several areas of the Study Area, and as near-bottom and near-surface samples from Round 3 sampling, were also used to estimate EPCs. For the Round 3 surface water samples collected as single point samples, the near-bottom and near-surface samples were combined for use in estimating EPCs, as described in Attachment F2. As with diver exposure to in-water sediment, diver exposure to surface water is expected to be in localized areas adjacent to facilities where commercial diving is required for purposes such as marine construction, underwater inspections, and routine operation and maintenance. Therefore, samples from single point stations were used to calculate EPCs for near-shore half-river mile segments along both sides of the river, consistent with the approach for in-water sediment EPCs and per direction from EPA. Surface water EPCs for exposures by divers are presented in Table 3-8.

3.4.3.4 ~~Hypothetical Future~~ Domestic Water User

~~EPA required the evaluation of hypothetical future use of untreated surface water as a domestic water source in this BHHRA.~~ The hypothetical use of untreated surface water as a domestic water source could occur within the Study Area throughout the year. As a result, data from all seven of the completed seasonal sampling events were used in estimating the surface water EPCs for ~~hypothetical~~ the domestic water user. EPCs were determined for individual transect stations and for single point stations with vertically integrated samples. This dataset included samples from the four transect stations within the Study Area and single point vertically integrated samples from Cathedral Park, Willamette Cove, and Swan Island Lagoon. In addition, EPA required that data from near-bottom and near-surface surface water stations where both samples were collected be averaged and used in the domestic water dataset. Study Area-wide EPCs included all vertically integrated samples. Transect data were used to estimate EPCs for hypothetical domestic water use as described for transient exposures (Section 3.4.3.1). For single point stations, ~~three~~ fewer than five samples were taken from each station, so the maximum detected concentration was used as the 95% UCL/max EPC~~,~~ and the mean of detected concentrations was used as the mean

EPC. Surface water EPCs for ~~exposures by hypothetical residents~~hypothetical use of untreated surface water as a domestic water source are presented in Table 3-9.

3.4.4 Groundwater Seeps

Direct contact with groundwater would occur only within human use areas where groundwater comes to the surface (i.e., seeps) on the beach above the water line. Each groundwater seep where direct contact could occur represents an exposure area for groundwater. The only groundwater seep where direct contact could occur within the Study Area is within the potential transient use area located on the west side of the river at RM 7 (Map 2-5). Outfall 22B, which is a potential conduit of groundwater discharge and results in the water present on that beach, was sampled twice between 2002 and 2007 at times that did not involve stormwater influence. If a chemical was detected in only one of the two samples, that result was used as both the 95% UCL/max and mean EPCs for that ~~chemical~~contaminant. If a ~~chemical~~ contaminant was detected in both samples, the maximum concentration was used as the 95% UCL/max EPC, and the arithmetic mean of the detected concentrations was used as the mean EPC. Groundwater seep EPCs are presented in Table 3-10.

3.4.5 Fish and Shellfish Tissue

Fish and shellfish tissue EPCs were derived from tissue sampling results of the LWG Round 1, Round 2, and Round 3 investigations and the ODHS study. Fish tissue EPCs are presented in Tables 3-11 through 3-21, and shellfish tissue EPCs are presented in Tables 3-22 though 3-25. The EPCs derived from Round 1 data were originally presented in *Round 1 Tissue Exposure Point Concentrations* (Kennedy/Jenks Consultants 2004b), which was approved by EPA. These EPCs were derived for fish species and crayfish that were evaluated for human consumption. Since Round 1, new data have been collected for clam, crayfish, smallmouth bass, and common carp. No new data have been collected since Round 1 for use in the calculation of brown bullhead and black crappie EPCs. The EPCs derived for adult salmon, adult lamprey, and adult sturgeon using the results of the ODHS study were originally presented in *Salmon, Lamprey, and Sturgeon Tissue Exposure Point Concentrations for Oregon Department of Human Services* (Kennedy/Jenks Consultants 2004c). These EPCs were derived for salmon whole body, fillet with skin, and fillet without skin composite samples, lamprey whole body composite samples, and sturgeon fillet without skin samples.

Crayfish and clams were collected and composited at each sampling location. EPCs were calculated for crayfish at individual locations, as well as for the entire Study Area per the Programmatic Work Plan. EPCs were calculated for clams for approximately one river mile on each side of the river, as well as for the entire Study Area, as required by EPA in its comments on the Round 2 Report. EPCs were also calculated for crayfish and clams collected between RM 1.0 and 1.9 and

between RM 11.8 and 12.2, per an agreement with EPA. EPCs for clams were calculated for both depurated and undepurated samples.

Smallmouth bass were collected and composited over a river mile. EPCs were calculated for smallmouth bass at each river mile as well as for the entire Study Area per the Programmatic Work Plan. EPCs were calculated for both whole body and fillet samples.

Common carp, black crappie, and brown bullhead were collected and composited within river segments designated as fishing zones. For Round 1 data collection, there were two fishing zones that extended over three-mile segments: RM 3-6 and RM 6-9. For Round 3 data collection, which included additional common carp collection but not black crappie or brown bullhead, there were three fishing zones that extended over four-mile segments: RM 0-4, RM 4-8, and RM 8-12. EPCs for common carp, black crappie, and brown bullhead were calculated for each fishing zone in which they were sampled, as well as for the entire sampling area to represent Study Area-wide exposure. EPCs were calculated for both whole body and fillet samples.

Adult salmon were collected at the Clackamas fish hatchery, adult lamprey were collected at Willamette Falls, and sturgeon were collected at locations throughout the Study Area. EPCs were calculated for adult salmon, adult lamprey, and sturgeon using available data to be representative of the entire Study Area. EPCs were calculated for both whole body and fillet samples for adult salmon. Only whole body data were available for adult lamprey and only fillet data were available for sturgeon, so the EPCs for adult lamprey were calculated for whole body samples and the EPCs for sturgeon were calculated for fillet samples.

In calculating the EPCs for fish and shellfish, if only one sample was collected within a given exposure area, that result was used as both the 95% UCL/max and mean EPC for that ~~chemical~~contaminant. If more than one sample was collected, either the 95% UCLs or maximum concentrations were used as the 95% UCL/max EPCs, depending on the number of reported concentrations. If detected concentrations for at least five samples were available, the 95% UCLs were calculated as described for in-water sediment. If less than five detected concentrations were available, the maximum detected concentration was used as the 95% UCL/ max EPC. EPCs for Study Area-wide exposure were calculated from the Study Area-wide data set. Uncertainties associated with estimating EPCs for small datasets (i.e., less than 10 detected concentrations) and in using the maximum detected concentration as the EPC are discussed in ~~Section~~ Section 6. The arithmetic mean of detected concentrations was used as the mean EPC, assuming that all non-detects were one--half the detection limit.

EPCs for multi-species fish tissue consumption scenarios were calculated using a weighted average of site-wide EPCs for each COPC, based on the percent of each species consumed in the diet.

3.5 PROCESS TO CALCULATE INTAKES

EPA (1989) defines exposure as "the contact with a chemical or physical agent" and defines the magnitude of exposure as "the amount of an agent available at human exchange boundaries (i.e., the lungs, gut, and skin) during a specified time period." Exposure assessments are designed to determine the degree of contact a person has with a chemical. Thus, estimating human exposure to a chemical requires information regarding the concentration of the chemical in the environmental media (sediment, water, tissue) with which a person will come into contact and the extent of contact the person will have with the media.

Chemical-specific intake or dose was quantified in this BHHRA by estimating the chronic daily intake (CDI) for noncarcinogens, or the lifetime average daily intake (LADI) for carcinogens. CDI and LADI, expressed in terms of the mass of substance taken into the body per unit body weight per unit time (mg/kg/day), were calculated using equations based on exposure parameters that represent the duration of exposure, frequency of exposure, and other factors that affect overall chemical dose. Consistent with EPA guidance (1989), exposure assessments were based on the RME expected to occur under both current and future land use conditions, as well as hypothetical future conditions. Exposure assessments using CT values, which are more representative of average exposures, were also conducted. Rationale and/or references for each of the RME and CT values for exposure pathways that were quantitatively assessed for each exposure scenario for different populations are presented in exposure factor Tables 3-26 through 3-30 and discussed in the following sections.

Intakes were quantified using standard exposure equations (EPA 1989). These equations take the general form:

$$\text{CDI or LADI} = \frac{EPC \times IR \times EF \times ED}{BW \times AT}$$

Where:

- CDI = Chronic daily intake
- LADI = Lifetime average daily intake
- EPC = Exposure point concentration
- IR = Intake rate
- EF = Exposure frequency
- ED = Exposure duration
- BW = Body weight
- AT = Averaging time.

The detailed intake equations, as well as the specific exposure parameters and associated units, are dependent on the exposure scenario evaluated; please see Tables 3-26 to 3-30 for additional details. For exposure areas outside of the Study Area, the same intake equations and exposure parameters were used as used for exposure areas within the Study Area.

3.5.1 Population-Specific Assumptions

Assumptions about each population evaluated in this BHHRA were used to select exposure parameters to calculate the pathway-specific chemical intakes. Currently, site-specific values are not available for all populations and pathways. Therefore, default values were used where site-specific values are not available. Where default values are not available, best professional judgment based on knowledge of human uses of the Study Area, or requirements from EPA, were used.

Exposure parameters that were used in this BHHRA to calculate the CDIs and LADIs for most receptors were previously included in *Exposure Point Concentration Calculation Approach and Summary of Exposure Factors* (Kennedy/Jenks Consultants 2006), which was approved by EPA. For divers, the exposure parameters were provided by EPA in a directive dated September 15, 2008. For hypothetical future domestic water use, EPA default exposure parameters for residential drinking water were used as required by EPA in its comments on the Round 2 Report. The exposure parameters are discussed below and presented in Tables 3-26 to 3-30. These values represent potential exposures for application at appropriate areas and/or areas agreed upon with EPA and its partners within the Study Area. Except where specifically noted, the exposure assumptions used in the BHHRA were applied uniformly to all of the Study Area, and may or may not be applicable at specific locations within the Study Area depending on factors not specifically addressed in the BHHRA (e.g., accessibility, habitat). The actual exposure at a given location may be less than that assumed for the population and Study Area as a whole due to location-specific conditions.

3.5.1.1 Dockside Worker

For the dockside worker, exposure to beach sediment is the only exposure pathway determined to be potentially complete and evaluated in this BHHRA. Industrial land use was assumed only for portions of the Study Area that are zoned for industrial use and with river~~-~~-front areas that include natural river beach or bank areas. Activities at Portland Harbor industrial sites do not occur frequently in these areas, which are the only areas where direct exposure to beach sediment might occur. It is unlikely that workers are in direct contact with beach sediment through typical industrial activities on a daily basis.

~~Although~~ Because it is unlikely that significant beach sediment exposure would occur for a dockside worker on a ~~regular~~ daily basis, exposure assumptions for the dockside worker were developed using EPA ~~based on typical occupational assumptions. For~~

~~the most part,~~ default exposure values for an industrial worker for most parameters except for exposure frequency~~from EPA were used~~. For ~~beach sediment~~ exposure frequency, it was assumed that a worker would ~~only~~ contact sediment one day per week while working at the industrial site, rather than the EPA default value or 5 days per week. Therefore, the default exposure frequency of 250 days per year, which represents 5 days per week for 50 weeks, was changed to 50 days per year (i.e., 1 day per week for 50 weeks) for RME. Table 3-26 summarizes RME and CT exposure values for the dockside worker and the reference or rationale for each value.

3.5.1.2 In-~~water~~ Water Worker

For the in-water worker, exposure to in-water surface sediment is the only exposure pathway determined to be potentially complete and evaluated in this BHHRA. In-water workers could contact in-water sediment while performing specific activities such as replacement of fender piles or maintenance dredging. Exposure factors for in-water sediment were developed for Terminal 4 based on in-depth interviews with several workers who conduct or oversee activities that could result in contact with in-water sediment. According to the Army Corps of Engineers (Siipola 2004), the Port of Portland conducts the most frequent dredging within the Study Area, so the exposure factors for workers at Terminal 4 are considered protective of in-water workers throughout the Study Area for potential in-water sediment exposures. For the RME scenario, in-water workers are assumed to contact in-water sediment for 10 years during 25 years of employment at a given facility with 10 days of sediment contact per year. For the CT scenario, in-water workers are assumed to contact in-water sediment for 4 years during 9 years of employment at a given facility with 10 days of sediment contact per year. ~~Although most maintenance dredging activities are mechanical and are unlikely to result in significant sediment contact, t~~The in-water worker exposure factor intake rates for in-water sediment are the same as the dockside worker for beach sediment, which in turn are the same as default exposure factors for soil for an industrial worker. Table 3-27 summarizes RME and CT exposure values for the in-water worker and the reference or rationale for each value.

3.5.1.3 Transients

Transient land use is assumed only for portions of the Study Area with riverfront access and that are not also active industrial sites. Transients may be exposed to beach sediment, surface water, and groundwater seeps while utilizing river beaches within transient use areas. EPA does not have recommended exposure parameters for transient scenarios, so the exposure frequency and duration for transients are based on best professional judgment. However, by definition, transient exposures are assumed to occur over a short duration of time. At the request of EPA, it was assumed that transients might remain at a single beach for up to two years for the RME scenario. For intake rates for transients, EPA required that the soil ingestion rate and soil adherence factor used for beach sediment be increased above those EPA default values ~~greater than those~~ recommended for residential soil exposures ~~be used for beach sediment~~ and that residential~~,~~ tap water ingestion rates be used for surface

water. A~~a~~ higher soil ingestion rate (200 mg/day instead of 100 mg/day) and soil adherence factor (0.3 mg/cm^2 instead of 0.07 mg/cm^2) were used as it is expected that transients living on a beach would have more contact with beach sediment than a residential adult might have with residential soil and dust. Transients may have limited access to washing facilities and could therefore more frequently transfer sediments from hand to mouth while eating, smoking, etc. Tables 3-26 and 3-28 summarize RME and CT exposure values for the transient scenario for beach sediment and water (surface water and groundwater seeps respectively), ~~for the transient scenario,~~ and the reference or rationale for each value.

3.5.1.4 Recreational Beach User

Recreational beach use is assumed only for portions of the Study Area where recreational exposures are reasonably likely to occur. Recreational beach users may have direct contact with beach sediment within river beach areas and with surface water while swimming or during other water activities. EPA does not have recommended exposure parameters for recreational beach use scenarios, so the exposure frequency and duration for recreational beach users are based on best professional judgment. Beach use was assumed to be more frequent (5 days per week) in the summer with less frequent use in the spring/fall (1 day per week) and even less use in the winter (1 day per month). The temperature of river water would limit swimming activities during much of the year. Therefore, exposure to surface water was only evaluated for the summer months when swimming might occur (2 days per week). For beach sediment intake, the recommended default values for residential soil were generally used but the adherence factor for children was more than 10 times greater than the value for residential soil. For surface water intake, the recommended default values for swimming scenarios were used. The recreational beach user includes both adults and children. Tables 3-26 and 3-28 summarize RME and CT exposure values for beach sediment and surface water, respectively, for adult and child recreational beach users. A reference or rationale is included for each value.

3.5.1.5 Non-Tribal Fishers

Exposure assessments for the non-tribal fisher scenarios evaluated potential exposure to COPCs through direct contact with beach and in-water sediment and through consumption of fish and shellfish. Direct contact with beach sediment only occurs in river beach areas where fishing activities occur. Non-tribal ~~F~~fishers could theoretically contact in-water sediment on anchors, hooks, or crayfish pots while fishing from boats or piers at the Study Area. For fish and shellfish consumption, it is assumed that exposure could occur throughout the Study Area and is continuous year-round as fishers may catch fish at the Study Area and then freeze them for later use.

This BHHRA evaluated both a non-tribal fisher exposure scenario and a tribal fisher exposure scenario, which is discussed in Section 3.5.1.6. The non-tribal fisher scenario included two different fishing frequencies for sediment exposures, three

different ingestion rates for fish consumption exposures, and two different ingestion rates for shellfish consumption exposures. Non-tribal ~~F~~ffish consumption was evaluated for both adults and children while sediment exposure was evaluated for adults only, with the assumption that fishing is done primarily by adults but both adults and children may consume the fish that are caught.

3.5.1.5.1 Beach Sediment Exposure

Beach sediment exposure would only occur for fishers during bank fishing at natural river beach areas within the Study Area. ~~EPA does not have recommended default exposure parameters for fishing scenarios, so the exposure frequency and duration for fishers are based on EPA's requirements or best professional judgment.~~ EPA specified ~~provided~~ the exposure frequencies and durations for the fishers used in this BHHRA. High-frequency fishers were assumed to fish from the same beach area three days per week for the entire year (156 days/year) for ~~the default residential exposure duration (~~30 years~~)~~ for the RME. Low-frequency fishers were assumed to fish from the same beach area for two days per week for the entire year (104 days/year) ~~for the default residential exposure duration (~~for 30 years~~)~~ for the RME~~.~~ ~~Although it is not known how much sediment contact actually occurs during fishing activities, default intake values for residential soil were used~~. Exposure assumptions for beach sediment contact for fishers are presented in Table 3-26.

3.5.1.5.2 In-~~water~~ Water Sediment Exposure

At the request of EPA, the exposure frequencies and durations for beach sediment for each fisher scenario were assumed to represent the fishing activity at the Study Area regardless of whether that fishing occurs from a beach or a boat. ~~In contrast to beach sediment, a fisher is unlikely to have significant contact with in-water sediment in a given area at the Study Area every time fishing occurs, especially given the number of days and length of time over which exposures are assessed.~~ A factor of 25 percent was used to represent the percent of time spent fishing in a single area within the Study Area.

Based on the exposure scenarios for in-water sediment (i.e., contact with sediment on anchors, hooks, or crayfish pots), the extent of contact with in-water sediment is expected to be ~~would be significantly~~ less than what would occur with residential soil. Ingestion rates for soil are based on exposure to soil during yard work and to indoor dust (EPA 1997a). These ingestion rates are not applicable to the in-water sediment exposure scenarios; however, incidental ingestion rates are not available for sediment. It is assumed that the incidental ingestion rate for in-water sediment is 50% of the ingestion rate for residential incidental soil scenarios. For dermal contact, hands and forearms are the only body parts that could be exposed to in-water sediment on a regular basis (i.e., on a year-round basis). It is assumed that the entire surface area of both hands and forearms would be exposed to in-water sediment. The adherence and absorption factors are assumed to be the same as those for beach sediment. Exposure assumptions for in-water sediment contact for fishers are presented in Table 3-27.

3.5.1.5.3 Fish Consumption

The fish consumption scenario included three different fish ingestion rates, as well as single species and multiple species diets of resident fish species. Study Area-specific fish consumption information is not available for the fish consumption scenarios. Therefore, to evaluate the potential range in consumption patterns that may exist, three ~~high-end~~ ingestion rates were used to calculate intakes for adults and three were used for children. EPA specified the ingestion rates used in this BHHRA. For adults, the fish ingestion rates were 17.5 grams per day (g/day), 73 g/day, and 142 g/day. These rates correspond to approximately 2 meals per month, 10 meals per month, and 19 meals per month, based on an 8-ounce serving size, every month of the year, consisting exclusively of fish caught within the Study Area. It should be noted that the current fish consumption advisory, based on PCBs, for the LWR recommends that children and expectant mothers do not eat resident fish from the Portland Harbor, and that healthy adults eat no more than one 8-ounce meal per month of resident fish from the Portland Harbor (ODHS 2007). However, it is unclear to what extent this advisory is followed by people who consume fish from the Study Area.

Two of these rates, 17.5 g/day and 142 g/day, represent the 90th and 99th percentile ingestion rates for diets including uncooked freshwater and estuarine finfish and shellfish ~~for~~ by individuals (consumers and non-consumers) of age 18 and over in the United States (EPA 2002b). The 90th and 99th percentile ingestion rates for uncooked freshwater and estuarine finfish and shellfish for consumers-only are 200 g/day and 506 g/day, respectively (EPA 2002b). Because these rates are from a national dietary study, they may not be representative of site-specific consumption patterns. Relative to the ingestion rate of 142 g/day, an adult consuming fish and shellfish tissue at a rate of 200 g/day would need approximately 70 percent of their total fish and shellfish diet to be fish caught within the Study Area, and an adult consuming fish and shellfish tissue at a rate of 506 g/day would need approximately 28 percent of their total fish and shellfish diet to be fish caught within the Study Area. If a different proportion of fish were caught within the Study Area versus outside of the Study Area, exposure to chemicals within the Study Area would change accordingly. Additional uncertainties associated with these ingestion rates are discussed in ~~Section 7~~Section 6. The other ingestion rate used in this BHHRA, 73 g/day, is from a creel study conducted in the Columbia Slough and is the 95 percent upper confidence limit on the average for ingestion of fish where 75 percent of the mass of the total fish is consumed (Adolfson 1996). While this study may be more representative of consumption patterns for the Study Area, the study was limited in scope and the reported ingestion rates were estimated based on numerous assumptions. ~~For all three of the ingestion rates evaluated, the ingestion rates represent high-end fish consumption relative to the average ingestion rates from these respective studies.~~ These ~~high-end~~ ingestion rates were used for both the mean and 95% UCL/max risk calculations~~, and for the purposes of this BHHRA, they are referred to as the high (17.5 g/day), higher (73 g/day), and highest (142 g/day) ingestion rates.~~.

Limited information is available about fish consumption by children. The child scenario evaluated in this BHHRA is for 0 to 6-year olds. The national dietary study does not include consumption information for this age range. However, this age range was evaluated in the CRITFC Fish Consumption Survey (CRITFC 1994). In that survey, the ratio of the child 95th percentile ingestion to the adult 95th percentile ingestion rate, which is the comparison specified by EPA, was 0.42. This ratio was applied to the three adult ingestion rates to estimate the child ingestion rates. The corresponding rates that were used for children were 7 g/day, 31 g/day, and 60 g/day. ~~As with the adult fisher, ingestion rates for the child fish consumption scenario are referred to as high (7 g/day), higher (31 g/day), and highest (60 g/day) for the purposes of this BHHRA.~~ Exposure assumptions for fish consumption are presented in Table 3-29.

For the fish consumption scenarios, risks were evaluated separately for consumption of each individual target resident fish species (smallmouth bass, black crappie, brown bullhead, and common carp) assuming only one species was consumed in each scenario. For these individual species scenarios the ingestion rates for the entire diet (regardless of species) were used with concentration data on each individual resident species (for both whole body and fillet tissue). EPCs were calculated for fishing zones (common carp, black crappie and brown bullhead) and mile reach (smallmouth bass) as well as for the entire Study Area, as described in Section 3.4.5. In addition to the individual species diet, a multiple species diet was also evaluated by using the fish ingestion rates for the scenarios with the concentration data of all resident species (for whole body and fillet tissue) for the Study Area (i.e., a multiple species diet assuming that each of the 4 fish target species represents 1/4 of a person's diet). The following scenarios were evaluated for each of the above ingestion rates using both the 95% UCL/max and mean EPCs described in Section 3.4.5 for both whole body and fillet samples (because these scenarios were not classified as CT or RME):

	River Mile	**Fishing Zone**	**Entire Study Area**
Smallmouth bass	X		X
Black crappie		X	X
Common carp		X	X
Brown bullhead		X	X
Multiple species			X

The uncertainties associated with the fish consumption scenarios are discussed in ~~Section~~ Section 6 of this BHHRA.

3.5.1.5.4 Shellfish Consumption

Site-specific shellfish consumption information is not available. For shellfish, only adult consumption was evaluated. It should be noted that there is currently a fish consumption advisory for wood-treating chemicals in a portion of the Study Area recommending that crayfish not be eaten (ODHS 2007). Ingestion rates of 3.3 g/day and 18 g/day were used to calculate intakes from shellfish consumption~~, and are referred to as "medium" and "high" ingestion rates, respectively, for the purposes of this BHHRA.~~ . These values represent the 50th percentile (3.3 g/day) and 95th percentile (18 g/day) ingestion rates for shellfish consumption from freshwater and estuarine systems for individuals of age 18 and older in the United States (EPA 2002b). These ingestion rates were used with 95% UCL/max and mean EPCs for crayfish and clams described in Section 3.4.5 (because these scenarios were not classified as CT or RME). Exposure assumptions for shellfish consumption are presented in Table 3-29. The uncertainties associated with the shellfish consumption scenario are discussed in ~~Section~~ Section 6 of this BHHRA.

3.5.1.6 Tribal Fishers

For thousands of years, the Willamette River has been an important ceremonial and subsistence fishery (i.e., salmon, lamprey, and sturgeon) for Native American tribes of the region. Native Americans continue to rely on the Willamette River. For example, tribal members conduct a ceremonial spring Chinook ~~fishery~~ harvest and continue to harvest lamprey at Willamette Falls annually.

3.5.1.6.1 Beach Sediment Exposure

Beach sediment exposure would only occur for tribal fishers during bank fishing at natural river beach areas within the Study Area. EPA provided the exposure frequencies and durations for the tribal fishers used in this BHHRA. Tribal fishers were assumed to fish from the same beach area five days per week for the entire year (260 days/year) for an entire lifetime (70 years) for the RME. Although it is not known how much sediment contact actually occurs during fishing activities, default intake values for residential soil were used. Exposure assumptions for beach sediment contact for tribal fishers are presented in Table 3-26.

3.5.1.6.2 In-~~water~~ Water Sediment Exposure

At the request of EPA, the exposure frequencies and durations for beach sediment were assumed to represent the fishing frequency at the Study Area regardless of whether that fishing occurs from a beach or a boat. ~~In contrast to beach sediment, a tribal fisher is unlikely to have significant contact with in-water sediment in a given area at the Study Area every time fishing occurs, especially given the number of days and length of time over which exposures are assessed.~~ Therefore, a factor of 25 percent was used to represent the percent of time exposed to in-water sediment while fishing in a single area within the Study Area.

Contact with sediment on anchors or hooks represents the most likely exposure route for contact with in-water sediments for tribal fishers.~~Based on the exposure scenarios for in-water sediment (i.e., contact with sediment on anchors, or hooks), the extent of contact with in-water sediment would be significantly less than what would occur with soil.~~ Ingestion rates for soil are based on exposure to soil during yard work and to indoor dust (EPA 1997a). These ingestion rates are not applicable to the in-water sediment exposure scenarios; however, incidental ingestion rates are not available for sediment. It is assumed that the incidental ingestion rate for in-water sediment is 50% of the ingestion rate for residential soil scenarios. For dermal contact, hands and forearms are the only body parts that could be exposed to in-water sediment on a regular basis. It is assumed that the entire surface area of both hands and forearms would be exposed to in-water sediment. The adherence and absorption factors are assumed to be the same as those for beach sediment. Exposure assumptions for in-water sediment contact for tribal fishers are presented in Table 3-27.

3.5.1.6.3 Tribal Fish Consumption

A multi~~ple -~~species diet that includes resident fish as well as salmonids, lamprey, and sturgeon was evaluated for tribal fish consumption. While site-specific fish consumption information is not available for the tribal fish consumption scenario, a fish consumption survey was conducted on the reservations of four of the participating Tribes (CRITFC 1994). The 95th percentile fish ingestion rate for consumers only from the CRITFC Fish Consumption Survey, which is 175 g/day, was used to calculate intakes for adult tribal fish consumers. On October 23, 2008, the Oregon Environmental Quality Commission approved a fish consumption rate of 175 g/day, referenced from the CRITFC (1994) survey, as the basis for ODEQ to revise state water quality standards. To date, the water quality standards have not yet been revised using the fish consumption rate of 175 g/day. This rate corresponds to approximately 23 meals per month every month of the year of fish caught exclusively within the Study Area. The CRITFC survey reported that none of the respondents fished the Willamette River for resident fish and approximately 4 percent fished the Willamette River for anadromous fish. The 95th percentile fish ingestion rate of 73 g/day for children from the CRITFC Fish Consumption Survey was used for child tribal fish consumers. Exposure assumptions for tribal fish consumption are presented in Table 3-29.

A multi~~ple -~~species diet was evaluated using the fish consumption data from the CRITFC Fish Consumption Survey (CRITFC 1994) with concentration data from the target resident species as well as from sturgeon, salmon and lamprey caught as a part of the ODHS sampling effort. The fish consumption information from the CRITFC survey was used to determine the ingestion rate for each fish species, as shown below:

Species	Grams per day[(a)]	Percent of diet
Salmon	67	38.4

Species	Grams per day[(a)]	Percent of diet
Lamprey	12.3	7.0
Sturgeon	8.6	4.9
Smelt	12.5	7.2
Whitefish	23.2	13.3
Trout	25.1	14.3
Walleye	9.9	5.7
Northern Pikeminnow	3.7	2.1
Sucker	7.3	4.2
Shad	5.2	3.0
Total Ingestion Rate	175	100

(a) Grams per day are based on the weighted mean data in Table 18 of the CRITFC Fish Consumption ~~study~~survey.

For adult tribal consumers, the ingestion rates for anadromous salmonids (67 g/day), lamprey (12.3 g/day), and sturgeon (8.6 g/day) were used with the respective 95% UCL/max and mean EPCs for those species to calculate intakes. For the remaining species, each of the 95% UCL/max and mean EPCs calculated for the entire Study Area for smallmouth bass, black crappie, common carp, and brown bullhead were used with an ingestion rate of 21.7 g/day (i.e., the ingestion rate for the sum of the species that are not anadromous salmonid, sturgeon or lamprey, 86.9 g/day, divided by 4). The combined intakes from anadromous salmonids and~~,~~ lamprey, from sturgeon, and from the remaining fish species in the above table were used to estimate risks from fish consumption. The intakes for child tribal fish consumers were calculated using the same dietary percentages as the adult tribal fish consumers, but with a total ingestion rate of 73 g/day.

Adult salmon, adult lamprey, and sturgeon have life histories such that significant exposure to contaminants can occur outside of the Study Area. The uncertainties in estimating the proportion of contaminants in sturgeon, salmon and lamprey and associated risks that result from contaminants at the Study Area are discussed in ~~Section~~ Section 6.

3.5.1.7 Divers

Divers could contact in-water sediment and surface water while performing specific commercial diving activities such as marine construction, underwater inspections, and routine operation and maintenance. As previously discussed in Section 3.3.2.2, exposure factors for divers were provided as a directive from EPA in a memorandum

dated September 15, 2008 (EPA 2008c). The EPA developed two exposure scenarios to differentiate exposures by divers wearing wet suits from exposures by divers wearing dry suits. For both the RME wet suit and dry suit scenarios, divers were assumed to contact in-water sediment and surface water for 25 years of employment with 5 days of exposure frequency per year. For the CT scenario, which only includes wet suit divers, divers were assumed to contact in-water sediment and surface water for 9 years of employment with 2 days of exposure frequency per year. The event duration for exposure to sediment and surface water for both diver scenarios was 4 hours per diver for the RME and 2 hours per diver for the CT exposure. Whole body exposure was assumed for the skin surface area for the wet suit diver scenario (RME and CT), so that the surface area for the exposed skin was 18,510 square~~d~~ centimeters (cm^2). For the skin surface area for the dry suit diver scenario (RME only), it was assumed that only the head and neck would be exposed, equivalent to a skin surface area of approximately 2,510 cm^2. The sediment dermal adherence factors for both diver exposure scenarios were the same as those for the in-water fishers. The sediment ingestion rates for both diver exposure scenarios were the same as the in-water fishers (RME of 50 mg/day and CT of 25 mg/day), though the sediment contact frequency term was not used for divers. The water ingestion rates for both diver exposure scenarios were the same as those used for the recreational beach swimmers. Tables 3-27 and 3-28 summarize exposure assumptions for the wet suit and dry suit divers for in-water sediment and surface water, respectively, and the reference or rationale for each value.

3.5.1.8 ~~Hypothetical~~ Domestic Water Use<u>rs</u>

~~Although s~~<u>S</u>urface water within the Study Area is not currently used as a domestic water source and there are no known plans to use it as a domestic water source in the future~~,~~<u>. However, the designated beneficial uses of the Willamette River include domestic water supply, assuming adequate pretreatment of the water prior to consumption. EPA specified that the BHHRA evaluate use of untreated river water as a domestic water supply. This scenario is considered hypothetical because pretreatment of surface water for domestic use would be required under current state laws.</u>

To evaluate this hypothetical scenario, default EPA intake parameters for residential drinking water were used for both adult and child exposures. Exposure duration was assumed to be 350 days per year for both adult and child residents. The water ingestion rates used for both adult and child were those recommended for residential ingestion of drinking water (EPA 1989). The event duration and skin surface area were the recommended values for adults and children while showering or bathing (EPA 2004). Event frequency was once per day for both adult and child. <u>None of the chemicals selected as COPCs for the domestic water use scenario were volatile, and therefore the inhalation exposure route was not evaluated for this scenario.</u>

Table 3-30 summarizes the exposure assumptions for the hypothetical domestic water use by adult and child residents, and the reference or rationale for each value.

3.5.2 Chemical-Specific Exposure Factors and Assumptions

In calculating chemical intakes, certain assumptions were made that were specific to a given chemical or class of chemicals. These chemical-specific assumptions had an effect on both EPCs and intake calculations, and are described below.

3.5.2.1 Exposure Point Concentrations

Calculations of EPCs are described in Section 3.4 and the resulting EPC values are presented in Tables 3-2 through 3-25. Inorganic arsenic EPCs were estimated from total arsenic concentrations, as described below. In addition, PCBs were summed in several different ways, as described below.

Arsenic was analyzed as total arsenic, but the toxicity values for arsenic are only relevant for inorganic arsenic, which is most significant for tissue. In previous fish tissue studies in the lower Columbia and Willamette Rivers, the percent of inorganic arsenic relative to total arsenic ranged from 0.1% to 26.6% with an average percent inorganic arsenic of 5.3% in the resident fish samples from the Willamette River (Tetra Tech 1995, EVS 2000). Shellfish may have a higher percentage of inorganic arsenic, as measured in studies on the Lower Duwamish River. The Columbia River Basin Fish Contaminant Survey (EPA 2002c) concluded that a "value of 10% is expected to result in a health protective estimate of the potential health effects from arsenic in fish." Therefore, it was assumed that 10% of total arsenic in tissue was in the form of inorganic arsenic for purposes of this BHHRA. The total arsenic concentrations were multiplied by 10% and the resulting value was used in calculating the tissue EPCs for arsenic. Uncertainties associated with the assumption that 10% of the total arsenic is in the inorganic form in fish and shellfish are discussed further in ~~Section~~ Section 6.

PCBs were analyzed as Aroclors and congeners in tissue. For PCBs analyzed as Aroclors, the summed concentration of individual Aroclors was used in calculating the EPCs, as described in Attachment F2. For PCBs analyzed as congeners, EPCs were calculated using both the total PCB value (sum of individual congeners) and an adjusted total PCB value. The adjusted total PCB value was calculated by subtracting the concentration of the coplanar PCB congeners from the total PCB concentration. This was done because the coplanar PCB congeners were evaluated separately (as TCDD toxic equivalents [TEQs]) for cancer risks. Further explanation of how PCB congeners were summed is provided in Attachment F2.

3.5.2.2 Dermal Absorption Factors for Sediment

EPA's Supplemental Guidance for Dermal Risk Assessment (2004) provides chemical-specific values for dermal absorption from contaminated soil. These chemical-specific dermal absorption factors were used in the intake equations for dermal contact with sediment and are presented in Table 3-31. However, as noted in EPA guidance (2004), the amount of chemical absorbed from sediment may differ from that absorbed from soil due to differences in the relative importance of

numerous chemical, physical, and biological factors. A default dermal absorption value was used for semi-volatile organic compounds (SVOCs) that do not have chemical-specific values. Per EPA guidance (2004), only those compounds or classes of compounds for which dermal absorption factors exist were evaluated quantitatively for the dermal contact exposure pathway. For compounds without dermal absorption factors, which are certain metals and perchlorate for the sediment COPCs, dermal intake was assumed to be zero. The uncertainties associated with chemicals lacking dermal absorption factors are discussed in Section Section 6.

3.5.2.3 Dermal Absorption Factors for Surface Water and Groundwater Seeps

One of the parameters in the intake equations for dermal contact with surface water or groundwater seeps is the absorbed dose per event (DA_{event}). This parameter was derived per EPA guidance (2004) using chemical-specific factors, which are presented in Table 3-32 for scenarios involving direct contact with surface water or groundwater seeps and in Table 3-33 for the hypothetical domestic water use scenario. The chemical-specific factors used in the calculation of DA_{event} were obtained from Appendix B (Screening Tables and Reference Values for the Water Pathway) of EPA's Supplemental Guidance for Dermal Risk Assessment (2004). The uncertainties associated with calculating DA_{event} for chemicals with factors outside of the predictive domain are discussed in Section Section 6.

3.5.2.4 Oral Bioavailability Factors for Sediment

Consistent with EPA guidance (1989), the chemical intake equations calculate the amount of chemical at the human exchange boundaries, not the amount of chemical available for absorption. Therefore, the estimated intakes calculated in this BHHRA are not the same as the absorbed dose of a chemical. However, the toxicity of an ingested chemical depends on the degree to which the chemical is absorbed from the gastrointestinal tract into the body. Per EPA guidance (1989, 2007c), if the exposure medium in the risk assessment differs from the exposure medium assumed by the toxicity value, an adjustment for bioavailability may be appropriate. For purposes of this BHHRA, oral bioavailability factors were not used to adjust the estimated exposures from COPCs in sediment. The uncertainties associated with not considering bioavailability in this BHHRA are discussed in Section Section 6.

4.0 TOXICITY ASSESSMENT

Toxicity values provide a quantitative estimate of the potential for adverse effects resulting from exposure to a chemical. Toxicity values are used in risk assessment to quantify the likelihood of adverse effects occurring at different levels of exposure to a chemical.

Toxicity values were identified for the COPCs that were selected in Section 2.4. The cancer and noncancer toxicity values are shown in Tables 4-1 and 4-2, respectively. The following sections discuss the toxicity values and describe how they were selected.

4.1 CARCINOGENIC TOXICITY VALUES

Slope factors (SFs) are used to quantify the dose-response potency of potential carcinogens. SFs are derived from either human epidemiological or animal studies by applying a mathematical model to the dataset to extrapolate from the high doses in studies to the lower exposure levels expected for human contact in the environment (EPA 1989). The SF is an upper-bound estimate or maximum likelihood estimate of the probability of a response over a lifetime.

Slope factors are available for oral and inhalation exposure pathways. The inhalation exposure pathway was not quantitatively evaluated in this BHHRA, so inhalation ~~SFs~~ unit risk values were not selected as toxicity values. Dermal SFs were derived from the oral SFs, as described in Section 4.7. The oral and dermal cancer slope factors are presented in Table 4-1. In accordance with EPA (2005a) guidance, the weight of evidence for carcinogenicity for each COPC is also presented in Table 4-1.

4.2 NONCARCINOGENIC TOXICITY VALUES

A chemical that exhibits adverse effects other than cancer or mutation-based developmental effects is believed to have a threshold (i.e., a dose below which no adverse effect is expected to occur). Reference doses (RfDs) are typically used as toxicity values for chemicals with noncarcinogenic effects. A chronic RfD is defined as a daily dose to which humans, including sensitive subpopulations, may be exposed throughout their lifetimes without adverse health effects.

Reference doses are available for oral and inhalation exposure pathways. The inhalation exposure pathway was not quantitatively evaluated in this BHHRA, so inhalation ~~RfDs~~ reference concentrations were not selected as toxicity values. Dermal reference doses were derived from oral reference doses, as described in Section 4.7. Reference doses for oral and dermal exposure pathways are presented in Table 4-2.

4.3 SOURCES OF TOXICITY VALUES

The following hierarchy of sources of toxicity values is currently recommended for use at Superfund sites (EPA 2003b):

- Tier 1 – EPA's Integrated Risk Information System (IRIS) database (EPA ~~2009b~~2010b) is the preferred source of information because it normally represents the official EPA scientific position regarding the toxicity of the chemicals based on the data available at the time of the review. IRIS contains RfDs and SFs that have gone through a peer review and EPA consensus review.
- Tier 2 - EPA's Provisional Peer Reviewed Toxicity Values (PPRTVs) are toxicity values derived for use in the Superfund Program when such values are not available in IRIS. PPRTVs are derived after a review of the relevant scientific literature using the methods, sources of data and guidance for value derivation used by the EPA IRIS Program. The PPRTV database includes RfDs and SFs that have undergone internal and external peer review. The Office of Research and Development/National Center for Environmental Assessment/Superfund Health Risk Technical Support Center (STSC) develops PPRTVs on a chemical-specific basis when requested by EPA's Superfund program.
- Tier 3 - Tier 3 includes additional EPA and non-EPA sources of toxicity information. Priority is given to those sources of information that are the most current, the basis for which is transparent and publicly available, and which have been peer reviewed. Tier 3 sources may include, but need not be limited to, the following sources:
  - The California Environmental Protection Agency (Cal EPA) Toxicity Criteria Database (Cal EPA 2008) includes toxicity value~~SF~~s that have been peer reviewed.
  - The ATSDR Minimal Risk Levels are similar to RfDs and are peer reviewed.
  - Health Effects Assessment Summary Table (HEAST) toxicity values are currently under review by the STSC to derive PPRTVs. The toxicity values remaining in HEAST are considered Tier 3 values.

Toxicity values were retrieved from the most current version of the Regional Screening Levels for Chemical Contaminants at Superfund Sites (EPA 20~~09a,~~10a, values updated ~~April, 2009~~ November 2010. These values follow the above hierarchy, and present toxicity values from IRIS for both noncarcinogenic and carcinogenic effects were selected when available. If a toxicity value is not available from IRIS, toxicity values from the PPRTV database are presented, if available. In the absence of toxicity values from either IRIS or the PPRTV database, toxicity values from Tier 3 sources are presented, if available. The sources of the cancer or noncancer toxicity value are indicated in Tables 4-1 and 4-2. The dates shown in Tables 4-1 and 4-2 indicate the date of release of the Regional Screening Levels for Chemical Contaminants at Superfund Site table (EPA ~~2009a20~~010a).

For trichloroethylene, EPA provided the draft toxicity value equal to the geometric mid-point of the slope factor range (EPA 2001b) to use as the oral cancer slope factor. Recommendations were not provided for evaluating oral exposures for noncancer endpoints for trichloroethylene.

4.4 CHEMICALS WITH SURROGATE TOXICITY VALUES

For some chemicals, if a toxicity value was not available from the above hierarchy, a structurally similar chemical was identified as a surrogate. The reference dose or slope factor for the surrogate chemical was selected as the toxicity value and the surrogate chemical was indicated in Tables 4-1 and 4-2. The following chemicals have toxicity values from surrogate chemicals:

- Butyltin ion. Toxicity values were identified from the recommended hierarchy for dibutyltin compounds and tributyltin compounds. Toxicity of alkyltin compounds depends on the number of alkyl side-chains, with monoalkyl tin being the least and trialkyl tin the most toxic (National Library of Medicine [NLM] 2004). Therefore, dibutyltin is thought to be more similar to butyltin than tributyltin in toxicity, and is more toxic than butyltin. As a health protective approach, the toxicity value for dibutyltin compounds was selected as a surrogate for butyltin ion.

- Dibutyltin ion. The available toxicity value for dibutyltin is for dibutyltin compounds. However, the BHHRA sample results were for dibutyltin ion. The dibutyltin compounds toxicity value was selected as a surrogate for dibutyltin ion.

- Tributyltin ion. The available toxicity value for tributyltin is for tributyltin compounds. However, the BHHRA sample results were for tributyltin ion. The tributyltin compounds toxicity value was selected as a surrogate for tributyltin ion.

- Acenaphthylene. IRIS classifies acenaphthylene as a category D carcinogen (not classifiable as to human carcinogenicity), and therefore, is considered a noncarcinogenic polycyclic aromatic hydrocarbon (PAH). Acenaphthene is the noncarcinogenic PAH most similar in structure and carbon number to acenaphthylene. Therefore, the acenaphthene toxicity value was selected as a surrogate for acenaphthylene.

- Benzo(e)pyrene. IRIS classifies benzo(e)pyrene as a category D carcinogen (not classifiable as to human carcinogenicity), and therefore, is considered a noncarcinogenic PAH. Of the noncarcinogenic PAHs most similar in structure and carbon number to benzo(e)pyrene, pyrene has the lowest toxicity value and is therefore, considered the most toxic. As a health protective

approach, the pyrene toxicity value was selected as a surrogate for benzo(e)pyrene.

- Benzo(g,h,i)perylene. IRIS classifies benzo(g,h,i)perylene as a category D carcinogen (not classifiable as to human carcinogenicity), and therefore, is considered a noncarcinogenic PAH. Of the noncarcinogenic PAHs most similar in structure and carbon number to benzo(g,h,i)perylene, pyrene has the lowest toxicity value and is therefore, considered the most toxic. As a health protective approach, the pyrene toxicity value was selected as a surrogate for benzo(g,h,i)perylene.

- Dibenzothiophene. Toxicity values were not available for dibenzothiophene. The chemical with the most similar structure with available toxicity values is fluorene. The toxicity value for fluorene was selected as a surrogate for dibenzothiophene.

- Dibenzofuran. Toxicity values were not available for dibenzofuran. The chemical with the most similar structure with available toxicity values is fluorene. The toxicity value for fluorene was selected as a surrogate for dibenzofuran.

- Di-n-octyl phthalate. Toxicity values were not available for di-n-octyl phthalate. The chemical with the most similar structure with available toxicity values is dibutyl phthalate. The toxicity value for dibutyl phthalate was selected as a surrogate for di-n-octyl phthalate.

- Perylene. IRIS classifies perylene as a category D carcinogen (not classifiable as to human carcinogenicity), and therefore, is considered a noncarcinogenic PAH. Of the noncarcinogenic PAHs similar in structure and carbon number to perylene, pyrene has the lowest toxicity value and is therefore, considered the most toxic. As a health protective approach, the pyrene toxicity value was selected as a surrogate for perylene.

- Phenanthrene. IRIS classifies phenanthrene as a category D carcinogen (not classifiable as to human carcinogenicity), and therefore, is considered a noncarcinogenic PAH. Of the noncarcinogenic PAHs similar in structure and carbon number to phenanthrene, pyrene has the lowest toxicity value and is therefore, considered the most toxic. As a health protective approach, the pyrene toxicity value was selected as a surrogate for phenanthrene.

- Retene. Retene is a PAH classified by IRIS as a category D carcinogen (not classifiable as to human carcinogenicity). Of the noncarcinogenic PAHs similar in structure and carbon number to ~~perylene~~retene, pyrene has the lowest toxicity value and is therefore, considered the most toxic. As a health

protective approach, the pyrene toxicity value was selected as a surrogate for ~~perylene~~retene.

- Endrin aldehyde. Endrin aldehyde can occur as an impurity of endrin or as a degradation product (ATSDR 1996). The toxicity value for endrin was selected as a surrogate for endrin aldehyde.

- Endrin ketone. Endrin ketone can occur as an impurity of endrin or as a degradation product (ATSDR 1996). The toxicity value for endrin was selected as a surrogate for endrin ketone.

- 4-Nitrophenol. IRIS has toxicity values for 2-methylphenol and 4-methylphenol, but not 4-nitrophenol.~~—~~ The toxicity value for 4-methylphenol was selected as a surrogate for 4-nitrophenol.

4.5 CHEMICALS WITHOUT TOXICITY VALUES

Only two COPCs, titanium and delta-hexachlorocyclohexane (delta-HCH), did not have available SF and RfD toxicity values or appropriate surrogate chemicals from sources included in the hierarchy. Titanium is a naturally occurring element and has been characterized as having extremely low toxicity (Friberg et al. 1986). An STSC review concluded that the other hexachlorocyclohexane isomers could not be used as surrogates for delta-HCH due to differences in toxicity (EPA 2002d). In this BHHRA, the potential risks from titanium and delta-HCH are discussed qualitatively in the uncertainty assessment in ~~Section~~ Section 6.

SFs and RfDs were not identified for lead because lead was evaluated through comparison with benchmark concentrations that are based on blood lead levels. Benchmark concentrations for child exposure scenarios were predicted by the Integrated Exposure Uptake Biokinetic (IEUBK) model. Benchmark concentrations for adult exposure scenarios were predicted by the Adult Lead Methodology (ALM). Uncertainties associated with using these benchmark concentrations are discussed in ~~Section~~ Section 6.4.4.

4.6 TOXICITY VALUES FOR CHEMICAL MIXTURES

Some toxicity values are based on exposure to chemical mixtures and not to individual chemicals. As a result, the risks were evaluated for the combined exposure to the chemicals and not on an individual chemical basis. The chemicals that were evaluated for toxicity as mixtures are indicated in Tables 4-1 and 4-2, and are discussed below.

- Chlordane. The chlordane toxicity values were derived for technical chlordane, which is composed of a mixture of chlordane isomers. The chlordane isomers analyzed in Round 1, Round 2, and Round 3 samples were

alpha-chlordane, trans-chlordane, cis-nonachlor, trans-nonachlor, and oxychlordane. These isomers were summed in a total chlordane concentration. The SF and RfD for technical chlordane were used to evaluate total chlordane.

- DDD, DDE, and DDT. Technical DDT includes 2,4'-DDT and 4,4'-DDT, as well as 2,4'-DDE, 4,4'-DDE, 2,4'-DDD, and 4,4'-DDD. DDD, DDE, and DDT have separate SFs included in IRIS. While the SFs were derived for the 4,4' isomers, the SFs were used to evaluate the sum of the 2,4' and 4,4' isomers because toxicity values are not available for the 2,4' isomers. The DDT RfD was derived for a mixture of the 2,4' and 4,4' isomers and was used to evaluate the noncancer endpoint of DDT. An RfD is not available for the DDD or DDE isomers, so the DDT RfD was selected as a surrogate toxicity value and was used to evaluate the noncancer endpoint of DDD and DDE.

- Endosulfan. The toxicity value (RfD) for endosulfan was derived from studies using technical endosulfan, which includes alpha-endosulfan, beta-endosulfan and endosulfan sulfate. These compounds were summed in a total endosulfan concentration. The RfD for technical endosulfan was used to evaluate total endosulfan.

- PCBs. The PCB cancer SF was derived for PCB mixtures based on administered doses of Aroclors to rats. The cancer SF was applied to total PCBs, measured either as congeners or Aroclors. The PCB SF was applied to the total PCB congener concentration after subtracting the total dioxin-like PCB congener concentration. Dioxin-like PCB congener concentrations were evaluated separately using the 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD) SF, as described below for dioxins and furans. This approach may double-count a portion of~~s~~ the toxicity of the dioxin-like PCBs, as discussed in ~~Section~~ Section 6.3.6. The Aroclor 1254 RfD was used to evaluate the noncancer endpoint for total PCBs, measured either as total unadjusted congeners or Aroclors.

- Dioxins and furans. Toxic Equivalency Factors (TEFs) from the World Health Organization (WHO) (Van den Berg 2006) were used to evaluate carcinogenic effects of dioxin and furan congeners and dioxin-like PCB congeners (see Table 4-3). Concentrations of congeners are multiplied by their TEFs to estimate the toxicity of these congeners relative to 2,3,7,8-TCDD; the resulting concentrations are then summed into a total 2,3,7,8-TCDD TEQ. The 2,3,7,8-TCDD SF was used to evaluate the cancer endpoint of the TEQ for dioxin and furan congeners and for dioxin-like PCB congeners. The 2,3,7,8-TCDD RfD was used with the same approach to evaluate the noncancer endpoint of the TEQ for dioxin and furan congeners and for dioxin-like PCB congeners.

- Carcinogenic PAHs. Carcinogenic PAHs can be evaluated for toxicity based on their potency equivalency factor (PEF), which estimates toxicity relative to benzo(a)pyrene (EPA 1993). The toxicity values for individual PAHs shown in Table 4-1 incorporate their respective PEFs. Risk from both individual and total carcinogenic PAHs was assessed in this BHHRA.

4.7 DERMAL TOXICITY ASSESSMENT

Most toxicity values are based on oral, not dermal, exposures. For oral exposures, toxicity values are often expressed as the amount of substance administered, whereas dermal exposures are expressed as absorbed dose. EPA has developed a simplified method for oral-to-dermal extrapolations (EPA 2004). These extrapolations involve an adjustment to the oral toxicity value based on the GI absorption factor of the specific chemical in the same administration vehicle (e.g., corn oil, food) as used in the critical toxicity study to derive an estimated dermal dose.

As recommended by EPA guidance (EPA 2004), an adjustment to the oral toxicity factor to account for the estimated absorbed dose was applied in this BHHRA when the following conditions are met:

- The toxicity value derived from the critical study is based on an administered dose (e.g., through diet or by gavage)

- A scientifically defensible database demonstrates the GI absorption of the chemical is less than 50% in a medium similar to the one used in the critical study.

If both of these conditions are met, the oral toxicity factor was adjusted to reflect the absorbed dose in this BHHRA. For carcinogenic effects, the oral slope factor was divided by the GI absorption factor to estimate the dermal slope factor. Hexavalent chromium was the only COPC for which the oral slope factor was adjusted to reflect the absorbed dose. For noncarcinogenic effects, the oral reference dose was multiplied by the GI absorption factor to estimate the dermal reference dose. The COPCs for which the oral reference dose was adjusted to reflect the absorbed dose are the metals: antimony, barium, cadmium, trivalent chromium, hexavalent chromium, manganese, mercury, silver, and vanadium.

If both conditions for adjustment are not met, the oral toxicity value was used as a surrogate for the dermal toxicity value in the BHHRA. Dermal toxicity factors are presented in Tables 4-1 and 4-2.

5.0 RISK CHARACTERIZATION

Risk characterization integrates the information from the exposure assessment and toxicity assessment, using a combination of qualitative and quantitative information. With this information, risk characterization estimates the potential health risk, based on the dose of a chemical, that a person may receive under certain site-specific exposure conditions and based on the toxicity of that chemical. Consistent with DEQ (DEQ 2000a) and EPA guidance (EPA 1989), noncarcinogenic and carcinogenic effects were evaluated separately. To characterize potential noncarcinogenic effects, comparisons were made between projected intakes of substances and toxicity values (Section 5.1.1). To characterize potential carcinogenic effects, projected intakes and chemical-specific, dose-response data were used to estimate the probability that an individual will develop cancer over a lifetime of exposure (Section 5.1.2).

5.1 RISK CHARACTERIZATION ESTIMATES

This section describes how ~~estimates for~~ noncancer hazards and cancer risks were estimated in this BHHRA.

5.1.1 Noncancer Hazard Estimates

The potential for adverse effects resulting from exposure to chemicals with noncarcinogenic effects is generally addressed by comparing the CDI or absorbed dose for a specific COPC to its RfD. This comparison was made by calculating the ratio of the estimated CDI (or absorbed dose) to the corresponding RfD to yield a hazard quotient (HQ):

$$HQ = \frac{CDI}{RfD}$$

HQs for individual chemicals were summed to yield cumulative hazard indices (HIs) that provide a ~~conservative~~n estimate of total hazard. Per EPA guidance (1989), HQs should only be summed for chemicals with common toxicological endpoints. Toxicological endpoints for COPCs are summarized in Table 5-1. Endpoint-specific HIs (e.g., neurological or immune system effects) were calculated for each exposure area in this BHHRA where the cumulative HI was greater than 1. The Columbia River Fish Contaminant Study performed a similar analysis for fish tissue collected from the Columbia River Basin (EPA 2002c). Toxicity endpoints were retrieved from EPA's Integrated Risk Information System (EPA ~~2009b~~2010b), and may differ from the endpoints used in CRITFC due to updates in the IRIS database since the CRITFC study.

Estimated HIs were compared to a target HI of 1, below which remedial action at a Superfund site is generally not warranted (EPA 1991a).

5.1.2 Cancer Risk Estimates

Potential cancer risks were assessed by multiplying the estimated LADI or absorbed dose of a carcinogen by its SF. This calculated risk is expressed as the probability of an individual developing cancer over a lifetime as a result of exposure to the potential carcinogen, and is a health protective estimate of the incremental probability of excess individual lifetime cancer risk.

$$Risk = LADI * SF$$

Initially, potential cancer risks were estimated separately for each chemical. The separate potential cancer risk estimates were summed across chemicals for each exposure area to obtain the cumulative excess lifetime cancer risk for the exposure scenario.

~~All c~~Cancer risks were calculated using this same linear model, even though risk estimates for some scenarios exceed 1 x 10^{-2}, in which case, EPA guidance (EPA 1989) states that risks ~~may~~ should be calculated using an exponential model. Where cancer risks exceeded 1 x 10^{-2}, the exponential model was used. Estimated total cancer risks were compared to 1 x 10^{-4}, 1 x 10^{-5}, and 1 x 10^{-6} cancer risk targets based upon the following language in EPA's National Contingency Plan (NCP): "For known or suspected carcinogens, acceptable exposure levels are generally concentration levels that represent an excess upper bound lifetime cancer risk to an individual of between 1 x 10^{-4} and 1 x 10^{-6}." The point of departure for cancer risks is 1 x 10^{-6}.~~Estimated total cancer risks were compared to a 10^{-4} to 10^{-6} risk range, which is the "target range" within which the EPA strives to manage risk as a part of the Superfund program (EPA 1991a). The DEQ acceptable risk levels are 1 x 10^{-6} for individual carcinogens and 1x10^{-5} for cumulative cancer risks.~~

5.1.3 Combined Adult/Child Scenarios

Cancer risks were calculated separately for adult and child receptors for the recreational beach user and fisher scenarios. To assess risks to individuals exposed as both a child and an adult, cancer risks were also calculated for a combined adult and child receptor for the recreational beach user and fisher scenarios. The combined adult and child receptor was based on EPA guidance (1991b, 2010a), in which 6 years of exposure is assumed to occur as a child and 24 years of exposure is assumed to occur as an adult for a total of 30 years for the non-tribal fisher scenario and the RME exposure duration for the beach user scenario. For the tribal fisher scenario, the combined adult and child scenario assumed 6 years of exposure as a child and 64 years of exposure as an adult. For the CT exposure duration for the beach user scenario, the combined adult and child scenario assumed 6 years of exposure as a child and 9 years of exposure as an adult.

For chemicals not acting by a mutagenic mode of action (i.e., all chemicals evaluated in this BHHRA other than carcinogenic PAHs), the cancer risks for the combined

adult and child receptor were calculated by adding the cancer risks for the adult to the cancer risks for the child. For the non-tribal fisher and the RME beach sediment exposure scenarios, the adult cancer risk was multiplied by a factor of 24/30 to account for the 24 years of exposure as an adult in the combined scenario versus the 30 years used in the adult only scenario and then added to the child cancer risk. For the tribal fisher scenario, the adult cancer risk was multiplied by a factor of 64/70 to account for the 64 years of exposure as an adult in the combined scenario versus the 70 years used in the adult only scenario and then added to the child cancer risk.

For chemicals acting by a mutagenic mode of action (i.e., carcinogenic PAHs), the cancer risks were calculated for the combined adult and child receptor by incorporating EPA's guidance (2005b) on early life exposures to carcinogens. Specifically, age dependent adjustment factors (ADAFs) were used to account for the increased carcinogenic potency during early life exposures. For ages 0 to 2 years, an ADAF of 10 was used. For ages 2 to 6 years and 6 to 16 years, an ADAF of 3 was used. For ages over 16 years, an ADAF of 1 was used. The ADAFs were incorporated into the risk calculations through the use of age adjusted factors. The exposure factors used for the ages 0 to 2 and 2 to 6 years were the same as the child receptor and the exposure factors used for the ages 6 to 16 years and over 16 years were the same as the adult receptor.

The cancer risk estimates for the combined adult and child receptor are presented in the beach sediment and fish consumption risk characterization results below.

5.1.4 Infant Consumption of Human Milk

For bioaccumulative chemicals, exposure to the mother can lead to the presence of those chemicals in human milk, which can pose a risk to breastfeeding infants. Per agreement with EPA and DEQ, risks to infants through the consumption of human milk were included for all receptors where PCBs, dioxins, and/or DDX were identified as COPCs. Risks were assessed in accordance with DEQ guidance (2010).

To assess risks to infants, infant risk adjustment factors (IRAFs) were applied to the mother's risk. For cancer risks, the combined adult and child risks were used for the mother cancer risk for receptors where both adult and child exposures could occur. For receptors where only adult exposure was evaluated, the adult cancer risk was used for the mother cancer risk. For noncancer hazards, the adult hazard quotient was used for the mother hazard quotient.

The IRAFs used to assess risks were from DEQ guidance (2010). Specifically, IRAFs of 1 were used for PCB, PCB TEQ, and dioxin TEQ cancer risks. An IRAF of 0.007 was used for DDX cancer risks. IRAFs of 2 were used for PCB TEQ, dioxin TEQ, and DDX noncancer hazards. An IRAF of 25 was used for PCB noncancer hazards.

The risks to infants through consumption of human milk are presented in the risk characterization results below.

~~5.1.3~~5.1.5 Cumulative Risk Estimates

Noncancer HQs and cancer risks were calculated for all individual contaminants ~~chemicals~~ for which EPCs were available, as described above. In some cases, contaminants ~~chemicals~~ were analyzed by different methods, so there were multiple EPCs for that contaminant~~chemical~~. In calculating the cumulative risks, only the risk associated with the EPC for one method was included in the sum to avoid double-counting the risks from a given contaminant~~chemical~~.

For example, total PCBs were analyzed both as congeners and as Aroclors. In sediment, the Aroclor dataset was larger, so the risk from total PCBs as Aroclors was included in the cumulative risk estimate for sediment. For tissue, the congener analysis provides better detection limits. Therefore, the risk from total PCBs as congeners was included in the cumulative risk estimate for tissue, if congener data were available. If congener data were not available for tissue, the risk from total PCBs as Aroclors was used in estimating the cumulative risk for tissue.

In surface water and most of the groundwater seep samples, metals were analyzed as both total and dissolved. Because total concentrations are typically higher, the EPCs for total metals were included in the cumulative risk estimates as a conservative approach.

The individual risks from the EPCs for all of the analytical methods are presented in the risk characterization result tables (Tables 5-2 through 5-~~1~~98). The tables also indicate which results were included in the cumulative risks when multiple EPCs were available for a given chemical.

5.2 RISK CHARACTERIZATION RESULTS

This section presents the results of the risk characterization for each of the scenarios described in Section 3. Uncertainties associated with the assumptions in each exposure scenario are discussed in detail in Section ~~6~~6. Risks from exposures to PBDEs in in-water sediment and tissue were assessed separately, and are presented in Attachment F3. If actual exposures for each scenario were less than the exposures assumed in the risk calculations, the estimated risks would also decrease correspondingly.

5.2.1 Beach Sediment Risk Characterization Results

Potential risks from exposure to beach sediment through incidental ingestion and dermal absorption were estimated for the dockside workers, transients, recreational beach users, fishers and tribal fishers. There were multiple uncertainties associated

with the direct exposure to beach sediment scenarios such as the spatial scale of the individual beaches and the exposure parameters, which are further described in the following sections. ~~. The health protective assumptions regarding direct exposure to beach sediment were multiplied together, which magnifies the overall conservatism in the risk estimates.~~ Beaches with cumulative cancer risks greater than 1 x 10^{-6} and 1 x 10^{-5} are summarized by exposure point and receptor in Map~~s~~ 5-1-1 and 5-1-2 ~~and 5-2, respectively~~. There were no beach areas associated with cancer risk levels greater than 1 x 10^{-4} or HIs greater than 1.

5.2.1.1 Dockside Worker

Risks for the dockside worker were estimated separately for each beach designated as a potential dockside worker use area, which are shown in Map 2-1. The results of the risk evaluation for dockside worker exposure to beach sediment are presented in Tables 5-2 through 5-~~5~~3.

The dockside worker RME scenario for beach sediment results in exceedances of a cumulative cancer risk level of 1 x 10^{-6} at beaches 06B025 (9 x 10^{-5} risk) and B004 (2 x 10^{-6} risk). There are no exposure areas that result in an exceedance of 1 x 10^{-4} cancer risk for the dockside worker RME scenario. The maximum cumulative cancer risk for an individual exposure area occurs at 06B025 ~~(9 x 10^{-5})~~ and is primarily due to incidental ingestion of beach sediment containing benzo(a)pyrene. In addition to benzo(a)pyrene, other chemicals contributing to a calculated individual cancer risk greater than 1 x 10^{-6} for at least one exposure area include: benzo(a)anthracene, benzo(b)flouranthene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene. The HIs for the dockside worker RME scenario do not exceed 1. ~~In estimating risks for the RME scenario, it was assumed that exposure occurs at an individual beach one day per week for 50 weeks a year for 25 years, and the level of exposure is the same as for soil.~~

The dockside worker CT scenario for beach sediment results in one exceedance of 1 x 10^{-6} cumulative cancer risk (at beach 06B025, 6 x 10^{-6} risk), which is primarily due to the incidental ingestion of sediment containing benzo(a)pyrene. There are no exposure areas that result in an exceedance of 1 x 10^{-4} cancer risk for the dockside worker CT beach sediment scenario. The dockside worker CT scenario results in no exceedances of a HI of 1. ~~In estimating risks for the CT scenario, it was assumed that exposure occurs at an individual beach one day per week for 44 weeks a year for nine years, and the level of exposure is the same as for soil.~~ Figures 5-1 shows risks to the dockside worker from exposure to beach sediment per beach, and shows the relative contribution of individual chemicals to total risk.

5.2.1.2 Transients

Risks for the transients were estimated separately for each beach designated as a potential transient use area, which are shown in Map 2-1. The results of the risk

evaluation for transient exposure to beach sediment are presented in Tables 5-~~6~~ 4 through 5-~~9~~5.

The transient RME scenario for beach sediment results in no exceedances of 1 x 10^{-6} cancer risk and no exceedances of a HI of 1. The transient CT scenario for beach sediment results in no exceedances of 1 x 10^{-6} cancer risk and no exceedances of a HI of 1.

5.2.1.3 Recreational Beach Users

Risks for the recreational beach users were estimated separately for each beach designated as a potential recreational use area, which are shown in Map 2-1. ~~Risks~~ Cancer risks and noncancer hazards were evaluated for both adult and child recreational beach users. In addition, carcinogenic risks were calculated for a combined child and adult scenario. The results of the risk evaluation for ~~adult~~ recreational beach user exposure to beach sediment are presented in Tables 5-~~6~~10 through 5-~~13~~11. ~~The results of the risk evaluation for child recreational beach user exposure to beach sediment are presented in Tables 5-14 through 5-17.~~

5.2.1.3.1 Adult Recreational Beach Users

The adult recreational beach user RME scenario for beach sediment results in cumulative cancer risk exceedances of 1 x 10^{-6} at the following beaches: 04B024 (risk is 3 x 10^{-6}), 06B030 (risk is 4 x 10^{-6}), B003 (risk is 3 x 10^{-6}), and B005 (risk is 2 x 10^{-6}). There are no exceedances of 1 x 10^{-4} cancer risk for the adult recreational beach user RME scenario. The maximum cumulative cancer risk from RME occurs at Beach 06B030 ~~(4 x 10^{-6})~~ and is primarily due to incidental ingestion of beach sediment containing arsenic. The adult recreational beach user RME scenario for beach sediment resulted in no HIs greater than 1. Figures 5-2 and 5-3 show the relative risk contribution of individual COPCs for each beach, as well as total risk by river mile for adult recreational beach user exposure to beach sediment.

Arsenic is a naturally occurring metal. The concentration for arsenic in soil recognized by DEQ to represent background levels in Oregon is 7 milligrams per kilogram (mg/kg) (DEQ 2007). At this background concentration, the calculated risk from arsenic would exceed 1 x 10^{-6} for the adult recreational beach user RME scenario. When a background concentration of 7 mg/kg is subtracted from detected concentrations of arsenic in beach sediment, resulting cumulative risks for the adult recreational beach user RME scenario exceed 10^{-6} at beaches 04B024 and B003. Beaches with risk exceedances of 1 x 10^{-6} excluding risks from background arsenic are shown for all exposure scenarios for beach sediment in Maps 5-~~3~~2-1 and 5-2-2. In addition to risks from exposure to arsenic in beach sediment, risks from exposure to total cPAHs in beach sediment exceed 1 x 10^{-6} at two beach locations: 04B024 (2 x 10^{-6}) and B003 (2 x 10^{-6}). At each of these beaches, benzo(a)pyrene is the cPAH with the highest contribution to total risks from cPAHs.

The adult recreational beach user CT scenario for beach sediment results in no exceedances of 1 x 10^{-6} cumulative cancer risk and no exceedances of an HI of 1.

~~In estimating risks for the RME scenario, it was assumed that exposure occurs at an individual beach five days per week in the summer, one day per week in the spring and fall, and one day per month in the winter for 30 years, and the level of exposure is the same as for residential soil, except the adherence factor is even greater than that recommended for residential soil. For the CT scenario, it was assumed that exposure occurs at an individual beach two days per week in the summer and two days per month in the spring and fall for nine years, and the level of exposure is the same as for residential soil, except the adherence factor is even greater than that recommended for residential soil.~~

5.2.1.3.2 Child Recreational Beach Users

The child recreational beach user RME scenario for beach sediment results in cumulative risk exceedances of 1 x 10^{-6} at ~~13 of the~~all 15 of the exposure areas ~~(beaches 09B024 and 09B028 do not exceed 10^{-6} cumulative cancer risk)~~. There are no exceedances of 1 x 10^{-4} cancer risk for the child recreational beach user RME scenario. The maximum cumulative cancer risk from RME occurs at beaches ~~06B030,~~ B003, and 04B024 (~~1~~ 4 x 10^{-5}) and is primarily due to dermal absorption of soil containing arsenic and benzo(a)pyrene. The child recreational beach user RME scenario resulted in no HIs greater than 1.

The cumulative risk exceedances are ~~primarily~~ due in part to arsenic, which is naturally occurring. At the DEQ background soil concentration of 7 mg/kg, the calculated risk from arsenic would exceed 1 x 10^{-6} for the child recreational beach user RME scenario. When a background arsenic concentration of 7 mg/kg is subtracted from detected arsenic concentrations in beach sediment from potential human use areas, resulting cumulative risks for the child recreational beach user RME scenario exceed 1 x 10^{-6} at five beaches, as shown in Map 5-~~3~~2-1. These exceedances are due to exposure to arsenic at one beach, and exposure to benzo(a) pyrene or total cPAHs at the other four. Cancer risks above 1 x 10^{-6} from exposures to cPAHs in beach sediment range from 2 x 10^{-8} to 4 x 10^{-5}, due primarily to contributions from benzo(a)pyrene. Figures 5-4 and 5-5 show the relative risk contribution of individual COPCs for each beach, as well as total risk by river mile for child recreational beach user exposure to beach sediment.

The child recreational beach user CT scenario for beach sediment results in an ~~no~~ exceedance~~s~~ of 1 x 10^{-6} cumulative cancer risk at two beaches (risk of 2 x 10^{-6} at 04B024 and B003). There are~~and~~ no exceedances of an HI of 1.

~~In estimating risks for the RME scenario, it was assumed that exposure occurs at an individual beach five days per week in the summer, 1 day per week in the spring and fall, and one day per month in the winter for 6 years, and the level of exposure is the~~

~~same as for residential soil, except the adherence factor is even greater than that recommended for residential soil. For the CT scenario, it was assumed that exposure occurs at an individual beach two days per week in the summer and two days per month in the spring and fall for six years, and the level of exposure is the same as for residential soil, except the adherence factor is even greater than that recommended for residential soil.~~

5.2.1.3.3 Combined Child/Adult Recreational Beach Users

Cancer risks were calculated for the combined child and adult recreational beach users to incorporate early life exposures in accordance with EPA (2005b) and DEQ (2010) guidance. Cumulative risks per exposure area for RME scenarios ranged from 2×10^{-6} to 5×10^{-5}. For the CT scenarios, risks ranged from 2×10^{-7} to 2×10^{-6}. The highest risk was at Beach 04B024, primarily due to exposures to benzo(a)pyrene in beach sediment.

5.2.1.4 Tribal Fishers

Risks for the tribal fishers were estimated separately for each beach designated as a potential transient or recreational use area, which are shown in Map 2-1. The results of the risk evaluation for tribal fisher exposure to beach sediment are presented in Tables 5-~~18~~ 12 through 5-~~21~~13.

The tribal fisher RME scenario for beach sediment results in exceedances of 1×10^{-6} cumulative cancer risk at 18 of 18 exposure areas. There are no exceedances of 1×10^{-4} cancer risk for the tribal fisher RME scenario. The maximum cumulative cancer risk occurs at beaches 06B030, B003 and 04B024 (2×10^{-5}) and is primarily due to incidental ingestion of sediment containing arsenic or benzo(a)pyrene. The tribal fisher RME scenario for beach sediment resulted in no HIs greater than 1. Figures 5-6 and 5-7 show the relative risk contribution of individual COPCs for each beach, as well as total risk by river mile for tribal fisher exposure to beach sediment.

The tribal fisher CT scenario for beach sediment results in exceedances of 1×10^{-6} cumulative cancer risk at one of the 18 exposure areas (beach 06B030) primarily due to incidental ingestion of sediment containing arsenic. There are no exceedances of 1×10^{-4} cancer risk or HI of 1 for the tribal fisher CT scenario.

The cumulative risk exceedances of 1×10^{-6} are primarily due to arsenic, which is naturally occurring. At the DEQ background soil concentration of 7 mg/kg, the calculated risk from arsenic would exceed 1×10^{-6} for the tribal fisher RME scenarios. When a background arsenic concentration of 7 mg/kg is subtracted from detected arsenic concentrations in beach sediment from potential human use areas, resulting cumulative risks for the tribal fisher RME scenario exceed 1×10^{-6} at eight beaches, due primarily to exposure to benzo(a)pyrene and total cPAHs, as shown in Map 5-~~3~~2-1. Risks from exposure to cPAHs in sediment at these eight beaches range from 2×10^{-6} to 1×10^{-5}. Excluding background arsenic concentrations, exposure to beach sediment results in risks exceeding 1×10^{-6} from exposure to arsenic at one

beach location. The maximum cumulative risk to tribal fishers from potential exposure to beach sediment excluding background contribution from arsenic is 1 x 10^{-5}, which occurs at beaches 04B024 and B003.

~~**5.2.1.5**~~

~~In estimating risks for the RME scenario, it was assumed that exposure occurs at an individual beach 5 days per week for the entire year for 70 years and the level of exposure is the same as for residential soil, except the adherence factor is even greater than that recommended for residential soil. For the CT scenario, it was assumed that exposure occurs at an individual beach two days per week for the entire year for 30 years, and the level of exposure is the same as for residential soil, except the adherence factor is even greater than that recommended for residential soil.~~

~~5.2.1.6~~5.2.1.5 Fishers

Risks for the high- and low- frequency fishers were estimated separately for each beach designated as a potential transient or recreational use area, which are shown in Map 2-1. The results of the risk evaluation for high-frequency fisher exposure to beach sediment are presented in Tables 5-~~22~~ 14 through 5-~~25~~15. The results of the risk evaluation for low-frequency fisher exposure to beach sediment are presented in Tables 5-~~26~~ 16 through 5-~~29~~17.

~~5.2.1.6.1~~5.2.1.5.1 High-~~frequency~~ Frequency Fishers

The high-frequency fisher RME scenario for beach sediment results in exceedances of 1 x 10^{-6} cumulative cancer risk at 9 of 18 exposure areas (see Table 5-~~22~~14). There are no exceedances of 1 x 10^{-4} cancer risk for the high-frequency fisher RME scenario. The maximum cumulative cancer risk occurs at beaches 04B024 and 06B030 (6 x 10^{-6}) and is primarily due to incidental ingestion of sediment containing arsenic. In addition to arsenic, benzo(a)pyrene is the only other individual analyte resulting in a cancer risk greater than 1 x 10^{-6} at some exposure areas. The high-frequency fisher RME scenario for beach sediment resulted in no HIs greater than 1.

The cumulative risk exceedances of 1 x 10^{-6} are primarily due to arsenic, which is naturally occurring. At the DEQ background soil concentration of 7 mg/kg, the calculated risk from arsenic would exceed 1 x 10^{-6} for the high-frequency fisher RME scenarios. When a background arsenic concentration of 7 mg/kg is subtracted from detected arsenic concentrations in beach sediment from potential human use areas, resulting cumulative risks for the high-frequency fisher RME scenario exceed 1 x 10^{-6} at three beaches, as shown in Map 5-~~3~~2-1. The maximum cumulative risk to high-frequency fishers from potential exposure to beach sediment excluding background contribution from arsenic is 3 x10^{-6}, which occurs at beaches 04B024 and B003.

The high-frequency fisher CT scenario for beach sediment results in no exceedances of 1 x 10^{-6} cumulative cancer risk and no exceedances of an HI of 1.

~~In estimating risks for the RME scenario, it was assumed that exposure occurs at an individual beach three days per week for the entire year for 30 years and the level of exposure is the same as for residential soil, except the adherence factor is even greater than that recommended for residential soil (approximately 4 times higher). For the CT scenario, it was assumed that exposure occurs at an individual beach one day per week for the entire year for nine years, and the level of exposure is the same as for residential soil, except the adherence factor is even greater than that recommended for residential soil.~~

~~5.2.1.6.2~~5.2.1.5.2 Low-~~frequency~~ Frequency Fishers

The low-frequency fisher RME scenario for beach sediment results in exceedances of 1×10^{-6} cumulative cancer risk at six of 18 exposure areas (see Table 5-~~26~~16). There are no exceedances of 1×10^{-4} cancer risk for the low-frequency fisher RME scenario. The maximum cumulative cancer risk occurs at beaches 06B030 and 04B024 (4×10^{-6}), and is primarily due to incidental ingestion of sediment containing arsenic. Besides arsenic, there are no individual analytes resulting in a cancer risk greater than 1×10^{-6}. The low-frequency fisher RME scenario for beach sediment resulted in no HIs greater than 1.

The cumulative risk exceedances of 1×10^{-6} are primarily due to arsenic, which is naturally occurring. When a background arsenic concentration of 7 mg/kg is subtracted from detected arsenic concentrations in beach sediment from potential human use areas, resulting cumulative risks for the low-frequency fisher RME scenario exceed 1×10^{-6} at three beaches, as shown in Map 5-~~3~~2-1. The RME cumulative risk to low-frequency fishers from potential exposure to beach sediment, excluding background contributions from arsenic, is 2×10^{-6} at all three of these beaches.

The low-frequency fisher CT scenario for beach sediment results in no exceedances of 1×10^{-6} cumulative cancer risk and no exceedances of an HI of 1.

~~In estimating risks for the RME scenario, it was assumed that exposure occurs at an individual beach two days per week for the entire year for 30 years and the level of exposure is the same as for residential soil, except the adherence factor is even greater than that recommended for residential soil. For the CT scenario, it was assumed that exposure occurs at an individual beach one day every other week for the entire year for nine years, and the level of exposure is the same as for residential soil, except, as with the other fisher scenarios, the adherence factor is even greater than that recommended for residential soil.~~

~~5.2.1.7~~5.2.1.6 Breastfeeding Infants of Adults Exposed to Beach Sediment

Risks and hazards to breastfeeding infants from exposure to bioaccumulative compounds in human milk were assessed for scenarios resulting in bioaccumulative compounds as COPCs. In the case of the beach sediment exposure scenarios, only

the dockside worker exposures include bioaccumulative compounds as COPCs. The assessment of risks to infants entails applying a compound-specific infant risk adjustment factor (IRAF) to risks and hazards to the adult mother, in accordance with DEQ guidance (2010). Cumulative cancer risks to an infant consuming human milk from a dockside worker range from 5 x 10^{-10} to 1 x 10^{-6} across both CT and RME scenarios. Noncancer hazards range from 6 x 10^{-3} to 1 across both CT and RME scenarios. Risks to breastfeeding infants of dockside workers exposed to beach sediment are shown in Tables 5-18 through 5-19.

5.2.1.7 Summary of Beach Sediment Risk Characterization

Direct contact with beach sediment resulted in cumulative cancer risks ranging from 8 x 10^{-9} to 9 x 10^{-5}. Cumulative HIs for direct exposure to beach sediment were at or below the EPA target HI of 1 for all exposure scenarios. The highest cumulative cancer risks at industrial use beaches were for the dockside worker scenario, and the highest cumulative cancer risks at residential use beaches were for the tribal fisher scenario. Two chemicals resulted in a cancer risk greater than 1 x 10^{-6} for at least one of the scenarios evaluated for direct contact with beach sediment: arsenic and PAHs. Arsenic occurs both naturally and as a result of environmental releases. A summary of risks from beach sediment per beach is shown in Maps 5-1-1 and 5-1-2, and risks after subtracting an assumed background arsenic concentration of 7 mg/kg from the EPCs are shown in Maps 5-2-1 and 5-2-2. Table 5-20 provides a summary of risks from exposure to beach sediment, per receptor and exposure area.

5.2.2 In-Wwater Sediment Risk Characterization Results

Potential risks from exposure to in-water sediment through incidental ingestion and dermal absorption were estimated for the in-water workers, fishers, tribal fishers, and divers. There were multiple uncertainties associated with the direct exposure to in-water sediment scenarios such as the spatial scale of the exposure areas and the exposure parameters, which are further described in the following sections. The health protective assumptions regarding direct exposure to in-water sediment were multiplied together, which magnifies the overall conservatism in the risk estimates. Risks were estimated separately for in-water sediment for each of the ½-mile river segment exposure areas (east (E) and west (W)) and for Study Area-wide exposure. In addition to calculating risks from in-water sediment exposure within the Study Area (which includes exposure areas from RM 1.9 to RM 11.8, including Swan Island Lagoon), risks from in-water sediment exposure were calculated for three river segments outside of the Study Area: the downstream reach (RM 1.0-1.9), the downtown river segment (RM 11.8 – 12.2), and Multnomah Channel. The exposure area from RM 11.5 to 12.0 encompasses samples from both inside and outside of the Study Area. However, Study Area-wide risks were calculated only for samples within the Study Area. Cumulative risk exceedances for in-water sediment scenarios are summarized by exposure area in Maps 5-45-3-1 through 5-63-2. In addition, risks from exposures to PBDEs in in-water sediment were evaluated separately and are

presented in Attachment F3, following the general methodology discussed in this BHHRA.

5.2.2.1 In-~~water~~ Water Worker

The results of the risk evaluation for in-water worker exposure to in-water sediment are presented in Tables 5-~~30~~ 21 through 5-~~33~~22.

The in-water worker RME scenario for in-water sediment results in cumulative cancer risk greater than 1 x 10^{-6} at RM segments 4.5E, 6W, and 7W. There are no exceedances of 1 x 10^{-4} cancer risk for the in-water worker RME scenario. The maximum cumulative cancer risk for an individual exposure area occurs at RM 7W (~~1~~ 2 x 10^{-5}) and is primarily due to incidental ingestion of sediment containing dioxins/furans. The only other individual ~~chemical~~ contaminant resulting in a cancer risk greater than 1 x 10^{-6} within the Study Area is benzo(a)pyrene. The HIs for in-water worker RME scenario do not exceed 1.

The in-water worker RME scenarios do not result in an exceedance of 1 x 10^{-6} cumulative cancer risk or an HI greater than 1 for exposure to in-water sediment from river segments assessed outside of the Study Area.

The in-water worker CT scenario for in-water sediment results in no exceedances of 1 x 10^{-6} cancer risk and no exceedances of an HI of 1.

~~In estimating risks for the RME scenario, it was assumed that exposure occurs at one ½-mile river segment 10 days every year for 10 years, and the level of exposure is the same as for industrial soil. For the CT scenario, it was assumed that exposure occurs at one ½-mile river segment 10 days every year for four years, and the level of exposure is the same as for industrial soil.~~

5.2.2.2 Tribal Fisher

The results of the risk evaluation for tribal fisher exposure to in-water sediment are presented in Tables 5-~~34~~ 23 through 5-~~37~~25.

The tribal fisher RME scenario for in-water sediment results in exceedances of 1 x 10^{-6} cumulative cancer risk in 33 of 40 river mile segments within the Study Area, and from Study Area-wide exposure (see Table 5-~~34~~23). The tribal fisher RME scenario for in-water sediment results in cumulative cancer risk greater than 1 x 10^{-4} at RM 6W and RM 7W~~, which are~~. RM 7W is the location~~s~~ of the maximum cumulative cancer risk (~~2~~ 3 x 10^{-4}). Risk at RM 7W is primarily due to incidental ingestion of sediment containing dioxins/furans (risk from dioxins/furan exposure is 3 x 10^{-4}); risk at RM 6W is primarily due to dermal contact with sediment containing benzo(a)pyrene (risk from benzo(a)pyrene exposure is 1 x 10^{-4}). In addition to these two contaminants~~chemicals~~, the following individual analytes also result in an individual cancer risk greater than 1 x 10^{-6} in at least one exposure area: arsenic,

PCBs, benzo(b)fluoranthene, dibenzo(a,h)anthracene, benzo(a)anthracene, indeno(1,2,3-cd)pyrene.

~~The tribal fisher RME scenario for in-water sediment results in no HIs greater than 1.~~

Exposure areas including river mile segments outside of the Study Area that result in risks above 1 x 10^{-6} from the tribal fisher RME scenario for in-water sediment are: RM 12W (includes samples from RM 12.0W – 12.2W), Multnomah Channel, and RM 1.5E (includes samples from RM 1.5E – RM 1.9E), RM 1E, and RM1W. Tribal fisher exposure to in-water sediment from river segments outside of the Study Area do not result in HIs greater than 1.

The tribal fisher CT scenario for in-water sediment results in exceedances of 1 x 10^{-6} cumulative cancer risk at two of the 40 river mile segments (RM 6W and RM 7W). There are no exceedances of 1 x 10^{-4} cancer risk for the tribal fisher CT scenario. The maximum cumulative cancer risk occurs at RM 6W (6 x 10^{-6}) and is primarily due to exposure to sediment containing benzo(a)pyrene. The tribal fisher CT scenario for in-water sediment results in no HIs greater than 1.

There are no risks greater than 1 x 10^{-6} or HIs greater than 1 for CT tribal fisher exposure to in-water sediment from river segments assessed outside of the Study Area.

~~In estimating risks for the RME scenario, it was assumed that exposure occurs at one ½-mile river segment five days per week for the entire year for 70 years and that exposure resulting in ingestion of sediment and coverage of the hands and forearms occurs 25 percent of the time. For the CT scenario, it was assumed that exposure occurs at one ½-mile river segment two days per week for the entire year for 30 years and that exposure resulting in ingestion of sediment and coverage of the hands and forearms occurs 25 percent of the time.~~

5.2.2.3 Fisher

To evaluate differences in fishing frequencies, risks were evaluated for both high-frequency and low-frequency fishers. High-frequency fishers were assumed to fish from the same 1/2-mile river segment three days per week for the entire year (156 days/year) for the default residential exposure duration (30 years) for the RME. Low-frequency fishers were assumed to fish from the same 1/2-mile river segment for two days per week for the entire year (104 days/year) for the default residential exposure duration (30 years) for the RME. The results of the risk evaluation for high-frequency fisher exposure to in-water sediment are presented in Tables 5-~~38~~ 26 through 5-~~41~~28. The results of the risk evaluation for low-frequency fisher exposure to in-water sediment are presented in Tables 5-~~42~~ 29 through 5-~~45~~30.

5.2.2.3.1 High-Frequency Fisher

The high-frequency fisher RME scenario for in-water sediment results in exceedances of 1 x 10^{-6} cumulative cancer risk in 17 of 40 river mile segments within the Study Area and from Study Area-wide exposure (see Table 5-3826). There are no exceedances of 1 x 10^{-4} cancer risk for the high-frequency fisher RME scenario. The maximum cumulative cancer risks occurs at RM 7W (8 x 10^{-5}) and RM 6W (5 x 10^{-5}). At RM 7W, risk is primarily due to incidental ingestion of sediment containing dioxins/furans. At RM 6W, risk is primarily due to incidental ingestiondermal contact with of sediment containing benzo(a)pyrene. In addition to these two chemicals, the following individual analytes also result in a cancer risk greater than 1 x 10^{-6} in at least one exposure area: arsenic, PCBs, benzo(b)fluoranthene, dibenzo(a,h)anthracene, benzo(a)anthracene, and indeno(1,2,3-cd)pyrene. The high-frequency fisher RME scenario for in-water sediment results in no HIs greater than 1.

For river mile segments outside of the Study Area, RM 12W is the only exposure area that results in risk above 1 x 10^{-6} for the high-frequency fisher RME scenario for in-water sediment. Risk at RM 12W is 2 x 10^{-6}, primarily due to exposure to benzo(a)pyrene. There are no exposure areas outside of the Study Area resulting in an HI greater than 1.

The high-frequency fisher CT scenario for in-water sediment results in no exceedances of 1 x 10^{-6} cumulative cancer risk and no exceedances of an HI of 1 for exposure areas assessed inside and outside of the Study Area.

In estimating risks for the RME scenario, it was assumed that exposure occurs at one ½ mile river segment three days per week for the entire year for 30 years and that exposure resulting in ingestion of sediment and coverage of the hands and forearms occurs 25 percent of the time (i.e., a factor of 25 percent was used to represent the percent of time spent fishing in a single exposure area). For the CT scenario, it was assumed that exposure occurs at one ½ mile river segment one day per week for the entire year for nine years and that exposure resulting in ingestion of sediment and coverage of the hands and forearms occurs 25 percent of the time.

5.2.2.3.2 Low-frequency Frequency Fisher

The low-frequency fisher RME scenario for in-water sediment results in exceedances of 1 x 10^{-6} cumulative cancer risk at 12 of 40 river mile segments within the Study Area, and from Study Area-wide exposure (see Table 5-4229). There are no exceedances of 1 x 10^{-4} cancer risk for the low-frequency fisher RME scenario. The maximum cumulative cancer risks occurs at RM 7W (6 x10^{-5}) and RM 6W (3 x10^{-5}). At RM 7W, risk is primarily due to incidental ingestion of sediment containing dioxins/furans. A; at RM 6W, risk is primarily due to incidental ingestion of dermal contact with sediment containing benzo(a)pyrene. In addition to these two chemicals, the following individual analytes also result in a cancer risk greater than 1 x 10^{-6} in at least one exposure area: PCBs, dibenzo(a,h)anthracene, benzo(a)anthracene,

benzo(b)fluoranthene, and indeno(1,2,3-cd)pyrene. The low-frequency fisher RME scenario for in-water sediment results in no HIs greater than 1.

There are no risks greater than 1 x 10^{-6} or HIs greater than 1 for the low-frequency fisher RME scenario for exposure to in-water sediment from river segments assessed outside of the Study Area.

The low-frequency fisher CT scenario for in-water sediment results in no exceedances of 1 x 10^{-6} cumulative cancer risk and no exceedances of an HI of 1 for exposure areas inside and outside of the Study Area.

~~In estimating risks for the RME scenario, it was assumed that exposure occurs at one ½-mile river segment two days per week for the entire year for 30 years and that exposure resulting in ingestion of sediment and coverage of the hands and forearms occurs 25 percent of the time. For the CT scenario, it was assumed that exposure occurs at one ½-mile river segment one day every other week for the entire year for nine years and that exposure resulting in ingestion of sediment and coverage of the hands and forearms occurs 25 percent of the time.~~

5.2.2.4 Diver

Risks were evaluated for commercial divers wearing either a wet suit or a dry suit. The results of the risk evaluation for commercial wet suit diver exposure to in-water sediment are presented in Tables 5-~~46~~ 31 through 5-~~49~~32. The results of the risk evaluation for a commercial dry suit diver exposure to in-water sediment are presented in Table~~s~~ 5-~~50 and 5-51~~33.

5.2.2.4.1 Diver in Wet Suit

The commercial diver in a wet suit RME scenario for in-water sediment results in exceedances of 1 x 10^{-6} cumulative cancer risk in ~~5~~ 10 of 40 ½-mile river mile segments within the Study Area and for Study Area-wide exposure (see Table 5-~~46~~31). There are no exceedances of 1 x 10^{-4} cancer risk for this scenario. The maximum cumulative cancer risk (3 x 10^{-5}) occurs at RM 6W and RM 7W.~~(3 x10^{-5}) and~~ At RM 6W, the risk is primarily due to ~~incidental ingestion~~dermal adsorption of sediment containing benzo(a)pyrene. At RM 7W, the risk is primarily due to dermal absorption of sediment containing dioxins and furans. In addition to ~~benzo(a)pyrene~~these two chemicals, the following individual analytes also result in a cancer risk greater than 1 x 10^{-6} in at least one exposure area: PCBs, ~~dioxin/furans,~~ benzo(b)fluoranthene, dibenzo(a,h)anthracene, benzo(a)anthracene, and indeno(1,2,3-cd)pyrene. The commercial diver in a wet suit RME scenario for in-water sediment results in no HIs greater than 1.

There are no exposure areas outside of the Study Area that result in risks above 1 x 10^{-6} or HIs greater than 1 for this scenario.

The commercial diver in a wet suit CT scenario for in-water sediment results in no exceedances of 1 x 10^{-6} cumulative cancer risk and no exceedances of an HI of 1 for exposure areas assessed inside and outside of the Study Area (see Table 5-~~47 and 5-49~~32).

~~In estimating risks for the RME scenario, it was assumed that exposure occurs at one ½-mile river segment five days per year for 25 years and that exposure resulting in ingestion of sediment and coverage of the hands and forearms occurs 100 percent of the time. For the CT scenario, it was assumed that exposure occurs at one ½-mile river segment two days per year for nine years and that exposure resulting in ingestion of sediment and coverage of the hands and forearms occurs 100 percent of the time. Skin surface area in contact with sediment is assumed to be over the entire body (18,150 cm^2).~~

5.2.2.4.2 Diver in Dry Suit

The commercial diver in a dry suit RME scenario for in-water sediment results in exceedances of 1 x 10^{-6} cumulative cancer risk in two of 40 river mile segments within the Study Area (see Table 5-~~50~~33). The maximum cumulative cancer risks occur~~s~~ at RM 7W (1 x 10^{-5}) and RM 6W (~~6 46~~ x 10^{-6}). At RM 7W, risk is primarily due to incidental ingestion of sediment containing dioxins/furans. At RM 6W, risk is primarily due to ~~incidental ingestion of~~dermal contact with sediment containing benzo(a)pyrene. ~~These are the only two chemicals that result in a cancer risk greater than 10^{-6}~~No other analytes result in a cancer risk greater than 1 x 10^{-6} for this scenario. The commercial diver in a dry suit RME scenario for in-water sediment results in no HIs greater than 1. There are no river mile segments outside of the Study Area that result in risk above 1 x 10^{-6} or an HI greater than 1. A CT scenario was not evaluated for a commercial diver in a dry suit, per direction from EPA.

~~In estimating risks for the RME scenario, it was assumed that exposure occurs at one ½-mile river segment five days per year for 25 years and that exposure resulting in ingestion of sediment and coverage of the hands and forearms occurs 100 percent of the time. Skin surface area exposed to sediment was assumed to be over the head, neck, and hands (2,510 cm^2).~~

5.2.2.5 Breastfeeding Infants of Adults Exposed to In-Water Sediment

Risks to infants consuming breastmilk from adults exposed to in-water sediment were calculated for all adult receptors for which bioaccumulative compounds were COPCs. This included all receptors assessed in this BHHRA for direct exposure to in-water sediment. These risk~~s~~ results are shown in Tables 5-34 through 5-44. The highest cumulative cancer risk to breastfeeding infants of adults exposed to in-water sediment occurs at RM 7W, due to consumption of dioxin/furans in human milk of a tribal fisher exposed to in-water sediment. The highest noncancer hazard to an infant also occurs at RM 7W (HI is 5).

5.2.2.6 Summary of In-Water Sediment Risk Characterization

Direct contact with in-water sediment resulted in cumulative cancer risks ranging from 5 x 10^{-9} to 3 x 10^{-4} across all scenarios. The only HI that was greater than 1 was for the tribal fisher and high frequency fisher RME scenario due to dioxin/furans, which occurred at the ½-mile exposure area at RM 7 west (W). The highest cumulative cancer risks and HIs from direct contact with in-water sediment were for the tribal fisher scenario. Four contaminants resulted in a cancer risk greater than 1 x 10^{-6} or hazard quotient greater than 1 for at least one of the in-water sediment scenarios: PCBs, dioxins, arsenic, and PAHs. A summary of in-water sediment risks by receptor and analyte are shown in Table 5-45.

5.2.3 Surface Water Risk Characterization Results

Potential risks from exposure to surface water through ingestion and dermal absorption were estimated for transients, recreational beach users, and divers. In addition, potential risks were estimated for a hypothetical future use of surface water as a domestic water source. There were multiple uncertainties associated with the direct exposure to surface water scenarios such as the exposure parameters, which are further described in the following sections, and contributions from background sources. ~~The health protective assumptions regarding direct exposure to surface water were multiplied together, which magnifies the overall conservatism in the risk estimates. In addition, potential risks were estimated for a hypothetical future use of surface water as a domestic water source.~~

5.2.3.1 Transients

Risks to transients from surface water were evaluated for drinking water and bathing scenarios. The risks were evaluated for year-round exposure to surface water for four individual transect stations, for the four transects grouped together (to represent Study Area-wide exposure), and for Willamette Cove. In addition to these exposure areas within the Study Area, risk was evaluated for exposure to surface water for a transect in Multnomah Channel, which is outside of the Study Area. The results of the risk evaluation for transient exposure to surface water are presented in Tables 5-~~52~~ 46 through 5-~~55~~47.

The transient RME and CT scenarios for surface water result in no exceedances of 1 x 10^{-6} cancer risk and no exceedances of an HI of 1 inside or outside of the Study Area.

5.2.3.2 Recreational Beach Users

Risks to recreational beach users from surface water were evaluated for swimming scenarios, using data from summer months. Risks were evaluated for exposure to surface water for three transects grouped together (to represent Study Area-wide exposure) and for exposure to surface water for three individual quiescent areas during summer months. Risks for both adults and children were evaluated, as well as cancer risks to a combined child and adult receptor, in order to incorporate early-life exposures. The results of the risk evaluation for adult recreational beach user exposure to surface water are presented in Tables 5-~~56~~ 48 through 5-~~59~~49. The results of the risk evaluation for child recreational beach user exposure to surface water are presented in Tables 5-~~60~~ 50 through 5-~~63~~51. The results of the combined child and adult receptor are presented in Tables 5-52 through 5-53.

The adult ~~and~~ , child, and combined recreational beach user RME and CT scenarios for surface water result in no exceedances of 1 x 10^{-6} cancer risk and no exceedances of an HI of 1.

5.2.3.3 Diver

Risks to commercial divers from surface water were evaluated for year-round exposure to four individual transect stations, and to single-point sampling stations within the Study Area grouped together on a ½-river mile basis, per side of river (E, W). In addition to these exposure areas within the Study Area, risk was evaluated for exposure to surface water for a transect in Multnomah Channel, which is outside of the Study Area. Risks were evaluated for commercial divers in wet suits and in dry suits. The results of the risk evaluation for commercial divers in wet suits exposure to surface water are presented in Tables 5-~~64~~ ~~53~~54 through 5-~~67~~~~54~~55. The results of the risk evaluation for commercial divers in dry suits are presented in Table 5-~~68~~ ~~55~~56 ~~and 5-69~~~~56~~.

5.2.3.3.1 Diver in Wet Suit

The commercial diver in a wet suit RME scenario for surface water results in exceedances of 1 x 10^{-6} cumulative cancer risk in one exposure area (RM 6W). There are no exceedances of 1 x 10^{-4} cancer risk for the commercial diver in a wet suit RME scenario. The maximum cumulative cancer risk occurs at RM 6W (1 x 10^{-5}) and is primarily due to dermal contact with surface water containing benzo(a)pyrene. There are no other analytes resulting in a cancer risk greater than 1 x 10^{-6}. The commercial diver in a wet suit RME scenario for surface water resulted in no HIs greater than 1. There are no exceedances of 1 x 10^{-6} risk or an HI of 1 for surface water exposure to river segments assessed outside of the Study Area.

The commercial diver in a wet suit CT scenario for surface water results in no exceedances of 1 x 10^{-6} cumulative cancer risk and no exceedances of an HI of 1 for exposure inside or outside of the Study Area.

~~In estimating risks for the RME scenario, it was assumed that exposure occurs at one ½ mile river segment or transect station five days per year for four hours at a time over 25 years. It was also assumed that exposure resulting in ingestion of surface water occurs at a rate of 50 milliliters per hour (ml/hr). Skin surface area exposed to surface water was assumed to be over the entire body (18,150 cm^2). For the CT scenario, it was assumed that exposure occurs at one ½ mile river segment or transect station two days per year for two hours at a time over nine years. The incidental ingestion rate of surface water and skin surface area exposed to surface water were the same as for the RME scenario.~~

5.2.3.3.2 Diver in Dry Suit

The commercial diver in a dry suit RME scenario for surface water results in exceedances of 1 x 10^{-6} cumulative cancer risk in one exposure area (RM 6W). This exposure area is the location of the maximum cumulative cancer risk (2 x 10^{-6}) and is primarily due to dermal contact with surface water containing benzo(a)pyrene. There are no individual analytes resulting in a cancer risk greater than 1 x 10^{-6}. The commercial diver in a dry suit RME scenario for surface water resulted in no HIs greater than 1. There are no exceedances of 1 x 10^{-6} risk or an HI of 1 for surface water exposure to river segments assessed outside of the Study Area.

The commercial diver in a dry suit was not evaluated for CT exposure, as directed by EPA.

~~In estimating risks for the RME scenario, exposure frequency and duration were the same as for the commercial diver in wet suit RME scenario. The incidental ingestion rate of surface water was assumed to be 50 ml/hr, and the skin surface area exposed to surface water was assumed to be over the head, neck, and hands (2,510 cm^2).~~

5.2.3.4 ~~Hypothetical~~ Domestic Water User

There is no known or anticipated future use of surface water within the Study Area for a domestic water supply. Because the designated beneficial use of the Willamette River is as a domestic water supply with adequate pretreatment~~However~~, ~~at~~ EPA~~'s direction, untreated~~directed that surface water ~~was~~ be evaluated as a ~~hypothetical~~ future domestic water source for both adult and child residents. For purposes of this BHHRA, untreated surface water was used to assess risks from future domestic water uses, so the risks are considered hypothetical. Risks were calculated for year-round exposure to surface water for the four transect stations within the Study Area and single point vertically integrated samples from Cathedral Park, Willamette Cove, and Swan Island Lagoon. In addition, Study Area-wide risk was calculated by combining the data from all vertically integrated samples to estimate Study Area-wide exposure. The results of the risk evaluation for surface water as a hypothetical future domestic water source are presented in Tables 5-~~70~~ 57 through 5-~~73~~ 58 for adult residents, ~~and~~ Tables 5-~~74~~ 59 through 5-~~77~~ 60 for child residents, and Tables 5-61 through 5-62 for combined child and adult residents.~~.~~

5.2.3.4.1 Adult Resident~~s~~

The adult resident RME scenario for hypothetical future use of untreated surface water as a domestic water source results in cumulative risk exceedances of 1 x 10^{-6} at all ~~seven~~ 20 of the ~~seven~~ 20 exposure areas, and for Study Area-wide exposure (see Table 5-~~70~~57). There ~~are no~~is one exceedance~~s~~ of 1 x 10^{-4} cancer risk for the adult resident RME future hypothetical domestic water scenario, which occurs at RM 6.1 (cumulative risk is 3 x 10^{-4}, primarily due to benzo(a)pyrene in drinking water). ~~The maximum cumulative cancer risk for the RME scenario is 1 x 10^{-5}, which occurs at the RM 2 transect and at Cathedral Park. This exceedance is due solely to the hypothetical ingestion of arsenic in untreated surface water.~~ Risks from untreated surface water exposure to both total and dissolved arsenic exceed 1 x 10^{-6} for all exposure areas. The adult resident RME scenario results in no HIs greater than 1.

Arsenic is a naturally occurring metal, and background concentrations in surface water may contribute to risk resulting from the hypothetical future use of untreated surface water as a domestic water source. Background concentrations for some chemicals in surface water were calculated using data collected from upstream of the Study Area, as described in ~~Section~~ Section 6 of the RI Report. The 95% UCL concentration of total arsenic in surface water upstream of the Study Area is 0.402 ug/l, and the 95th percentile value is 0.485 ug/l, which are both above the EPA tap water RSL for arsenic of 0.045 ug/l but below the EPA MCL of 10 ug/l. The 95% UCL/max EPCs for total arsenic for the hypothetical future use of untreated surface water for domestic use within the Study Area range from 0.~~45~~ 32 to 0.60 ug/l, which include both maximum concentrations for an exposure area and 95% UCLs for an exposure area. EPCs at 17 out of 21 locations within the Study Area exceed 0.402 ug/l (the 95% UCL concentration of total arsenic in surface water upstream of the Study Area), and seven out of 21 of the EPCs exceed 0.485 ug/l (the 95th percentile value of total arsenic in surface water upstream of the Study Area). These concentrations are similar to the upstream arsenic concentration statistics~~, which do not include the maximum concentrations of arsenic in upstream surface water~~. The 95% UCL concentration of total arsenic upstream of the Study Area (0.402 ug/l) results in a cancer risk of 7 x 10^{-6} for the adult resident exposure scenario.

The adult resident CT scenario for hypothetical use of untreated surface water as a future domestic water source results in cumulative risk exceedances of 1 x 10^{-6} at ~~four~~ ~~20~~17 of the ~~seven~~ 20 exposure areas, and for Study Area-wide exposure (see Table 5-~~71~~58). There are no exceedances of 1 x 10^{-4} cancer risk for the adult resident CT future hypothetical domestic water scenario. The maximum cumulative cancer risk for the CT scenario is ~~2~~ 3 x 10^{-6}~~5~~, which occurs at ~~all four exposure areas exceeding 10^{-6} risk~~RM 6.1. This exceedance is due to the hypothetical ingestion of untreated surface water containing ~~arsenic~~benzo(a)pyrene. The adult resident ~~RME~~ CT scenario results in no HIs greater than 1.

~~In estimating risks for the RME scenario, it was assumed that exposure occurs 350 days per year for 30 years. It was also assumed that the adult resident drinks two~~

~~liters of untreated water and bathes in untreated river water for more than ½ hour each day. For the CT scenario, it was assumed that exposure occurs 350 days per year for nine years, the daily ingestion rate is 1.4 liters per day (l/day), and bathing duration is 15 minutes per day.~~

5.2.3.4.2 Child Resident

The child resident RME scenario for hypothetical future use of untreated surface water as a domestic water source results in cumulative risk exceedances of 1 x 10^{-6} at all ~~seven~~ 20 of the ~~seven~~ 20 exposure areas, and for Study Area-wide exposure (see Table 5-~~59~~74). There ~~are~~ is ~~no~~one exceedance~~s~~ of 1 x 10^{-4} cancer risk for the child resident RME future hypothetical domestic water scenario, which occurs at RM 6.1 (cumulative risk is 7 x 10^{-4}, primarily due to benzo(a)pyrene in drinking water). ~~The maximum cumulative cancer risk for the RME scenario is 7 x 10^{-6}, which occurs at the RM 2 transect and at Cathedral Park. This exceedance is due solely to the hypothetical ingestion of untreated surface water containing arsenic. Arsenic is a naturally occurring metal, and may contribute to risks from the hypothetical future use of untreated surface water within the Study Area for domestic use, as previously discussed in the presentation of risk estimates for adult residents. Risks from exposure to both total and dissolved arsenic exceed 10^{-6} for all exposure areas.~~ The child resident RME scenario results in ~~no~~ HIs greater than 1 at two locations: RM 2.9 (Multnomah Channel) and RM 8.5. The HI at both of these locations is 2, due primarily to exposures to MCPP in drinking water.

The child resident CT scenario for hypothetical use of surface water as a future domestic water source results in cumulative risk exceedances of 1 x 10^{-6} at all ~~seven~~ 20 of the ~~seven~~ 20 exposure areas, and for Study Area-wide exposure (see Table 5-~~75~~60). There is one exceedance ~~are no exceedances~~ of 1 x 10^{-4} cancer risk for the ~~adult~~ child resident CT future hypothetical domestic water scenario, which occurs at RM 6.1 (cumulative risk is 2 x 10^{-4}, primarily due to benzo(a)pyrene in drinking water). ~~The maximum cumulative cancer risk from CT is 3 x 10^{-6}, which occurs at all seven exposure areas exceeding 10^{-6} risk. This exceedance is due to hypothetical ingestion of arsenic in untreated surface water.~~ The child resident CT scenario results in no HIs greater than 1.

~~In estimating risks for the child RME scenario, it was assumed that exposure occurs 350 days per year for six years. It was also assumed that the child resident drinks 1.5 liters of untreated water and bathes in untreated river water for one hour each day. For the CT scenario, it was assumed that exposure occurs 350 days per year for six years, the daily ingestion rate is 0.9 l/day, and bathing duration is 20 minutes per day.~~

5.2.3.4.3 Combined ~~Adult/Child~~Child and Adult Resident

Cancer risks for a combined child and adult resident were calculated to incorporate early life exposures, per EPA (2005) and DEQ (2010) guidance. The maximum cancer risk for the combined child and adult receptor is 9 x 10^{-4}, occurring at RM 6.1,

primarily from exposures to benzo(a)pyrene in drinking water. Risks from RME and CT scenarios exceed 1 x 10^{-6} for all exposure areas evaluated.

5.2.3.5 Summary of Surface Water Risk Characterization

Direct contact with surface water resulted in cumulative cancer risks ranging from 8 x 10^{-10} to 9 x 10^{-4} across all scenarios, including hypothetical future use as a domestic water source. The only HIs that were greater than 1 were for hypothetical future use as a domestic water source by a child resident under the RME scenario. The HI was 2 at Multnomah Channel and RM 8.5, due primarily to ingestion of MCPP in surface water. Eight contaminants resulted in a cancer risk greater than 1 x 10^{-6} or hazard quotient greater than 1 for at least one of the surface water scenarios, including: benzo(a)pyrene, benzo(a)anthracene, benzo(b)fluoranthene, dibenzo(a,h)anthracene, indeno(1,2,3-cd)pyrene, MCPP, arsenic, hexavalent chromium, and total PAHs. A summary of risks from exposure to surface water is provided in Table 5-63.

5.2.4 Groundwater Seep Risk Characterization Results

Only one groundwater seep was identified in a transient or recreational use area where upland COIs were potentially discharging. The seep identified is actually the potential groundwater discharge that could occur from Outfall 22B, which discharges into a transient use area. As a result, risks to transients from potential exposure to groundwater seeps were evaluated at that beach (07B024).

5.2.4.1 Transients

Risks to transients from the groundwater seep were evaluated for direct contact scenarios. There were multiple uncertainties associated with the exposure parameters for the direct exposure to groundwater seeps scenario. ~~The health protective assumptions regarding direct exposure to groundwater seeps were multiplied together, which magnifies the overall conservatism in the risk estimates.~~ To evaluate the risks from exposure to the groundwater seep without stormwater influence, outfall data from stormwater sampling events was excluded from the dataset. The results of the risk evaluation for transient exposure to the groundwater seep are presented in Tables 5-~~78~~ 64 through 5-~~81~~65.

The transient RME and CT scenarios for the groundwater seep results in no exceedances of 1 x 10^{-6} cancer risk and no exceedances of an HI of 1.

5.2.4.1 Summary of Groundwater Seep Risk Characterization

There were no cancer risk or noncancer hazard exceedances from exposure to the groundwater seep. A summary of groundwater seep risks is provided in Table 5-66.

5.2.5 Fish Consumption Risk Characterization Results

Potential risks from fish consumption were estimated for fisher and tribal fisher scenarios. There were multiple uncertainties associated with the fish consumption scenarios such as assumptions regarding fish consumption rates, tissue type and fish species consumed, EPCs, and the use of cooking and preparation methods[7]. ~~In estimating the risks in this BHHRA, the health protective assumptions regarding fish consumption were multiplied together, which magnifies the overall conservatism in the risk estimates. The cumulative effects of the numerous conservative assumptions made during this BHHRA are risk estimates that are potentially significantly higher than actual risks that may exist within the Study Area.~~ Uncertainties associated with this scenario are discussed further in ~~Section~~ Section 6.

5.2.5.1 Tribal Fishers

Risks to tribal fishers who consume fish caught within the Study Area were evaluated for a multi-species diet that includes salmon, lamprey, and sturgeon, in addition to resident fish species. A single ingestion rate for the multi-species diet was used to evaluate risks to the tribal fish consumer. Risks were evaluated using both 95% UCL/max and mean Study Area-wide tissue concentrations for both fillet and whole body tissue (see Section ~~3.3.5~~3.4.5). Risks were higher for whole body tissue than for fillet tissue; however, fillet tissue was not analyzed for PCB or dioxin/furan congeners in all resident species. The results of the risk evaluation for adult tribal fish consumption are presented in Tables 5-~~82~~ 67 through 5-~~85~~70. The results of the risk evaluation for child tribal fish consumption are presented in Tables 5-~~86~~ 71 through 5-~~89.~~74, and the results of the risk evaluation for the combined child and adult tribal consumers of fish are presented in Tables 5-75 through 5-76.

5.2.5.1.1 Tribal Adult, Fish Consumption

The risks ranged from a cumulative cancer risk of ~~1~~ 2 x 10^{-2} for the 95% UCL/max EPCs of whole body tissue to a cumulative cancer risk of 2 x 10^{-3} for the mean EPCs of fillet tissue. For all scenarios, estimated risks are above a 1 x 10^{-4} cumulative cancer risk and are primarily due to PCBs and dioxins/furans. Figure 5-8 shows the relative risk contribution of individual COPCs for both whole body and fillet tissue diets of an adult tribal consumer, and Figure 5-9 shows a comparison of total risk per tissue type.

The ~~highest endpoint specific~~cumulative HIs ranged from ~~200~~ 400 for the 95% UCL/max EPCs of whole body tissue to ~~40~~ 50 for the mean EPCs of fillet tissue. For the whole body tissue, 95% UCL/max EPC scenario, the PCB HQ is approximately 26 times higher than any other HQ. The toxicity endpoint for PCBs is immunological and skin. The immunological- and skin-specific HIs for tribal adult consumption are the highest endpoint-specific HIs, and exceed the next highest HI by a factor of 10.

[7] For the purposes of the risk calculations, reference to "uncooked" fish tissue is the same as not accounting for reductions in contaminant concentrations from cooking or other food preparation.

Additional endpoints that exceed an HI of 1 for the tribal adult 95% UCL/max consumption scenario are reproduction, central nervous system (CNS), and blood.

The multi~~ple -~~species diet evaluated in this BHHRA included resident fish as well as salmon, sturgeon, and lamprey. Because salmon, sturgeon, and lamprey spend time outside the Study Area, the risks from ingestion of salmon, sturgeon, and lamprey cannot be conclusively associated with sources within the Study Area. However, resident fish accounted for approximately 95 percent of the cumulative risk in the whole body diet. Of the four resident fish species included in the multi~~ple -~~species diet, risks from ingestion of smallmouth bass and common carp were the primary contributors to the cumulative risk.

~~The ingestion rate used for the adult tribal fish consumer (175 g/day) is the 95th percentile from the CRITFC Fish Consumption Study (EPA 1994). Fish consumption was assumed to occur at this level every day of every year for 70 years and consist entirely of fish caught within the Study Area. If the level of ingestion were higher or lower or if a portion of the fish consumed includes store-bought fish or fish caught at other locations, the calculated risks from fish consumption at the Study Area would be correspondingly higher or lower. The calculated risks do not account for any decrease changes in tissue concentrations of chemicals that may occur during preparation or cooking of the fish.~~

5.2.5.1.2 Tribal Child, Fish Consumption

The risks ranged from a cumulative cancer risk of ~~2~~ 3 x 10^{-3} for the 95% UCL/max EPCs of whole body tissue to a cumulative cancer risk of 4 x 10^{-4} for the mean EPCs of fillet tissue. For all scenarios, risks are above a 1 x 10^{-4} cumulative cancer risk and are primarily due to PCBs and dioxins/furans.

The ~~highest endpoint-specific~~cumulative HIs ranged from ~~400~~ 800 for the 95% UCL/max EPCs of whole body tissue to ~~80~~ 100 for the mean EPCs of fillet tissue. The PCB HQ for the whole body tissue diet is approximately ~~40~~ 26 times higher than any other HQ. The immunological- and skin- specific HIs for tribal child consumption are the maximum endpoint-specific HIs, and exceed the next highest HI by a factor of 10. Additional health endpoints that exceed an HI of one for the tribal child 95% UCL/max consumption scenario are reproduction, CNS, liver, and blood.

The multi-species diet evaluated in this BHHRA included resident fish as well as salmon, sturgeon, and lamprey. Because salmon, sturgeon, and lamprey spend time outside the Study Area, the calculated risks from ingestion of salmon, sturgeon, and lamprey cannot be conclusively associated with sources within the Study Area. However, resident fish accounted for approximately 95 percent of the cumulative risk associated with this scenario.

~~The ingestion rate used for the child tribal fish consumer (73 g/day) is the 95th percentile from the CRITFC Fish Consumption Survey (CRITFC 1994). Fish consumption was assumed to occur at this level every day of every year for six years~~

~~and consist entirely of fish caught within the Study Area. If the level of ingestion were higher or lower, or if a portion of the fish consumed includes store-bought fish or fish caught at other locations, the risks from fish consumption at the Study Area would be correspondingly higher or lower. The calculated risks do not account for any decrease changes in tissue concentrations of chemicals that may occur during preparation or cooking of the fish.~~

5.2.5.1.3 Combined Tribal Child and Adult, Fish Consumption

Cancer risks were calculated for the combined child and adult tribal fisher scenarios in order to incorporate early life exposures (EPA 2005, DEQ 2010). Cumulative cancer risks from fish consumption for the combined child and adult tribal fisher ranged from 3 x 10^{-3} (fillet tissue consumption, mean scenario) to 2 x 10^{-2}, (whole body tissue consumption, 95% UCL/Max scenario) primarily due to ingestion of PCBs in tissue. The results of the combined tribal child and adult cancer risks for consumption of fish tissue are presented in Tables 5-75 and 5-76.

5.2.5.1.4 Breastfeeding Infant of Tribal Adult Who Consumes Fish

Risks and hazards to an infant consuming human milk of a tribal adult who consumes fish were calculated for bioaccumulative compounds, consistent with EPA (2005) and DEQ (2010) guidelines. These risks are presented in Tables 5-77 and 5-78. Cancer risks range from 2 x 10^{-3} to 2 x 10^{-2}, and noncancer hazards range from 1,000 to 9,000.

5.2.5.1.5 Summary of Risks from Tribal Consumption of Fish

A summary of risks from tribal consumption of fish is provided in Table 5-79. Both cancer risks and noncancer hazards exceed the target risk values of 1 x 10^{-6} and 1, respectively, for all tribal receptors.

5.2.5.2 Non-tribal Fishers

Risks for the non-tribal fish consumption scenarios were estimated for both single- and multi-species diets consisting only of resident fish species (smallmouth bass, black crappie, brown bullhead, and common carp). Risks were estimated separately for each exposure area (based on species home range) and for Study Area-wide exposure. Consumption of smallmouth bass was evaluated on a river mile basis, and consumption of common carp, brown bullhead, and black crappie was evaluated on a fishing zone basis (fishing zones were designated from RM 3-6 and from RM 6-9 for black crappie and brown bullhead, and from RM 3-6, RM 6-9, RM 0-4, RM 4-8, and RM 8-12 for common carp). In addition to evaluating risks using mean and 95% UCL/max tissue concentrations for both whole body and fillet tissue, each fish consumption scenario was evaluated using three different ingestion rates for adult and child consumers. The results of the risk evaluation for fish consumption by an adult are presented in Tables 5-~~90 to~~80 through 5-~~129~~119. The results of the risk evaluation for fish consumption by a child are presented in Tables 5-~~130~~ 120 ~~to~~ through 5-~~169~~159. The results of the risk evaluation for fish consumption by a

combined child and adult receptor are presented in Tables 5-160 through 5-169. In addition, Maps 5-~~7~~ 4-1 through 5-~~14~~ 7-3 show exposure areas with risk exceedances from 95% UCL/max EPCs for single species diets, at ~~both~~ the ~~high (~~17.5 g/day, 73 g/day,~~,~~ and ~~7~~ 142 g/day~~)~~ ingestion rates for adults~~and highest (142 g/day, 60 g/day) ingestion rates, for adult and child consumers, respectively~~.

5.2.5.2.1 Adult, Fish Consumption

Risks to ~~Adult~~adult~~,~~ ~~Fish~~ fish ~~Consumption~~ consumers were evaluated for ~~highest (142 g/day), higher (73.5 g/day), and high (17.5 g/day) ingestion rates~~ingestion rates of 142 g/day, 73 g/day, and 17.5 g/day. These rates correspond to approximately 19 meals per month, 10 meals per month, and two meals per month, based on an 8-ounce serving size, every month of the year exclusively of resident fish caught within the Study Area.

The highest risk for all adult consumer scenarios was equal to a cumulative cancer risk of 6 x 10^{-2}. This was for the scenario based on the 95% UCL/max EPC, ~~highest (~~142 g/day~~)~~ ingestion rate, and a fish diet comprised solely of whole-body common carp. The lowest risk was equal to a cumulative cancer risk of 7 x 10^{-6} for the 95% UCL/max and mean EPCs, ~~high (~~17.5 g/day~~)~~ ingestion rate, and a fish diet comprised solely of black crappie fillet tissue. For all tissue consumption scenarios, PCBs are the primary contributor to cumulative cancer risks ~~are primarily driven by PCBs~~.

The highest ~~endpoint-specific HIs~~cumulative HI from fish tissue ranged from ~~3~~3,000 for the 95% UCL/max EPC, ~~highest (~~142 g/day~~)~~ ingestion rate, common carp ~~whole body only~~ fillet tissue scenario to ~~3~~ 0.5 for the mean EPC, ~~high (~~17.5 g/day~~)~~ ingestion rate, black crappie fillet tissue-only scenario. For the 95% UCL/max EPC, multi-species, whole body tissue scenario, the PCB HQ is approximately 30 times higher than the HQ for any other chemical. In general, the immunological-specific HIs for adult consumption scenarios are the highest of all endpoint-specific HIs, and exceed the next highest HIs by a factor of 10 to 100. Additional health endpoints that exceed an HI of 1 for the 95% UCL/max EPCs at the ~~high (~~17.5 g/day~~)~~ ingestion rate are reproduction, CNS, liver, skin, and blood.

Figures 5-10 through 5-17 show a summary of risk results for adult consumption of tissue for single species diets. These figures illustrate the relative contribution of individual COPCs to total risk for both whole body and fillet tissue consumption, per river mile, per fishing area, and per species.

In general, risks from consuming whole body tissue were greater than risks from consuming fillet tissue; however, fillet tissue was not analyzed for PCB or dioxin/furan congeners in black crappie or brown bullhead, and therefore PCB TEQ and dioxin/furan TEQ risks could be not evaluated in fillet tissue for those species. Smallmouth bass and common carp diet scenarios generally resulted in higher risks than the other diets evaluated. Black crappie diet scenarios generally resulted in the lowest risks of the diets evaluated.

~~The fish consumption risk estimates are based on: 1) the assumption that tissue consumption occurs at the stated ingestion rate every day of every year for a 30-year duration, 2) the assumption that all of the fish in the diet were resident fish caught within the Study Area, and 3) the assumption that the EPCs used in this BHHRA represent the average (or UCL on the mean) fish tissue concentrations over a 30-year duration. If the ingestion rate were higher or lower, if a portion of the fish consumed included store-bought fish, non-resident fish, or fish caught at other locations, or if the average fish tissue concentrations over the 30-year duration were higher or lower than the EPCs, the calculated risks from fish consumption at the Study Area would be correspondingly higher or lower. The risks do not account for any decrease changes in tissue concentrations of chemicals that may occur during preparation or cooking of the fish.~~

5.2.5.2.2 Child, Fish Consumption

Risks to child consumers were evaluated for ~~highest (~~60 g/day~~)~~, ~~higher (~~31 g/day~~)~~, and ~~high (~~7 g/day~~)~~ ingestion rates. The risks for all child consumer scenarios ranged from a cumulative cancer risk of 2 x 10^{-2} for the 95% UCL/max EPC, ~~highest (~~60 g/day ~~)~~ ingestion rate, common carp whole body tissue-only scenario to a cumulative cancer risk of 3 x 10^{-6} for the mean EPC, ~~high ingestion rate (~~7 g/day~~),~~ ingestion rate, black crappie fillet tissue-only scenario. For all tissue consumption scenarios, PCBs are the primary contributor to cumulative cancer risks ~~are primarily driven by PCBs~~.

The highest endpoint-specific HIs ranged from 5,000 for the 95% UCL/max EPC, 60 g/day~~highest~~ ingestion rate ~~(60 g/day)~~, common carp whole body tissue-only scenario to ~~5~~ 0.9 for the mean EPC, ~~high (7~~ 7 g/day~~)~~ ingestion rate scenario for black crappie fillet tissue-only scenario. For the 95% UCL/max EPC, multi-species, whole body tissue diet scenario, the PCB HQ is approximately ~~40~~ 30 times higher than the HQ for any other chemical. In general, the immunological-specific HIs for child consumption scenarios exceed the next highest HIs by a factor of approximately ~~-~~10. Additional health endpoints that exceed an HI of 1 for the child 95% UCL/max consumption scenarios at the ~~highest (30~~ 31 g/day~~)~~ ingestion rate are reproduction, CNS, liver, skin, and blood.

In general, risks from whole body tissue were greater than risks from fillet tissue. Smallmouth bass and common carp diet scenarios generally resulted in higher risks than the other diets evaluated. Black crappie diet scenarios generally resulted in the lowest risks of the diets evaluated.

~~The fish consumption risk estimates are based on: 1) the assumption that tissue consumption occurs at the stated ingestion rate every day of every year for a six-year duration, 2) the assumption that all of the fish in the diet were resident fish caught within the Study Area, and 3) the assumption that the EPCs used in this BHHRA represent the average fish tissue concentrations over a 6-year duration. If the ingestion rate were higher or lower, if a portion of the fish consumed included store-bought fish, non-resident fish, or fish caught at other locations, or if the average fish~~

~~tissue concentrations over the 6-year duration were higher or lower than the EPCs, the calculated risks from fish consumption at the Study Area would be higher or lower. The calculated risks do not account for any decrease~~ changes ~~in tissue concentrations of chemicals that may occur during preparation or cooking of the fish.~~

5.2.5.2.3 Combined Child and Adult, Fish Consumption

Cancer risks were calculated for a combined child and adult consumer of fish, to account for early life exposures, for all fish consumption scenarios evaluated in this BHHRA. Results for the evaluation of combined child and adult cancer risks from fish consumption are presented in Tables 5-160 through 5-169. Cancer risks for the combined child and adult consumer of fish are generally the same order of magnitude as adult-only risks. The highest cumulative cancer risk for the combined child and adult consumer is 7×10^{-2}, which occurs at the child ingestion rate of 60 g/day and the adult ingestion rate of 142 g/day, due to consumption of whole body carp from the fishing zone covering RM 4 through RM 8.

~~5.2.5.2.3~~5.2.5.2.4 Breastfeeding Infant of Adult Who Consumes Fish

Risk and hazards to infants consuming human milk from adults consuming fish collected from the Study Area were assessed for bioaccumulative compounds for all adult fish consumption scenarios, in accordance with EPA (2005) and DEQ (2010) guidance. Cancer risks to infants were calculated by applying an IRAF to the combined child and adult cancer risk from fish consumption. Noncancer hazards were calculated by applying an IRAF to the adult HQ for each fish consumption scenario. Results of the risk and hazard calculations for breastfeeding infants of adult consumers of fish are provided in Tables 5-170 through 5-179. The highest cancer risk to a breastfeeding infant of an adult consumer of fish is 7×10^{-2}, due primarily to PCBs in breastmilk. The highest noncancer hazard is 60,000, also due primarily to PCBs in breastmilk.

5.2.5.3 Consideration of Regional Tissue Concentrations

PCBs and dioxins/furans have been detected in fish tissue collected in the Willamette and Columbia Rivers, outside of the Study Area. In the Columbia River Basin Fish Contaminant Survey, the basin-wide average concentrations of total PCBs in resident fish ranged from 0.032 to 0.173 parts per million (ppm) for whole body samples and from 0.033 to 0.190 ppm for fillet with skin samples (EPA 2002c). In the Middle Willamette River (RM 26.5 to 72), the average concentrations of total PCBs in resident fish ranged from 0.086 to 0.146 ppm for whole body samples and from 0.026 to 0.071 ppm for fillet with skin samples (EVS 2000). These concentrations are lower than the concentrations detected in the Study Area where average concentrations ranged from 0.16 to 2.8 ppm in whole body samples and from 0.17 to 2.5 ppm in fillet with skin samples (for PCBs as ~~Aroclors)~~total congeners). The fish species included in the studies were different than those collected within the Study Area, so the concentrations may not be directly comparable. Sources contributing to the PCBs and dioxins/furans detected in fish collected outside of the Study Area are

unknown and may not be relevant to the Study Area. ~~0.102 to 0.146 ppm for whole body samples and from 0.026 to 0.139 ppm for fillet with skin samples (EVS 2000).~~

In addition, the LWG collected upstream fish tissue samples at RM 20 and 28 during Round 1. The data for the upstream fish tissue samples are described in further detail in Section 5.5 of the RI Report. While there are a limited number of samples and species in the upstream fish tissue dataset, the results from the upstream fish tissue are consistent with the results from the Columbia and mid-Willamette River studies.

The EPA established a target fish tissue concentration of 0.0015 ppm for PCBs to allow a monthly fish consumption rate of more than 16 meals per month (EPA 2000c). The highest fish ingestion rates used in this BHHRA, 142 g/day for adult fishers and 175 g/day for adult tribal fishers, equate to over 19 and 23 meals per month, respectively, assuming an eight--ounce meal size.

The target fish tissue concentration established by EPA is based on a target cancer risk level of 1×10^{-6}. The regional PCB concentrations detected in resident fish from the Willamette and Columbia Rivers are approximately 20 to 100 times higher than the EPA target fish tissue concentration. These concentrations from outside of the Study Area are equivalent to cancer risks ranging from 2×10^{-5} to 1×10^{-4} relative to the EPA target fish tissue concentration, indicating that regional concentrations of PCBs exceed the lowest target cancer risk level of 1×10^{-6} for fish consumption rates higher than 16 meals per month. For noncancer endpoints, the EPA established a target tissue concentration is 0.0059 ppm. Concentrations detected in resident fish from the Willamette and Columbia Rivers are up to 30 times higher than this target tissue concentration. Regional efforts are underway to reduce concentrations in fish tissue.

5.2.5.4 Summary of Fish Consumption Risk Characterization

~~**Summary of Fish Consumption Risk Characterization**~~

Consumption of individual species by the fisher resulted in cumulative cancer risks ranging from 7×10^{-6} to 6×10^{-2} for the adult consumer and from 3×10^{-6} to 2×10^{-2} for the child consumer. The maximum endpoint-specific hazard index (HI) for both adult and child fish consumption scenarios was for the immunological endpoint, primarily due to consumption of PCBs in tissue. The highest HI for the immunological endpoint occurs from child consumption of whole body common carp tissue from river miles (RM) 4-8. The range of HIs for the immunological endpoint across all single-species exposure scenarios evaluated for non-tribal consumers is from 0.9 to 3,000 for the adult fish consumer and from 0.7 to 5,000 for the child fish consumer.

Fish consumption risks were also evaluated for adult and child tribal fishers based on the 95th percentile ingestion rate from the CRITFC Consumption Study (1994). The tribal fish consumption risks assumed a multi-species diet consisting of resident fish species (common carp, black crappie, brown bullhead, and smallmouth bass) as well

as sturgeon, lamprey, and salmon. Risks from the tribal fish diet were based on consumption of either whole body or fillet with skin tissue. It was assumed that all fish consumed were caught within the Study Area. Consumption of fish by the tribal fisher resulted in cumulative cancer risks ranging from 2×10^{-3} to 2×10^{-2} for the tribal adult fisher and from 4×10^{-4} to 3×10^{-3} for the tribal child consumer. The maximum endpoint-specific HIs for both the tribal adult and tribal child fishers were for the immunological endpoint, primarily due to consumption of PCBs in fish tissue. The range of immunological HIs for all tribal fisher fish consumption scenarios was from 50 to 400 for the tribal adult and from 100 to 800 for the tribal child.

Twenty-four contaminants resulted in a cancer risk greater than 1×10^{-6} or hazard quotient greater than 1 for at least one of the fish consumption scenarios evaluated in the draft BHHRA. The contaminants identified as posing potentially unacceptable risks were: PCBs, dioxins, six metals (antimony, arsenic, lead, mercury, selenium, and zinc), bis 2-ethylhexyl phthalate (BEHP), PAHs, hexachlorobenzene, and eleven pesticides (aldrin, dieldrin, heptachlor epoxide, total chlordane, total DDD, total DDE, total DDT, alpha-, beta, and gamma-hexachlorocyclohexane, and heptachlor). Of these, PCBs resulted in the highest cancer risks and hazard quotients.

A summary of risks from fish consumption is provided in Tables 5-180 and 5-181.

5.2.6 Shellfish Consumption Risk Characterization Results

5.2.6.1 Adult, Shellfish Consumption

~~**5.2.5.4 Adult, Shellfish Consumption**~~

Potential risks from shellfish consumption were estimated for the adult fisher scenarios. Risks to adult shellfish consumers were evaluated for clam and crayfish diets. For crayfish, risks were evaluated for each sample station and for Study Area-wide exposure. For clam, risks were evaluated on a river-mile basis and for Study Area-wide exposure separately for depurated and undepurated tissue, as agreed upon with EPA. Risks were estimated for~~-~~ an ~~high (~~18 g/day~~)~~ ingestion rate, which equates to approximately two and a half 8-ounce meals per month, and ~~medium~~ for a ~~(~~3.3 g/day~~)~~ ingestion rate~~s~~, which is just less than an 8-ounce meal every 2 months. Risks were calculated using both the 95% UCL/max and mean tissue concentrations of shellfish tissue. The results of the risk evaluation for shellfish consumption are presented in Tables 5-~~170~~ 182 to 5-~~181~~193. Cumulative risk exceedances for shellfish scenarios are summarized by exposure point in Maps 5-~~15~~ 8-1 through 5-8-4~~through 5-17~~. ~~In estimating the risks in this BHHRA, the health protective assumptions regarding shellfish consumption were multiplied together, which magnifies the overall conservatism in the risk estimates. The cumulative effects of the numerous conservative assumptions made during this BHHRA are risk estimates that are potentially significantly higher than actual risks that may exist within the Study Area.~~

Estimated risks from shellfish consumption within the Study Area ranged from a high cumulative cancer risk of 7 x 10^{-4}, which was for the 95% UCL/max EPCs, ~~high (~~18 g/day~~)~~ ingestion rate undepurated clam tissue scenario, to a cumulative cancer risk of 9 x 10^{-7}, which was for the mean EPC, ~~medium (~~3.3 g/day~~)~~ ingestion rate crayfish tissue scenario. Estimated risks from shellfish consumption in areas assessed outside of the Study Area ranged from 2 x 10^{-6} to 8 x 10^{-5}. Clam samples were not all analyzed for the same chemicals, and the uncertainties associated with the resulting risks are discussed in ~~Section~~ Section 6. Study Area-wide risks from ingestion of undepurated clam tissue are two to three times higher than Study Area-wide risks from ingestion of depurated clam tissue, as shown in Table 5-182 and Table 5-183. ~~.~~ Depurated clam tissue samples were collected from five locations at the northern and southern edges of the Study Area, while undepurated clam tissue samples were collected from 22 locations throughout the Study Area. For all high ingestion rate scenarios, risks are above a 1 x 10^{-6} cumulative cancer risk and are primarily due to PCBs.

Figures 5-18 through 5-21 show the relative contribution of individual COPCs to total risks from clam and crayfish consumption, as well as a summary of total risks per exposure point for the different ingestion rates.

The ~~highest endpoint specific~~cumulative HIs from shellfish consumption ranged from ~~30~~ 40 for the 95% UCL/max EPCs, ~~high (~~18 g/day~~)~~ ingestion rate, undepurated clam tissue scenario to ~~1~~ 0.06 for the mean EPCs, ~~medium (~~3.3 g/day~~)~~ ingestion rate, ~~depurated clam~~crayfish tissue scenario. Noncancer hazards above an HI of 1 are primarily due to PCBs. Study Area-wide HIs from ingestion of undepurated clam tissue are one to two times higher than Study Area-wide risks from ingestion of depurated clam tissue. These results are shown in Table 5-182 and Table 5-183.

~~There were multiple uncertainties associated with the shellfish consumption scenarios such as assumptions regarding shellfish tissue consumption rates, shellfish tissue EPCs, and the use of cooking and preparation methods. The shellfish consumption scenario assumes the stated ingestion rate every day of every year for a 30-year duration, assumes that the EPCs used in this BHHRA represent the average shellfish tissue concentrations over a 30-year duration, and assumes that all shellfish ingested were collected at the same station within the Study Area, despite the fact that there is no documented ongoing consumption of shellfish in the Study Area and the harvest or possession of Asian clams, the species assessed in the BHHRA, is illegal. If the ingestion rate were higher or lower, if the average shellfish tissue concentrations over the 30-year duration were higher or lower than the EPCs, or if a portion of the shellfish consumed included store-bought shellfish or shellfish caught at other locations, the calculated risks from consuming shellfish collected from the Study Area would be higher or lower. In calculating the risk estimates it was assumed that the whole organism was consumed, and there was no decrease in chemical concentrations in tissue during preparation, such as removal of crayfish heads, or cooking.~~

5.2.6.2 Breastfeeding Infant of Adult Who Consumes Shellfish

~~**5.2.5.5 Breastfeeding Infant of Adult Who Consumes Shellfish**~~

Risk and hazards to infants consuming human milk from adults consuming shellfish were assessed for bioaccumulative compounds for all adult shellfish consumption scenarios, in accordance with EPA (2005) and DEQ (2010) guidance. Cancer risks and noncancer hazards to infants were calculated by applying an IRAF to the adult cancer risk and noncancer results from shellfish consumption, as shown in Tables 5-194 through 5-197. The highest cancer risk to a breastfeeding infant of an adult consumer of shellfish is 7×10^{-4}, from human milk consumption of an adult who consumed undepurated clam tissue at the 18 g/day ingestion rate. The risk is primarily from PCBs in breastmilk. The highest cumulative hazard quotient from bioaccumulative chemicals is 800 due primarily to PCBs in breastmilk.

5.2.6.1 Summary of Risks from Consumption of Shellfish

A summary of risks from consumption of Shellfish is provided in Table 5-198 by receptor and analyte. Cancer risks and noncancer hazards exceed the targets of 1×10^{-6} and 1, respectively, for all scenarios evaluated.

5.2.7 Evaluation of Cumulative and Overlapping Scenarios

As shown in the conceptual site model (Figure 3-1), multiple exposure scenarios may exist for a given population. For example, recreational beach users are potentially exposed to both beach sediment and surface water. The risks for each of the exposure scenarios that are considered potentially complete and significant for a given population were summed to estimate the cumulative risks for that population. The cumulative risks are presented in Table 5-~~182 191~~199 for 95% UCL/max exposures, and in Table 5-~~183 192~~200 for mean exposures. Additionally, cumulative risks for divers exposed to both in-water sediment and surface water are presented on a ½-river mile basis, per side of river, in Table 5-~~184 199~~ 201 for ~~95% UCL/max~~RME exposures and Table 5-~~185 200~~202 for ~~mean~~ CT exposures.

As discussed in Section 3, certain individuals may be exposed to COPCs within the Study Area through multiple exposure scenarios; for example, a recreational beach user might also be a fisher. This BHHRA quantitatively estimated risks for the individual exposure scenarios. Due to multiple exposure locations over different scales for both RME and CT scenarios, as well as ranges of ingestion rates and multiple diets for fish consumption, there are numerous potential combinations of overlapping scenarios. As a result, this BHHRA did not quantitatively evaluate all possible overlapping scenarios. However, risks from fish consumption are generally at least an order of magnitude higher than risks from other exposure scenarios, so if an individual consumes fish, the contribution from other exposure scenarios is not likely to contribute significantly to the overall risks for that individual.

5.2.8 Risk Characterization of Lead

A great deal of information on the health effects of lead has been obtained through decades of medical observation and scientific research. By comparison to most other environmental toxicants, the degree of uncertainty about the health effects of lead is quite low. Because age, health, nutritional state, body burden, and exposure duration influence the absorption, release, and excretion of lead, EPA has not established standard toxicity endpoints for lead. Instead, the concentration of lead in the blood is used as an index of the total dose of lead, regardless of the route of exposure (EPA 1994). As a result, blood lead levels, rather than intakes, are used to evaluate potential risks associated with exposure to lead. The Centers for Disease Control (CDC) has identified a blood lead level of 10 micrograms per deciliter (µg/dl) as the level of concern above which significant health risks may occur (CDC 1991). An acceptable risk for lead exposure typically equates to a predicted probability of no more than 5 percent greater than the 10 µg/dl level (EPA 1998).

Lead was identified as a COPC for in-water sediment, fish and shellfish. The following discusses the evaluation of risks from lead for each of those media.

5.2.8.1 In-~~water~~ Water sediment

Lead was identified as a COPC for in-water sediment because the maximum detected concentration exceeds the RSL for industrial soil of 800 mg/kg. The RSL was developed to be protective of the fetus of a pregnant woman exposed to lead. The only receptors for in-water sediment exposures are adults. Therefore, the fetus of a pregnant in-water worker or fisher is the most sensitive scenario for exposure to lead in in-water sediment, and the RSL is protective of that scenario. While maximum detected concentrations were used in identifying COPCs, EPCs were used to calculate risks. The maximum EPC for one of the in-water sediment exposure areas (2,200 mg/kg) is greater than the RSL. The adult lead model (ALM, Version 5/19/05, EPA 2003c) was used to estimate the probability of exceeding a target blood level for lead of 10 µg/dl from exposure to in-water sediment. Exposure parameters from Table 3-27 were used to develop site-specific ALM input parameters. For scenarios modeling exposure to in-water sediment, the exposure factors from Table 3-27 were adjusted with the assumption of a 25% sediment contact frequency. For ALM parameters without site-specific values, the model defaults for the West Region from Phases 1 and 2 of the National Health and Nutrition Evaluation Survey (NHANES III) (EPA 2002e) were used. The site-specific ALM blood lead concentration estimates for receptors potentially exposed to in-water sediment within the Study Area are presented in Tables ~~F4~~F5-1 and ~~F4~~F5-2 of Attachment ~~F4~~F5.

Using the maximum EPC of 2,200 mg/kg, the maximum estimated probability of exceeding a fetal blood lead level of 10 µg/dL for any in-water sediment exposure scenario is one percent, which is for the RME in-water worker and RME high-frequency fisher scenarios. Because the maximum EPC for lead results in a probability of exceeding protective blood lead levels in the fetus of a pregnant woman

that is less than 5 percent, lead is not considered a chemical potentially posing unacceptable risks ~~COC~~ for in-water sediment. All other EPCs for lead were below the RSL. The uncertainty associated with the evaluation of lead is discussed further in ~~Section~~ Section 6.

5.2.8.2 Fish

Lead was identified as a COPC for fish consumption because it was detected in fish tissue. The Columbia River Basin Fish Contaminant Survey (EPA 2002c) determined fish tissue concentrations for lead that are unlikely to result in blood lead levels exceeding 10 µg/dl for the fetus of a pregnant adult, and for children. These concentrations were developed using the ALM (EPA 2003c) and the Integrated Exposure Uptake Biokinetic Model for Lead in Children (IEUBK, EPA 2007d), in combination with the fish ingestion rates from the CRITFC Fish Consumption Survey (CRITFC 1994). The concentrations of concern were developed using health protective exposure assumptions and were considered unlikely to underestimate risks from fish consumption.

Adults
The following equations from the ALM were used in the Columbia River Basin Fish Contaminant Survey (EPA 2002c) to develop tissue concentrations to be protective of fetuses of tribal adults:

$PbB_a = PbB_o + BKSF * (PbF * IR_F * AF_F * EF_F)/AT$

$PbBf = PbB_a * 0.9$

Probability that fetal blood lead is less than 10 µg/dl using the z-value where:

$p' = \Phi z\ [\ (\ln(PbBf)-\ln(10))\ /\ln(GSD)\ ]$

Where:
PbB_a = Central tendency of adult blood lead level
PbB_o = Adult baseline blood lead level
PbBf = Fetal blood lead level
GSD = Geometric standard deviation
BKSF = Biokinetic slope factor
PbF = Lead fish tissue concentration
IR_F = Fish tissue ingestion rate
AF_F = Absolute gastrointestinal ingestion factor for ingested lead in tissue
EF_F = Exposure frequency of fish ingestion
AT = Averaging time

The EPA (2003c) ALM approach was used to determine protective fish tissue concentrations for the fetuses of both adult fishers and adult tribal fishers in the Study Area, using updated default ALM assumptions for the West Region, which are based on current EPA guidance (EPA 2003c). Differences in default parameter values from the EPA (2003c) application of the ALM to the ALM application for this BHHRA

include a change in PbB_o from 2.2 µg/dl to 1.4 µg/dl, and a change in AF_F from 0.1 to 0.12.

The evaluation of risks from lead is based on geometric mean levels and associated probabilities, so median values are generally used as inputs to the equations. The mean estimate of national per capita fish consumption of 7.5 g/day was used as the consumption rate for adults (EPA 2000b). The median fish ingestion rate for tribal fishers is 39.2 g/day, as stated in the CRITFC Fish Consumption Survey (CRITFC 1994) and used by the EPA (2002c) in calculations of protective lead tissue concentrations. The ALM inputs and results for estimating protective lead tissue concentrations for fetuses of adult fishers and adult tribal fishers consuming fish in the Study Area are provided in Table ~~F4~~F5-3 of Attachment ~~F4~~F5.

Using the above equations, the ALM predicts that fetal blood lead levels will exceed 10 µg/dl less than 5 percent of the time for adult fishers at a lead fish tissue concentration of 5.25 mg/kg. The maximum fish tissue EPC for lead in the Study Area is 1,100 mg/kg, detected in a smallmouth bass whole body tissue sample. This is above the protective concentration of 5.25 mg/kg. However, this maximum EPC is orders of magnitude greater than all other resident fish EPCs and may be attributable to lead in the gut of the fish due to the ingestion of a metallic object (e.g., sinkers) (Integral 2008). There are no other resident fish tissue EPCs which exceed a protective lead concentration of 5.25 mg/kg. Therefore, while lead is considered a preliminary chemical potentially posing unacceptable risks~~COC~~ for fish ingestion by an adult fisher, the uncertainties associated with the maximum detected concentration and evaluations of lead are discussed further in ~~Section~~ Section 6.

The protective lead tissue concentration for fetuses of tribal adults, using the above methods, is 1.01 mg/kg. The maximum fish tissue lead EPC for an adult tribal fisher is 23 mg/kg. However, the tribal fisher tissue ingestion scenario is for a multi-species diet consisting of both resident and anadromous species. There are no detected concentrations in anadromous species exceeding 1.01 mg/kg. Over 99% of the lead in the maximum lead EPC for tribal fishers is attributable to the Study Area-wide EPC for lead in smallmouth bass, which is influenced by the maximum EPC mentioned above for adult fishers. Therefore, while lead is considered a preliminary chemical potentially posing unacceptable risks~~COC~~ for fish ingestion by an adult tribal fisher, the uncertainties associated with the maximum detected concentration and evaluations of lead are discussed further in ~~Section 7~~Section 6.

Children

The EPA (2002c) used the IEUBK model in the Columbia River Basin Fish Contaminant Survey to determine risks from ingestion of lead in tissue in tribal children. The same IEUBK methodology was applied to assess risks to children from ingestion of lead in fish tissue for this BHHRA.

To assess risks to children from ingestion of lead in fish tissue, a protective tissue concentration of lead in fish tissue was calculated using the IEUBK model with all exposure parameters set to default levels and with the addition of a fish ingestion rate based on the child consumption scenario for this BHHRA. The default exposure parameters for the IEUBK model, provided as Table ~~F4~~F5-4, are the same model parameters used by the EPA (2002c) because~~.~~ site-specific values for soil lead concentration, house dust lead concentration, lead concentration in air and drinking water are not readily available. The ratio of child to adult consumption rates of 0.42, described in Section 3.5.1.5, was applied to the consumption rate for adults of 7.5 g/day to obtain a consumption rate for children of 3.15 g/day. In accordance with the methodology used by the EPA (2002c), fish ingestion was specified in the IEUBK model as the percentage of meat in diet consisting of locally caught fish and the lead concentrations in the fish. The protective fish tissue concentration for a child consumer, using the above method, is 2.6 mg/kg lead in fish tissue. The protective fish tissue concentration of 2.6 mg/kg is the fish tissue concentration resulting in predicted geometric blood lead level of 4.6 µg/dl and the probability of achieving a blood lead level greater than 10 µg/dl is no more than 5 percent.

The Columbia River Basin Fish Contaminant Survey (EPA 2002c) determined that 0.5 mg/kg is a protective tissue concentration for tribal children consuming tissue at a rate of 16.2 g/day, which is the 65th percentile consumption rate from their survey. Within the Portland Harbor Study Area, the maximum lead tissue EPC for the tribal child consumption scenario is 23 mg/kg, which is greater than the estimated protective concentration. Over 99% of this concentration is attributable to the contribution from the Study Area-wide smallmouth bass EPC. There are no anadromous species with detected lead concentrations exceeding 0.5 mg/kg. Therefore, while lead is considered a preliminary chemical potentially posing unacceptable risks ~~COC~~ for fish tissue for a tribal child consumer, the uncertainties associated with the maximum detected concentration and evaluations of lead are discussed further in ~~Section~~ Section 6.

5.2.8.3 Shellfish

Lead was identified as a COPC for shellfish consumption because it was detected in shellfish tissue. Shellfish consumption was only evaluated for adult scenarios. Therefore, the tissue concentration of concern for fetuses is the only tissue concentration relevant for shellfish consumption. The CRITFC approach to assessing risks from lead using the ALM was applied to the shellfish ingestion scenario for the site. Using the ALM equations applied to adult fishers in the previous section, the mean shellfish ingestion rate of 3.3 g/day, and the maximum shellfish exposure point concentration of 1,320 µg/kg, the ALM predicts that fetal blood lead levels will exceed 10 µg/dl less than 5 percent of the time. Therefore, lead is not considered a chemical potentially posing unacceptable risks~~COC~~ for shellfish consumption. The ALM parameter values and results used to assess risk from adult exposure to lead via ingestion of shellfish are shown in Attachment ~~F4~~F5.

5.3 SUMMARY OF RISK CHARACTERIZATION

The ranges of estimated potential risks resulting from the different exposure scenarios evaluated in this BHHRA are summarized in Table 5-~~186~~203. The ranges included in Table 5-~~186~~ 203 for different scenarios reflect differences in CT vs. RME scenarios, differences in tissue EPCs (mean vs. 95% UCL/max), level of fish consumption (~~high [~~17.5 g/day ~~]~~[EPA 2002b], ~~higher [~~73 g/day ~~]~~[Adolfson 1996], and ~~highest [~~142 g/day ~~]~~[EPA 2002b]), location of sediment (for beach scenarios), tissue type (whole body vs. fillet or depurated vs. undepurated), and species of fish consumed. There were multiple uncertainties associated with the different scenarios such as ~~use of maximum concentrations as EPCs,~~ the spatial scale of EPCs, sediment and surface water exposure parameters, tissue consumption rates, tissue type and fish and shellfish species consumed, fish and shellfish cooking and preparation methods, and contributions from background. ~~In estimating the risks in this BHHRA, the health protective assumptions associated with each of the scenarios were multiplied together, which magnifies the overall conservatism in the risk estimates. The cumulative effects of the numerous conservative assumptions made during this BHHRA are risk estimates that are potentially significantly higher than actual risks that may exist within the Study Area.~~

In general, the risks from fish consumption are higher than any of the other exposure scenarios evaluated in this BHHRA. These risks can be summarized as follows:

- The range of cumulative risks from all fish consumption scenarios is 3×10^{-6} to ~~6~~ 7 $\times 10^{-2}$, and the ~~highest endpoint-specific~~cumulative HIs range from 0.5 to 5,000. The highest HI for a breastfeeding infant of a fish consumer is ~~5000~~60,000.

- Cumulative cancer risks from consumption of shellfish range from 9×10^{-7} to 7×10^{-4}, and the cumulative HIs range from 0.06 to 40. ~~and t~~The highest ~~endpoint-specific~~ HI~~s range from~~ for a breastfeeding infant of a shellfish consumer is ~~1 to 30~~800.

- For beach sediment, cumulative cancer risks range from ~~5~~ 8 $\times 10^{-10}$ - 9 to 9×10^{-5}, and the cumulative HIs range from ~~2~~ 5 $\times 10^{-5}$ - 4 to 1.

- For in-water sediment, cumulative cancer risks range from ~~4~~ 3 $\times 10^{-11}$ - 9 to ~~2~~ 3 $\times 10^{-4}$, and the cumulative HIs range from ~~1~~ 6 $\times 10^{-9}$ - 5 to ~~15~~3. The highest HI for a breastfeeding infant of an in-water sediment receptor is 5 (for the tribal fisher).

- For direct contact to surface water, cumulative cancer risks range from 8×10^{-10} to ~~7~~ 9 $\times 10^{-4}$, and the cumulative HIs range from 1×10^{-9} - 5 to 2.

- For groundwater seeps, cumulative cancer risks range from 4×10^{-10} to 3×10^{-9}, and the cumulative HIs range from 1×10^{-6} - 3 to 6×10^{-4}3.

Chemicals that resulted in a cancer risk greater than 1 x 10^{-6} or an HQ greater than 1 under any of the exposure scenarios for any of the exposure point concentrations evaluated in this BHHRA are presented in Table 5-204. ~~Chemicals were identified as preliminary COCs if they resulted in a cancer risk greater than 1 x 10^{-6} or an HQ greater than 1 under any of the exposure scenarios for any of the exposure point concentrations evaluated in this BHHRA, regardless of the uncertainties. The preliminary COCs and the associated exposure scenarios are presented in Table 5-187. The final COCs, which are based on consideration of the uncertainties in this BHHRA, are presented in Section 8. Certain chemicals and media contribute significantly more than others to overall risk for the Study Area. A more detailed description of risk drivers for the Study Area is provided in Section 8.~~

6.0 SCREENING OF SURFACE AND TRANSITION ZONE WATER DATA

This BHHRA evaluated risks associated with the potentially complete and significant exposure pathways identified in the CSM. In addition to the quantitative evaluation of risks presented in Section 5, this BHHRA includes a screening evaluation of surface and shallow (less than or equal to 38 cm in depth) TZW relative to the possible contribution to potentially complete and significant exposure pathways. Specifically, surface water data were evaluated as a potential source of contamination for biota that are consumed by humans. TZW data were evaluated as a potential source to untreated surface water that is hypothetically used as a domestic water source. TZW data were also evaluated relative to collocated in-water sediment and shellfish tissue data as a potential source of contamination for biota that are consumed by humans. The criteria that were used in the screening evaluations of surface water and TZW were specified by EPA in comments on the preliminary remediation goal (PRG) TM dated June 30, 2006 and on the Round 2 Report dated January 15, 2008.

6.1 SCREENING OF SURFACE WATER DATA

This section presents the results of screening the complete surface water dataset (i.e., all Study Area-wide surface water samples from the SCRA dataset, including those not used previously in the BHHRA) against human health based screening levels for the consumption of organisms. This is a separate evaluation from the identification of COPCs presented in Section 2.

Risks from consumption of biota were evaluated in this BHHRA using empirical tissue data collected within the Study Area. The use of actual tissue data to assess risks provides for greater confidence in calculated risk estimates than attempting to model tissue data from sediment and/or water. However, in some instances, biota data may not be available from all areas where surface water is potentially contaminated.

In the EPA's comments on the PRG TM (dated June 30, 2006) and Round 2 Report (dated January 15, 2008), EPA requested that surface water data be screened, as a source of contaminants to biota consumed by humans, against Human Health Ambient Water Quality Criteria for the Consumption of Organisms (human health AWQC) (EPA 2009c). Human health AWQC are not site-specific but rather rely on default assumptions about bioconcentration in aquatic organisms. Since bioconcentration can vary greatly between sites and species, site-specific information on uptake or on concentrations in food items reduces uncertainty greatly.

To comply with EPA's request the biota consumption exposure pathway was evaluated for surface water by comparing the maximum concentration detected in surface water for each chemical to the respective human health AWQC for consumption rates of 17.5 grams per day (g/day) and 175 g/day. If the human health AWQC was exceeded, the 95% UCL for surface water for each chemical was compared to the respective human health AWQC.

Table 6-1 presents the results for screening surface water against human health AWQC. All Study Area-wide LWG surface water samples were included in the dataset screened for this evaluation. There are 23 chemicals for which the maximum detected concentration exceeded the human health AWQC at both consumption rates screened. There are 22 chemicals for which the 95% UCL exceeded the human health AWQC at a consumption rate of 175 g/day, and 11 chemicals for which the 95% UCL exceeded the human health AWQC for a consumption rate of 17.5 g/day. Locations of surface water exceedances of the human health AWQC for 175 g/day are shown in Map 6-1.

Of the list of chemicals for which the maximum detected surface water concentration exceeded the human health AWQC, only chrysene was not identified as a COC for shellfish or fish tissue. The AWQC for chrysene was derived using the benzo(a)pyrene toxicity value; however, the cancer slope factor for chrysene is 1,000 times less than that of benzo(a)pyrene, so exceedance of the AWQC for chrysene is not an indication of unacceptable risk.

Chrysene was detected in clam and crayfish tissue at concentrations that do not lead to unacceptable risk levels. Chrysene was detected in only two of the 35 crayfish tissue samples analyzed. For consumption of crayfish, the maximum cancer risk level from chrysene was 7×10^{-8} (18 g/day ingestion rate). Chrysene was detected in 40 of the 42 undepurated clam samples in which it was analyzed. For consumption of clams, the maximum cancer risk level from chrysene was 5×10^{-7} (18 g/day ingestion rate).

The results of the screening evaluation of surface water data indicate that chemicals in surface water may be contributing to the risks from consumption of biota. The relative contribution of sediment and surface water concentrations to concentrations in biota and the contribution of sediment to the surface water concentrations will be further evaluated as part of the fate and transport modeling efforts in the feasibility study.

6.2 SCREENING OF TRANSITION ZONE WATER DATA

6.2.1 Potential Contribution to Surface Water

There are no direct exposure pathways for human populations to TZW. However, in theory, chemicals present in TZW could contribute to surface water concentrations. This section presents the results of the screening of shallow TZW data for contributions to surface water used in untreated form as a hypothetical domestic water source. To evaluate the potential for contributions to surface water, TZW data were initially screened directly against drinking water screening values. For those chemicals with concentrations exceeding screening values in TZW, surface water concentrations were estimated through loading calculations and those surface water concentrations were compared against drinking water screening values. Shallow TZW data (less than or equal to 38 cm in depth) collected within the Study Area during the Siltronic supplemental in-river TZW sampling event, and the Round 2a groundwater pathway assessment TZW sampling event, were used for the screening, including both filtered and unfiltered sample results. Deep TZW (greater than 38 cm in depth) does not pose a potentially complete pathway for human exposure, and thus was not

evaluated in this screening. A discussion of the relationship between deep TZW and surrounding media is provided in Appendix D of the RI Report.

For direct screening of TZW, the BHHRA data rules for handling of replicates and summing of analytes (described in Attachment F2) were applied to the dataset. It should be noted that TZW data were collected from targeted areas within the Study Area based on likelihood of contamination contribution from upland sources. The selective nature of the TZW data set represents a conservative evaluation for human health risks from potential contributions from TZW to surface water.

The maximum detected concentration in TZW was screened against the respective RSLs for tap water (EPA 2009a, values updated April, 2009) and the MCL, when one was available, as required by EPA in its comments on the Round 2 Report (dated January 15, 2008). The results of this comparison are presented in Table 6-2.

In this BHHRA, untreated surface water was evaluated as a hypothetical future domestic water source. While there are no direct exposure pathways to TZW, concentrations of chemicals in TZW could contribute to surface water concentrations. Loading estimates and models were used to estimate surface water concentrations resulting from TZW based on the central tendency flow estimates of groundwater to the Willamette River. Loading estimates were calculated based on assumptions, data rules, and the TZW data set used for the RI. In order to provide a reasonable estimate of surface water concentrations based on loading from groundwater discharge, central flow loading estimates were used with the average annual mean flow rate (measured from 1973 through 2007) to calculate surface water concentrations. The average annual mean flow was used to calculate loading in order to represent the exposure that would hypothetically occur with daily exposure over a 30 year exposure duration, which are the exposure assumptions that were used in this BHHRA to assess risks from the hypothetical future use of surface water as a domestic water source. Further detail regarding the derivation of the surface water estimates is provided in Section 6 and Appendix D of the RI Report. These estimates are considered mean approximations of upland groundwater plume loading to surface water for several reasons that are discussed in detail in Appendix D.

Table 6-3 provides the comparison of the estimated surface water concentrations against the EPA RSLs and MCLs. Of the chemicals listed, only the surface water concentration estimate for chloroform exceeds the respective RSLs. There are no exceedances of MCLs. The tap water RSL for chloroform is 1.9×10^{-1} ug/l, and the estimated surface water concentration estimate is 2.0×10^{-1} ug/l. As described in Appendix D, the loading estimates for chloroform are dominated by TZW sample concentrations from a single location. More than 99 percent of the estimated chloroform load is associated with a TZW sample concentration of 770,000 µg/l at location AP03D, which is near RM 7W.

The results of the screening evaluation of TZW data indicate that TZW is not likely to significantly contribute to the overall risk, even if untreated surface water was used as a domestic water source. As presented in Section 5, the Study Area-wide RME cumulative cancer risk associated with the hypothetical future use of untreated surface water as a

domestic water source is 8 x 10^{-6}, primarily due to the presence of arsenic. Given the small magnitude of the exceedance of the EPA RSL for tapwater, the conservatism in the approximations of upland groundwater plume loading to surface water, and the uncertainty associated with loads that are dominated by individual TZW sample concentrations, TZW is not likely to significantly contribute to overall risk.

Potential for Bioaccumulation

This section presents the results of screening shallow TZW data for the biota consumption exposure scenarios, as directed by EPA, and an evaluation of corresponding collocated in-water sediment and biota samples. Shallow TZW data were screened against surface water screening levels derived using AWQC (EPA 2009c) and at the high (17.5 g/day) and highest (175 g/day) fish consumption rates of the BHHRA. AWQC are published for an ingestion rate of 17.5 g/day, which represents the 90th percentile ingestion rate for combined freshwater and estuarine shellfish and finfish (EPA 2000d). For this screening, AWQC for a consumption rate of 175 g/day were calculated based on direction from EPA, as documented in Attachment F1. As mentioned previously, risks from consumption of biota were evaluated in this BHHRA using empirical tissue data collected within the Study Area. The use of empirical tissue data to assess risks provides for less uncertainty in calculated risk estimates than the use of modeling tissue concentrations from TZW contributions. Evaluating collocated shellfish tissue, TZW, and in-water sediment data provides context for possible contributions of different media to risks from bioaccumulation.

To perform this screening, data for shallow TZW samples collected within a 100-foot radius of a shellfish sampling station were compiled. There were between one and two TZW samples within 100 feet of each shellfish station evaluated. Chemicals included in the TZW screening were those which resulted in an exceedance of 10^{-6} risk or HQ of 1 for consumption of shellfish for at least one exposure area in the BHHRA, and for which there were also TZW analytical results. Based on directive from the EPA (see attachment F1), the maximum TZW concentration within each shellfish sampling station radius was compared to the respective human health AWQC for biota consumption rates of 17.5 g/day and 175 g/day[8].

Also based on direction from EPA (see attachment F1), both filtered and unfiltered TZW data were screened, of which there were more unfiltered TZW data available. AWQC were developed by the EPA for evaluation of surface water. However, for the purposes of this bioaccumulation screening, TZW data were compared to respective AWQC values without applying a dilution or loading factor or consideration of bioavailability based on known mechanisms for partitioning chemicals among biotic and abiotic media.

Table 6.4 shows the results for screening collocated TZW data against respective AWQC. Filtered and unfiltered TZW data were screened separately. Additionally, Table 6.4 shows the respective shellfish tissue analytical concentrations and associated cancer risk, as well as

[8] AWQC based on consumption rates of both 17.5 g/day and 175 g/day were used in the bioaccumulation TZW screening; however, the highest shellfish consumption rate assumed in the BHHRA was 18 g/day.

~~the maximum in-water sediment concentration for samples collected within a 100-foot radius of each shellfish station. There were between one and six in-water sediment samples collected within 100 feet of each shellfish station evaluated.~~

~~One metal and ten organic chemicals were screened for bioaccumulation from TZW, including: arsenic, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, dibenzo(a,h)anthracene, indeno(1,2,3-cd)pyrene, total DDD, total DDE, total DDT, and total dioxin/furan TEQ. Of these, 10 chemicals exceeded AWQC values at one or more of the shellfish stations.~~

~~Unfiltered TZW samples exceeded the 17.5-g/day AWQC in 17 of 35 possible comparisons of individual chemicals. Unfiltered samples exceeded the 175-g/day AWQC in 19 of 35 possible comparisons of individual chemicals. Filtered TZW samples exceeded the 17.5-g/day AWQC in 1 of 14 possible comparisons of individual chemicals. Filtered TZW samples exceeded the 175-g/day AWQC in 5 of the 14 possible comparisons of individual chemicals. Arsenic was the only analyte that did not exceed AWQC values. For both filtered and unfiltered TZW data, maximum TZW concentrations of pesticides and PAHs also exceeded their respective AWQC values in locations where shellfish tissue data did not result in an exceedance of 10-6 cancer risk from shellfish consumption. However, comparisons of unfiltered TZW values for highly hydrophobic organic chemicals may be affected by the presence and organic content of total suspended solids.~~

~~The results of this TZW screening do not suggest that TZW data are a reliable indicator of potential risk from tissue consumption because of significant uncertainties in accounting for chemical bioavailability and human exposure. Chemical partitioning among competing abiotic media (e.g., sediments, total suspended solids, particulate and dissolved organic matter) can substantially affect estimates of chemical uptake via TZW. Many of the these factors were considered in the methodology and Technical Support Documents that EPA (2000d) used to develop AWQC values, but are often ignored in making simple screening comparisons (e.g., use of unfiltered samples).~~

~~Although default assumptions concerning ingestion rates of aquatic organisms are also a useful screening tool, they too carry a significant amount of uncertainty that should be weighed in making such comparisons. EPA's (2000d, 2009c) AWQC values for consumption of aquatic organisms only are based on combined ingestion rate of freshwater and estuarine fish and invertebrates. As indicated in EPA's (2002b) analysis of per capita fish consumption in the United States, the contribution of shellfish to the default consumption rate is dominated by estuarine organism, principally shrimp. For consumption of freshwater organisms only, shellfish account for about 0.01 g/day, which is only a small fraction (<1 percent) of the total freshwater fish and shellfish ingestion rate. Consequently, TZW screening based on a shellfish consumption rate of 17.5 g/day or 175 g/day are more likely than not to be overestimates of freshwater shellfish ingestion may not be accurate metrics for judging the importance of bioaccumulation via TZW. Consequently, empirical tissue data provide a more reliable and preferred indication of possible health risk via consumption of freshwater aquatic organisms.~~

~~7.0~~6.0 UNCERTAINTY ANALYSIS

Uncertainty is associated with every step of a risk assessment, from the sampling and analysis of chemicals in environmental media to the assessment of exposure and toxicity and the risk characterization. In general, the approach and methodologies used in a risk assessment are designed to err on the side of conservatism, i.e., protection of health. In a deterministic risk assessment, ~~multiple~~ conservative assumptions can compound to result in an estimate of risk that ~~can be many times (or orders of magnitude) greater than the likely actual risk posed by a particular site~~is at the upper end of the probable risk range.

~~Probabilistic risk assessment uses probability distributions for one or more variables in a risk equation in order to quantitatively characterize variability and/or uncertainty related to lack of knowledge (EPA 2001c). As stated in EPA guidance: "Information from a probabilistic risk assessment can be used to make statements about the likelihood of exceeding a risk level of concern, given the estimated variability in elements of the risk equation. Since the results of point estimate methods generally do not lend themselves to this level of risk characterization (e.g., quantitative uncertainty assessment), probabilistic risk assessment can provide unique and important supplemental information that can be used in making Superfund risk management decisions at Superfund sites." (EPA 2001c). This BHHRA does not include a probabilistic risk assessment, by agreement with EPA. However, EPA guidance states that the value of probabilistic methods has become increasingly apparent in evaluating uncertainty at some sites. The need for a probabilistic risk assessment to support risk management decisions for the Site should be considered.~~

Uncertainty can have two components: 1) variability in data or information, and 2) lack of knowledge. An uncertainty analysis conducted as part of a risk assessment focuses on issues of variability and knowledge uncertainty associated with each of the inputs and models used to derive the risk estimates.

Variability arises from true heterogeneity in exposure variables or responses, such as dose-response differences within a population or differences in contaminant levels in the environment. The values of some variables used in an assessment change with time and space, or across the population whose exposure is being estimated. Although variability can be better understood, it cannot be reduced through further study. Use of RME and CT scenarios provide an estimate of high-end and average exposures that may reasonably occur. The difference between the RME and CT risk estimates provides an initial evaluation of the degree of variability in exposure between individuals.

The second factor that generates uncertainty is a lack of knowledge about factors such as adverse effects or chemical concentrations. Uncertainty may be reduced by increasing knowledge about a factor through additional study, although it is impossible to gather enough data to eliminate uncertainty. In addition, at some point,

there are diminishing returns associated with the collection of additional data; the cost of data collection is substantial and disproportional to the reduction in uncertainty. A substantial amount of uncertainty is often inherent in environmental sampling as well as in the scientific models used in risk assessment.

This section includes a detailed analysis of uncertainties associated with each step of the BHHRA. ~~The objective of the uncertainty analysis is to understand the overall degree of conservatism in the risk estimates for consideration when reviewing and applying the results of this BHHRA in the feasibility study and in risk communication.~~ However, ~~as indicated above,~~ a deterministic risk assessment alone cannot quantify the degree of conservatism in risk estimates, and this BHHRA does not include a probabilistic risk assessment, per agreement with EPA. This uncertainty analysis addresses variability and/or uncertainty in the inputs to the risk estimates, focusing on those inputs likely to have the greatest effects on the results of the risk analyses. A summary of uncertainties associated with this BHHRA and discussed in this section are provided in Table ~~7~~6-1.

~~7.1~~6.1 DATA EVALUATION

As discussed in Section 2, data collected during the RI, as well as data of confirmed quality that meet the DQOs for risk assessment, were used in this BHHRA to estimate risks. Sediment, surface water, groundwater seep, ~~transition zone water,~~ and biota data were collected for use in this BHHRA. Use of the EPA's DQO planning process (EPA 2000e) minimized the uncertainty associated with the data collected during the RI; however, some amount of uncertainty is inherent in environmental sampling. The following data evaluation uncertainties have been identified.

~~7.1.1~~6.1.1 Use of Target Species to Represent All Types of Biota Consumed

Because it is not practical to collect samples of every resident species consumed by humans within the Study Area, target resident species were selected to represent the diet of all biota consumed by humans, as recommended by EPA guidance (2000a). Four target species were collected to represent resident fish tissue diet (smallmouth bass, black crappie, common carp, and brown bullhead), and two species were collected to represent shellfish diet (crayfish and clam). ~~The target species were selected to provide the most conservative estimate of risk to human health and are a source of uncertainty when used to represent the risk from consumption of all biota within the Study Area.~~ Factors in selecting the target species included: consumption by humans, home range, potential for bioaccumulation, trophic level of species, and abundance.

The range of concentrations detected in the target species generally coincides with the range of concentrations detected in other species that were collected. Furthermore, the concentrations of PCBs, which is the chemical group with the greatest

contribution to risk, are generally highest in smallmouth bass and common carp, both of which were included in this BHHRA. Therefore, the use of target resident species to represent all biota consumed should not impact the conclusions of this BHHRA, and may in fact overestimate risks, especially if non-resident species are consumed.

~~7.1.2~~6.1.2 Source of Chemicals ~~For~~ for Anadromous and Wide-Ranging Fish Species

For non-resident fish species, salmon, lamprey, and sturgeon were chosen as target species to represent a portion of the tribal fish tissue diet. Due to the life cycles of these species, these fish spend some portion of their lives outside of the Study Area. The time spent outside the Study Area may be significant for bioaccumulation of chemicals due to the growth, development, and feeding that occurs, as well as the relative amount of time spent within the Study Area versus outside of the Study Area.

The Washington Department of Ecology analyzed returning fall Chinook salmon, as fillet tissue with skin, collected from three coastal rivers (Queets, Quinault, and Chehalis Rivers) in 2004 (Ecology 2007). PCBs as Aroclors were detected at concentrations ranging from 5.0 µg/kg to 6.3 µg/kg in the Ecology study relative to the maximum detected concentration of 20 µg/kg for salmon fillet tissue with skin collected from the Lower Willamette. The dioxin TEQ concentrations ranged from 0.09 picograms per gram (pg/g) to 0.23 pg/g in the Washington coastal rivers relative to the maximum detected concentration of 2 pg/g for salmon fillet tissue with skin collected from the Lower Willamette. A comparison of the tissue concentrations from the Ecology study and the Lower Willamette are presented in Table 6-2. While the Chehalis River passes through some developed areas and therefore may have localized sources, both the Queets and Quinault Rivers are located almost entirely within Olympic National Forest and wilderness areas, so the potential for contribution from localized sources should be minimal. These results indicate that sources of chemicals outside of the Study Area may contribute to bioaccumulation of chemicals in anadromous fish species.

~~The Washington Department of Ecology analyzed returning fall Chinook salmon, as fillet tissue with skin, collected from three coastal rivers (Queets, Quinault, and Chehalis Rivers) in 2004 (Ecology 2007). The concentrations of PCBs and dioxins detected in the Chinook salmon from the coastal rivers result in risks from fish ingestion that are greater than 10^{-6}, based on the exposure assumptions used in this BHHRA[9]. PCBs as Aroclors were detected at concentrations ranging from 5.0 µg/kg to 6.3 µg/kg in the Ecology study. The dioxin TEQ concentrations ranged from 0.09 picograms per gram (pg/g) to 0.23 pg/g. These results indicate that sources of chemicals outside of the Study Area may contribute to bioaccumulation of chemicals in anadromous fish species to a significant extent.~~

~~[9] Based on BHHRA exposure assumptions for single-species diet consumed by adult or child fisher.~~

There is a high degree of uncertainty as to the source of chemicals detected in non-resident fish species and whether those chemicals are actually due to exposures within the Study Area. However, approximately 95 percent of the cumulative risk from fish consumption is due to chemical concentrations detected in resident fish, even though resident fish only account for 50 percent of the mass of fish consumed. Therefore, using the results of the BHHRA to focus on potential sources of chemicals potentially posing unacceptable risks~~COCs~~ in resident fish species should address sources of chemicals potentially posing unacceptable risks~~COCs~~ within the Study Area that contribute to concentrations in non-resident fish species as well. As a result, the uncertainty associated with the source of chemicals to non-resident fish species should not impact the conclusions of this BHHRA.

~~7.1.3~~6.1.3 Use of Either Whole Body or Fillet Samples to Represent All Fish Consumption

Chemicals bioaccumulate differently in different parts of an organism. Organic compounds tend to accumulate more in the fatty tissues, and heavy metals more in muscle tissues. The chemicals with the greatest contribution to the cumulative cancer risk and with the highest noncancer HQ are PCBs, which are organic compounds that accumulate preferentially in fatty tissue. Diets consisting of different fish parts result in varying levels of risk to the consumer. Using only whole body or fillet tissue with skin to evaluate risk from all types of fish tissue diets is a conservative representation of actual consumption of fish. Depending on the species and chemical, the difference in concentrations between fillet and whole body tissue can be minimal or more than a factor of 10, as discussed in Attachment ~~F5~~F6. Since PCBs contribute to the vast majority of risks from tissue consumption on a Study Area-wide scale and on a localized scale for most exposure areas, this uncertainty could have a significant impact on the conclusions of this BHHRA. Alternatively, chemicals such as methyl mercury preferentially accumulate in muscle tissue, which means concentrations of mercury in fillet tissue would likely be higher than concentrations of mercury in whole body tissue.

Based on the Columbia Slough consumption survey (Adolfson 1996), the majority of fishers are most likely to consume only the fillet portion of the fish, which may not include skin. Based on the CRITFC Fish Consumption Survey (CRITFC 1994), tribal fish consumers are also most likely to consume only the fillet portion of the fish, which may not include skin. However, some individuals may consume other portions of the fish, and the whole body diet is the most conservative estimate of potential cumulative risk from tissue consumption, as organic chemicals have the greatest contribution to risk. For an individual who consumes primarily fillet tissue, it would be appropriate to focus on risk results from fillet tissue consumption, recognizing that the risks are based on fillet with skin tissue and that risks associated with fillet without skin would likely be even lower for organic chemicals.

While it is not known to what extent consumption of non-fillet portions of fish occurs, this BHHRA evaluated risks associated with consumption of only fillet tissue or only whole body tissue. This approach provides the potential range of risks associated with the different diets, and the risks from consumption of fillet tissue without skin would likely be even lower than those presented in this BHHRA. If an individual consumes mostly fillets, but occasionally other portions of the fish, the risks to that individual should fall within the range of risks estimated in this BHHRA. Because it is unlikely that a diet consists entirely of whole body tissue, the evaluation of risks associated with consumption of only whole body tissue provides a health protective approach.

~~7.1.4~~6.1.4 Use of Undepurated Tissue ~~To~~ to Represent Clam Consumption

Clam tissue throughout most of the Study Area was analyzed as undepurated samples, and a limited number of clam samples were depurated before analysis. A common practice in the preparation of clam tissue for consumption includes depuration, although undepurated clam may also be consumed. The amount of COPC-containing particles within the gut of bivalves can vary widely; however, studies have demonstrated that the sediment content in the gut of bivalves could represent up to 39% of the total body load of metals (Wallner-Kersanach et al. 1994). With the exception of a few metals, average chemical concentrations were higher in undepurated clam tissue collected at the Study Area than in depurated clam tissue collected at the Study Area. However, depurated clam tissue accounted for only five of the 22 clam samples collected for the BHHRA dataset, and the depurated samples were collected from edges of the site (northern and southern stretches). Therefore, there are uncertainties associated with comparing depurated and undepurated tissue in the BHHRA dataset. These concentrations are shown in the EPC tables in Section 3 (Tables 3-24 and 3-25). Using analytical concentrations of undepurated tissue to represent tissue consumption throughout most of the Study Area provides a health-protective approach to assessing risk from clam tissue consumption.

~~7.1.5~~6.1.5 Use of Different Tissue Types t~~T~~o Assess the Same Chemical

For resident tissue samples from the Round 1 sampling event, mercury was analyzed in fillet tissue without skin. For resident tissue samples from the Round 3 sampling event, mercury was analyzed in fillet tissue with skin. The BHHRA resident species included in the Round 3 tissue sampling were smallmouth bass and common carp. These fillet datasets were combined for Study Area analysis. For the reasons presented in ~~Section 7~~Section ~~6~~Section 6.1.3, the comparability of analytical data from fillet tissue with skin and fillet tissue without skin creates uncertainty in the BHHRA. Because mercury preferentially accumulates in muscle tissue, one would

expect mercury concentrations to be slightly higher in fillet tissue samples without skin. However, for the smallmouth bass, mercury concentrations were generally higher in fillet tissue with skin, and in common carp, mercury concentrations were generally higher in fillet tissue without skin. A comparison of mercury tissue concentrations is provided in Table 6-3. T~~As a result, t~~he uncertainty associated with the use of different tissue types to assess risks from mercury should not impact the conclusions of this BHHRA.

~~7.1.6~~6.1.6 Detection Limits That Are Above Analytical Concentration Goals (ACGs)

Uncertainty exists in the evaluation of chemicals that were not detected for which the method detection limits (DLs) exceed the ACGs. Site-specific ACGs were established for each media. However, ACGs for some chemicals are exceptionally low, and in some instances, not attainable with present laboratory methods. DLs for chemicals that were analyzed but never detected were compared to the appropriate ACG for each media. For sediment, maximum DLs exceed both ACGs and method reporting limits (MRLs) for four analytes (see Table ~~7~~6-~~2~~4).

In tissue, maximum DLs exceed ACGs and MRLs for eight analytes (see Table ~~7~~6-~~3~~5). Five chemicals were never detected in tissue, but their DLs were below ACGs. It should be noted that DLs were above ACGs for PAHs, and PAHs were not detected in Round 1 fish tissue. However, fish metabolize and excrete PAHs, and thus there is less likelihood for PAHs to bioaccumulate in fish. PAHs were detected in Round 3B fish tissue, as well as in Round 1, 2, and 3B shellfish tissue, indicating that data were sufficient to estimate risk from PAHs in both fish and shellfish tissue. As discussed in Attachment F2, when a non-detected result was greater than the maximum detected concentration for a given exposure area, that result was removed from the dataset prior to calculation of an EPC. When a non-detected result was less than the maximum detected concentration, it was included in the dataset for calculation of EPCs according to the rules presented in Attachment F2. These data rules apply to non-detected PAHs in Round 1 fish tissue. In addition, DLs for PCB congeners were elevated for some smallmouth bass tissue samples, which may add uncertainty to PCB TEQ estimates. However, the risks from total PCBs (due to detected congeners) were higher than the risks from the PCB TEQ for those exposure areas with elevated detection limits. Because the PCB congeners were detected in other smallmouth bass tissue samples, the elevated DLs were incorporated in the PCB TEQ estimates at one half the DL. Therefore, while the elevated detection limits contribute to uncertainty, using the elevated detection limits in this BHHRA should not significantly affect the risk results.

In the groundwater seep sample, maximum DLs exceed both ACGs and MRLs for one analyte (see Table ~~7~~6-~~4~~6). In surface water samples, five analytes plus PCB Aroclors exceed ACGs; two analytes plus PCB Aroclors exceed MRLs (see Table ~~7~~6-

~~5~~7). However, for surface water PCB congener data were used instead of Aroclor data, as discussed in Attachment F2.

Chemicals that were not detected were not quantitatively evaluated further in this BHHRA. If chemicals were present at concentrations above the ACGs but below the DLs, those chemicals could contribute to unacceptable risks. However, given the number of chemicals that were detected at concentrations above their respective ACGs and the magnitude of difference between detected concentrations and ACGs, it is unlikely that exclusion of chemicals that were not detected would impact the conclusions of this BHHRA.

6.1.7 Removal of Non-~~d~~Detected Results Greater Than the Maximum Detected Concentration for a Given Exposure Area

As discussed in Attachment F2, if a given non-detected result was greater than the maximum detected concentration for an exposure scenario and exposure area, that result was removed from the dataset prior to calculation of EPCs. These results are discussed in Attachment F2 and presented in tables F2-7 through F2-13. Inclusion of non-detected data greater than the maximum detected concentrations would likely have resulted in higher risk estimates in the risk characterization of the BHHRA.

~~7.1.7~~6.1.8 Using N-~~qualified~~ Qualified Data

As discussed in Section 2.2.3 of the RI report, some data were qualified using the "N" qualifier, which indicates that the identity of the analyte is not definitive. The use of the N qualifier is generally a result of the presence in the sample of an analytical interference such as hydrocarbons or, in the case of pesticides, PCBs. Pesticide data and SVOCs analyzed by EPA Method 8081A were most commonly N-qualified as a result of analytical interference. N-qualified data were used in the BHHRA for calculating tissue EPCs (for hexachlorobenzene and several pesticides) that resulted in cancer risk estimates exceeding 1×10^{-6} or HIs exceeding 1. Alpha-hexachlorocyclohexane, beta-hexachlorocyclohexane, and gamma-hexachlorocyclohexane were identified as ~~preliminary~~ contaminants ~~chemicals~~ potentially posing unacceptable risks ~~COCs~~ in fish tissue based on EPCs that were calculated using only N-qualified data. Heptachlor epoxide was identified as a ~~preliminary chemical~~ contaminant potentially posing unacceptable risks ~~COC~~ in clam tissue based only on N-qualified data. While these contaminants ~~chemicals~~ were identified as ~~preliminary~~ contaminants ~~chemicals~~ potentially posing unacceptable risks ~~COCs~~ based on the results of the BHHRA, it is important to note that there is uncertainty in both the identity and concentration of these contaminants~~chemicals~~. These contaminants ~~chemicals~~ were not detected in abiotic media at levels posing risk to human health. Attachment ~~F5~~ F6 discusses how EPCs and risk estimates would change for adult consumption of whole body fish tissue and shellfish tissue if N-qualified data were not included in the BHHRA dataset.

~~7.1.8~~6.1.9 Using One-Half The Detection Limit ~~For~~ for Non-Detect Results in Summed Analytes

When an individual analyte that is part of a summed analyte (i.e. total PCB congeners, total endosulfans, etc.) was determined to be present in a given medium according to the rules for non-detects discussed in Section 2, but was not detected for a specific sample, one-half of the detection limit was used to calculate the summed analyte result, as described in Attachment F1. This value is assumed to represent a conservative estimate for the concentrations below the detection limit, and introduces uncertainty into the summed analyte calculations. In general, the detection limits for non-detect results were low relative to detected concentrations. In addition, by only including those contaminants ~~chemicals~~ that were determined to be present in a given medium, the uncertainty associated with the use of non-detect results was minimized. However, in cases where the detection limits were above analytical concentration goals and the chemical was detected infrequently, use of one-half the detection limit could impact the risk results.

~~7.1.9~~6.1.10 Contaminants ~~Chemicals~~ That Were Not Analyzed ~~i~~In Certain Samples

Per the sampling and analysis plan that was approved by EPA, certain fish tissue samples were analyzed for a subset of the analytes. For example, Round 1 fillet tissue samples were not analyzed for PCB, dioxin, or furan congeners. In Round 3B, smallmouth bass and common carp fillet tissue samples were analyzed for PCB, dioxin, and furan congeners. In samples where congeners were analyzed, the risks from the total TEQ, which is not included through other analytes (i.e., risks from total PCBs are included through PCBs as Aroclors) comprise approximately 1 to 70 percent of the cumulative risks. Therefore, the risks from consumption of black crappie and brown bullhead fillet tissue, which were only analyzed in Round 1, likely underestimate the actual risks. However, a range of risks was calculated for fish consumption scenarios, which included samples that were analyzed for congeners, so the lack of analysis of contaminants ~~chemicals~~ in certain samples should not impact the conclusions of this BHHRA.

In addition, not all clam samples were analyzed for the same number of contaminants~~chemicals~~, due to lack of available tissue mass for some composites collected during the Round 2 sampling efforts. Missing analytes and associated sample identifications for clam tissue collected in Round 2 are shown in Table ~~7~~6-~~6~~8. In Round 3B, additional clam samples were collected and analyzed for additional contaminants~~chemicals~~. The Round 2 and Round 3B clam tissue data were combined and evaluated on a river-mile basis in the BHHRA. Therefore, EPCs were available for almost all COPCs in each exposure area. Lack of analytical values for COPCs in all samples within an exposure area may over or underestimate the risk for that exposure area. However, a range of risks was calculated for shellfish consumption scenarios, which included samples where all COPCs were analyzed, so the lack of

analysis of contaminants ~~chemicals~~ in certain samples should not impact the conclusions of this BHHRA.

~~7.1.10~~6.1.11 Chemicals That Were Not Included ~~As~~ as Analytes

It is not possible to analyze for every chemical, and thus chemicals and chemical groups were chosen for analysis based on an investigation of known or probable sources and pollutants. Because chemicals expected to have the potential for significant contributions to risk are included in the risk assessment, chemicals not included as analytes introduce a low level of uncertainty to overall risk. The list of chemicals for analysis was determined in collaboration with EPA and its partners and was included in the sampling and analysis plan that was approved by EPA. Since then, there has been interest in two groups of chemicals that were not included as analytes in this BHHRA: polybrominated diphenyl ethers (PBDEs) and volatile organic compounds (VOCs) in tissue. Risks have subsequently been assessed for exposures to PBDEs in in-water sediment and resident fish tissue, as presented in Attachment F3.

~~PBDEs are flame retardants that leach from products with residential, commercial, and industrial uses. As a result, they are ubiquitous in the environment. The ODHS study analyzed the sturgeon, salmon, and lamprey tissue for PBDEs. The concentrations of PBDEs in salmon in the ODHS study were within the range of those found in store-bought salmon in a 2005 study by the Washington State Department of Health (WDOH 2005). Using the maximum detected concentration of total PBDEs in the ODHS dataset (53 µg/kg for total PBDEs in sturgeon) and the lowest RfD (0.0001 mg/kg-day) for any PBDE congener (EPA 2009b2010b), the maximum potential HQ associated with PBDEs does not exceed 1 for the highest ingestion rate (142 grams per day) ingestion rate for a single-species diet. If the congener-specific RfDs were applied to the specific congener fractions detected in sturgeon, the HQ would be even less. The maximum HQs for PCBs and mercury in the ODHS dataset are 95 and 6, respectively. In addition to a non-cancer hazard for PBDEs, recent studies on BDE congener 209 have indicated that there is "suggestive evidence of carcinogenic potential" for this congener (EPA 2009b2010b), and EPA has established a cancer slope factor of 7 x 10^{-4} (mg/kg-day)$^{-1}$ for BDE-209. The maximum detected concentration for BDE-209 in the ODHS study is 139 pg/g, detected in a Pacific lamprey tissue sample. Applying the cancer slope factor of BDE-209 to this concentration, using the exposure assumptions in this BHHRA for an adult, single-species diet, the resulting estimated cancer risk from ingestion of BDE-209 in tissue is 2 x 10^{-13}, which is below EPA's target risk range of 10^{-6} to 10^{-4}. Given the magnitude of concentrations and toxicities of other chemicals that were analyzed for and detected and the detected concentrations of PBDEs in the ODHS study, PBDEs are unlikely to contribute significantly to the overall risks.~~

VOCs were not analyzed in the BHHRA tissue or surface water datasets. Because of the nature of VOCs, they are not expected to accumulate in tissue to a degree high

enough to pose significant risk via tissue consumption, especially given the other chemicals detected in tissue that are clearly primary contributors to the calculated risk (e.g., PCBs). ~~Furthermore, if VOCs were present in tissue, VOCs would volatilize during cooking. VOCs were analyzed in transition zone water, and analytical results were evaluated in Section 6 to determine if TZW loading to surface water could create a potential risk from hypothetical future use of untreated surface water as a domestic water source. Based on that evaluation, VOCs in transition zone water are not expected to contribute significantly to risks from the hypothetical future use of surface water as a domestic water source.~~ Given the magnitude of concentrations and toxicities of other chemicals that were analyzed for and detected in surface water and tissue, VOCs are unlikely to contribute significantly to the overall risks. Therefore, the lack of analysis for VOCs should not impact the conclusions of this BHHRA.

As mentioned earlier in this section, it is impossible to analyze for every chemical, and there are a number of constituents that have not been historically considered as contaminants but are recently gaining attention as research provides documentation that they are ubiquitous in the environment. These chemicals are generally referred to as "emerging contaminants", and are not considered in this BHHRA, with the exception of PBDEs, which are discussed in Attachment F3. In accordance with EPA guidance on risk assessment for superfund sites, this BHHRA assessed risks associated with CERCLA releases, and did not include studies focused on non-CERCLA releases, which include some recent studies on regional emerging contaminants. From a human health perspective, unregulated chemicals such as emerging contaminants may exist at the Site, but lack of knowledge and data regarding many of these chemicals precludes a human health risk assessment. Because emerging contaminants are not related to CERCLA releases for the Study Area, the lack of analysis for these chemicals should not impact the conclusions of this BHHRA.

~~7.1.11~~6.1.12 Chemicals That Were Analyzed But Not Included ~~In~~ in BHHRA

Not all chemicals analyzed for were included in the BHHRA. Specifically, not all conventional analytes or nutrient metals were analyzed for potential risk. Many conventional analytes are essential nutrients, and are not evaluated under the CERCLA program. The two conventionals that were included in this BHHRA are cyanide and perchlorate. The conventional analytes and metals that were excluded from assessment are listed here:

- Ammonia
- Calcium
- Calcium carbonate
- Carbon dioxide
- Chloride
- Ethane
- Ethylene
- Magnesium
- Methane
- Nitrate
- Nitrite
- Oxygen
- Phosphate
- Phosphorus
- Potassium
- Silica
- Sodium
- Sulfate
- Sulfide

Because of the lack of toxicity and/or essential nature of these analytes, exclusion of these chemicals from the BHHRA should not impact the conclusions of this BHHRA.

6.1.13 Data Not Included in BHHRA due to Collection Date

Data collected after June 2008 were not included in this BHHRA due to the collection date of the data relative to the RI/FS completion schedule. These data sets are discussed in the Portland Harbor RI Report, and include a number of in-water sediment samples. Because these data were not included in the BHHRA, there is uncertainty in the in-water sediment exposure scenarios. However, due to the large spatial coverage of the existing in-water sediment BHHRA dataset, this uncertainty is not expected to impact the overall conclusions of this BHHRA.

~~7.1.12~~6.1.14 Compositing Methods for Biota and Beach Sediment Sampling

Compositing methods for biota and beach sediment sampling were designed to provide a conservative estimate of risk. Compositing schemes need to be developed to be representative of the medium sampled (grid pattern, stratified random, etc.) and to be representative of an exposure unit.

Fish were composited based on an estimate of the average home range for each species. The home ranges for common carp~~, black crappie,~~ and brown bullhead may be as large as the Study Area and possibly even larger, and the home range for bass may be larger or smaller than ~~span from~~the one mile ~~to seven miles~~assumed in the BHHRA. For example, bass may only reside on one side of a river mile reach instead of throughout the one mile reach on both sides of the river as assumed for the HHRA. Smallmouth bass were composited on a river mile basis, while ~~and~~ black crappie, ~~and~~ brown bullhead, and carp were composited on a fishing zone basis. Fishing zones for brown bullhead and black crappie were from RM 3-6 and RM 6-9; fishing zones for common carp were from RM 0-4, RM 4-8 and RM 8-12 as well. Uncertainty exists in this compositing scheme because the delineation of home range boundaries for the purposes of the risk evaluation are only an approximation of the home ranges of the fish samples actually collected. However, composite samples typically consisted of five individual fish, replicate composite samples were collected, and risks were evaluated both for individual sample locations as well as on a Study Area-wide basis. Therefore, the compositing method for biota is not expected to impact the conclusions of this BHHRA.

Beach sediment was composited on a beach by beach basis, resulting in one sample for each exposure area. Uncertainty exists in this compositing scheme because the results of the risk evaluation are dependent on a single sample. Composite samples are generally assumed to represent the area from which the individual samples of the composite were taken, but an unrepresentative individual sample (e.g., one representing extremely localized or ephemeral contamination) used in the composite

could significantly bias the composite results. The compositing scheme for beaches results in risk evaluation based on a single sample at a single point in time. If a beach was found to pose an unacceptable risk, additional samples at that beach might be warranted. However, all of the beach sediment exposure scenarios ranged from 8 x 10^{-9} to 9 x 10^{-5}, which are ~~were~~ below or within the target risk range of 10^{-4} to 10^{-6}.

~~7.1.13~~6.1.15 Mislabeling of Smallmouth Bass Fish Sample

One smallmouth bass sample collected from the west side of RM 11 (LW3-SB11W-11) during the Round 3 sampling event was incorrectly recorded as LW3-SB11E-01 (RM 11 east) at the field lab. This fish became part of the final LW3-SB11E-C00B and LW3-SB11E-C00F composite samples, which are the body and fillet composites from RM 11 east. Fish SB11E-01 (actually from SB11W) accounted for 15% of both sample types on a mass basis. This results in uncertainty in the concentration of the smallmouth bass sample from the east side of RM 11, since a fish from outside RM 11E was included in the composite. However, since smallmouth bass exposure areas are on a river mile basis, the data from RM 11E and RM 11W were included in the same EPC calculations, and the effects of this uncertainty are not expected to impact the conclusions of this BHHRA.

~~7.1.14~~6.1.16 Use of DEQ Risk-Based Concentrations ~~For~~ for Screening Values

EPA RSLs were used to screen chemicals detected in in-water sediment for the identification of COPCs. RSLs are not available for petroleum hydrocarbons, so DEQ risk-based concentrations (RBCs) for occupational surface soil exposure DEQ 2003) were used. DEQ does not have specific RBCs for lube oil, motor oil, or residual range hydrocarbons, so the screening value for generic oil was used as a surrogate. There is uncertainty associated with applying the screening value for generic oil to heavier oils, as lighter range petroleum hydrocarbons tend to be more toxic than heavier-range petroleum hydrocarbons. However, the maximum detected concentrations of these three oils in in-water sediment also does not exceed the screening value for the lighter range hydrocarbons detected within the Study Area (diesel, gasoline), so the uncertainty associated with the COPC screening values for heavier oils are not expected to impact the conclusions of this BHHRA.

~~•~~6.1.17 ~~-~~Selection of Tissue COPCs Based On Detection of An Analyte

~~o~~ The selection of fish and shellfish tissue COPCs was based on whether an analyte was detected in each species/tissue type, and not based on a comparison with health-protective screening levels. ~~This resulted in a potentially larger number of COPCs being carried forward in the risk assessment process compared to other media, and potentially biases cumulative risk estimates to be high relative to other~~

~~media.~~ There is uncertainty associated with identification of tissue COPCs based on detections alone, and this could potentially impact the conclusions of this BHHRA.

~~7.2~~6.2 EXPOSURE ASSESSMENT

Uncertainties that arise during the exposure assessment typically have some of the greatest impacts on the risk estimates. The following subsections address uncertainties associated with exposure models, exposure scenarios, exposure factors, and EPCs used in the risk estimates.

~~7.2.1~~6.2.1 Model Applicability

The standard exposure models used to estimate risks may result in uncertainty. The exposure models rely on identification of exposure scenarios and selection of appropriate exposure factors for those scenarios. Uncertainty in the applicability of the exposure scenarios will result in uncertainty in the risk estimates. Site-specific exposure scenarios were developed to provide a conservative estimate of risk within the Study Area, using conservative exposure factors to represent both reasonable maximum and central tendency exposures that could hypothetically occur within the Study Area. While uncertainties associated with the exposure models could impact the conclusions of this BHHRA, the models used are consistent with applicable risk assessment guidance and are a source of uncertainty in all risk assessments.

~~7.2.2~~6.2.2 Subsurface Sediment Exposure

A complete exposure pathway needs to include retention or a transport medium, an exposure point, and an exposure route. Subsurface sediment was not considered an exposure medium for this BHHRA because it was assumed that any potential human contact with river sediment below 30 cm in depth was unlikely, and if it does occur, the frequency and extent would be minimal. Situations in which exposure to subsurface might occur include: potential scouring, natural hydraulic events that are not well understood, future development of near-shore and upland properties, maintenance of the federal navigation channel, ports, and docks, placement and maintenance of cable and pipe crossings, pilings and dolphins, anchoring and spudding of vessels, and exposure to propeller wash from vessels. All of these situations could provide minimal impact to subsurface in-water sediment as well as to surface sediment, and thus the assessment of risk from exposure to surface sediment would be adequately protective of potential exposure to subsurface sediment. However, the uncertainty associated with not directly assessing subsurface sediment exposure could underestimate risks from multiple exposure pathways for the Study Area. Due to the low levels of possible exposure to subsurface sediment, this uncertainty is not expected to impact the conclusions of this BHHRA.

~~7.2.3~~6.2.3 Potential Exposure Scenarios

Some of the exposure scenarios evaluated in this BHHRA have limited documentation regarding the actual extent of exposure to receptors in the Portland Harbor. These scenarios were included in this BHHRA at the direction of EPA Region 10. The uncertainties associated with these scenarios are discussed in the following subsections. ~~As required by EPA Region 10, this BHHRA included exposure scenarios that are not well documented, so it is unknown to what extent exposures currently occur, if at all, within the Study Area. In addition, this BHHRA evaluated risks associated with a hypothetical future scenario, which is not anticipated to reasonably occur in the future based on current information for the Study Area. The uncertainties associated with these potential and hypothetical exposure scenarios are discussed in the following subsections.~~

6.2.3.1 Human Milk Consumption

The BHHRA evaluated risks to an infant consuming human breastmilk for receptors exposed to bioaccumulative compounds selected as COPCs. The evaluation of this pathway was performed consistent with DEQ guidance (2010), but there are a number of uncertainties associated with modeling infant exposure to contaminants through breastmilk based on exposure to the mother, which could potentially affect the outcomes of this BHHRA.

Risks to an infant consuming breastmilk from the adult receptors evaluated in this BHHRA resulted in risks above the EPA points of departure for cancer and noncancer endpoints. However, breastfeeding is still the healthiest way to feed a baby, even if the milk contains contaminants. Even though infants may receive a dose of contaminants from their mothers' milk, human milk also contains hundreds of healthy nutrients, vitamins, minerals, and immune system boosters. These natural, healthy substances more than compensate for any health risks from contaminants and may even help repair damage caused by contaminants before the baby was born. Breastfeeding has been shown to boost immunity and IQ and prevent many diseases. Calculated risk to infants from breastfeeding presented in this report should not discourage any mother from breastfeeding her infant (adapted from DEQ, 2010).

~~7.2.3.1~~6.2.3.2 Shellfish Consumption

This BHHRA evaluated risks from shellfish consumption based on crayfish and clam tissue data. However, ~~there is no documentation of ongoing shellfish consumption by humans occurring in the Study Area, and~~ the harvest or possession of Asian clams, which is the species assessed in this BHHRA, is illegal.

A commercial crayfish fishery exists in the LWR. Crayfish landings must be reported to ODFW by water body and county. Per ODFW, the crayfish fishery in the LWR is not considered a large fishery (Grooms 2008). Based on ODFW's data for 2005 to 2007, no commercial crayfish landings were reported for the Willamette River in Multnomah County. DHS had previously received information from ODFW

indicating that an average of 4300 pounds of crayfish were harvested commercially from the portion of the Willamette River within Multnomah County each of the five years from 1997-2001. In addition to this historical commercial crayfish harvesting, DHS occasionally receives calls from citizens who are interested in harvesting crayfish from local waters who are interested in fish advisory information. According to a member of the Oregon Bass and Panfish club, crayfish traps are placed in the Portland Harbor Superfund sSite boundaries and collected for bait and possibly consumption (ATSDR 2006). It is not known to what extent non-commercial harvesting of crayfish occurs within the Study Area, if at all, or whether those crayfish are consumed and/or used for bait.

The only reported clam consumption was from a project conducted by the Linnton Community Center (Wagner 2004). As part of the project, conversations were conducted with transients about their consumption of fish or shellfish from the Willamette River. These conversations were not conducted by a trained individual nor were the conversations documented. The transients that were contacted reported consuming various fish species, as well as crayfish and clams. Many of the individuals indicated that they were in the area temporarily, move from location to location frequently, or have variable diets based on what is easily available. Assuming that clam consumption occurs, the Linnton Community Center project suggests that it does not occur on an ongoing basis within the Study Area.

The evaluation of risks from shellfish consumption in this BHHRA is a ~~conservative~~ health protective approach~~, as it is not known whether shellfish consumption actually occurs on an regular basis within the Study Area~~.

~~7.2.3.2~~6.2.3.3 Wet Suit Divers

Commercial diving companies in the Portland area were contacted to develop a better understanding of potential diver exposures within the Study Area. All of the diving companies that were contacted indicated that the standard of practice for commercial divers is the use of dry suits and helmets when diving in the LWR (Hutton 2008, Johns 2008, and Burch 2008). EPA Region 10 reported observing divers in wet suits and with regulators that are held with the diver's teeth within the Study Area, so a wet suit diver and associated ingestion for the "in the mouth" regulator exposure scenarios ~~was~~ were included at the direction of EPA. Evaluation was also performed of helmet diving with use of a neck dam, which allows polluted water leakage into the diving helmet. Commercial divers as recently as 2009 have been observed using techniques to don a diving helmet which increase exposure (Sheldrake personal communication with RSS, 2009, DEQ, 2008). The observed wet suit divers were performing environmental investigation and remedial activities, which are not activities evaluated as part of a commercial diver scenario. Also, it is not known whether the individuals who were observed diving in wet suits on specific occasions are diving within the Study Area on a regular basis, as they do not work for the commercial diving companies in the Portland area. Recreational diving also takes place in Portland

Harbor (Oregon Public Broadcasting Think Out Loud, "Are you going to swim in that?" August 22, 2008). Therefore, including a wet suit diver scenario with associated ingestion from use of a recreational type regulator, rather than a full face mask or diving helmet, and full body dermal exposure in this BHHRA (in addition to a dry suit diver scenario) is a conservative approach. ~~Therefore, including a wet suit diver scenario in this BHHRA in addition to a dry suit diver scenario is a conservative approach.~~

~~7.2.3.3~~6.2.3.4 ~~Hypothetical~~ Domestic Water Users

The domestic water user risks are based on the hypothetical use of untreated surface water drawn from the Study Area as a domestic water source. Surface water in the LWR within the Study Area is not currently used as a domestic water source~~, nor are there plans to use surface water within the Study Area as a domestic water source in the future~~. According to the City of Portland, the primary domestic water source for Portland is the Bull Run watershed, which is supplemented by a groundwater supply from the Columbia South Shore Well Field (City of Portland 2008). In addition, the Willamette River was determined not to be a viable water source for future water demands through 2030 (City of Portland 2008). ~~Given that current knowledge of the City of Portland planning for water supply does not indicate that the reach of the Willamette River including the Study Area will be used for domestic purposes in the future.~~

~~Even if the Willamette River were to be used as a domestic water source, which is not likely, that would only occur after adequate pretreatment to meet Safe Drinking Water Act standards and Oregon rules.~~ Under OAR 340-041-0340 Table 340A, domestic water supply is a designated beneficial use of the Willamette River, but only with adequate pretreatment and natural quality that meets drinking water standards. The use of the Willamette River as a domestic water source would only occur after adequate pretreatment to meet Safe Drinking Water Act standards and Oregon rules. As a result, the term hypothetical was used to describe the scenario, which was based on the use of untreated surface water.

Therefore, the evaluation of untreated surface water as a domestic water source, even under hypothetical future conditions, is a conservative approach and is not based on current knowledge of future planned uses of the Willamette River within the Study Area as a domestic water source or based on Oregon rules that require adequate pretreatment.~~an indication of current or reasonably anticipated future risks at the Study Area.~~

~~7.2.4~~6.2.4 Potentially Complete and Insignificant Exposure Pathways

Exposure pathways that have been determined to be potentially complete and insignificant were not evaluated further in this BHHRA. As described in Section 3.2, these exposure pathways have a "source or release from a source, an exposure point where contact can occur, and an exposure route by which contact can occur; however,

the pathway is considered a negligible contributor to the overall risk". The exposure pathways identified as potentially complete and insignificant were related to Willamette River surface water exposures to populations evaluated in this BHHRA. The populations that are expected to have the most frequent contact with surface water (transients, recreational beach users, and hypothetical future residents) as well as the EPA directed evaluation of surface water exposure to divers were quantitatively evaluated in this BHHRA for ingestion and dermal absorption of chemicals from surface water. The populations for which surface water exposures were not evaluated were for dockside workers, in-water workers, tribal fishers, and fishers. For several other populations, only the inhalation exposure pathway was determined to be insignificant. These populations were transients, divers, recreational beach users, and hypothetical future residents.

This BHHRA identified and evaluated the exposure pathways that were expected to result in the most significant exposure to COPCs in the Study Area. The magnitude of exposures experienced by populations for these exposure pathways are much greater than that expected for the exposure pathways identified as "insignificant". Thus, the assessment of risk to populations from exposure pathways that were quantitatively evaluated in this BHHRA would be adequately protective of exposed populations in the Study Area. However, the uncertainty associated with not directly evaluating "insignificant" exposure pathways could underestimate risks for the Study Area. Due to the low levels of possible exposure for these "insignificant" exposure pathways, this uncertainty is not expected to impact the conclusions of this BHHRA.

~~7.2.5~~6.2.5 Exposure Factors

Assumptions about exposure factors typically result in ~~a high degree of~~ uncertainty in any risk assessment.~~ Because many of the exposure scenarios that were evaluated in this BHHRA are highly variable and do not have standard default exposure factors, uncertainties associated with the exposure factors are anticipated to have some of the greatest impacts on the risk estimates.~~

RME and CT values were used for some of the exposure scenarios to evaluate the overall impact that variability in each of the exposure assumptions has on the risk estimates. As discussed previously, most of the RME scenarios represent the reasonable maximum exposures that could occur in the Study Area under current and future conditions. In the case of the scenarios assessing the use of untreated surface water as a domestic water source, both the RME and CT scenarios represent hypothetical exposures. The other CT exposure scenarios represent the expected average or mean exposure for exposures that could occur in the Study Area in the present and future. The range of risk estimates between these two exposure scenarios provides a measure of the uncertainty surrounding these estimates.

For fish consumption, a range of ingestion rates ~~representing possible high-end consumption scenarios~~ were used to evaluate ~~the impact of~~ variability on the risk estimates (see discussion of exposure parameters for tissue ingestion scenarios

below). ~~These~~ As recommended by EPA guidance, these ~~high-end~~ ingestion rates were used with EPCs calculating using both the mean and 95% UCL~~/max EPCs~~ on the mean (or maximum concentrations for EPCs when sample size was less than 5), and thus the resulting risks in this BHHRA ~~do not necessarily~~ represent ~~the entire~~ a range of ~~actual~~ possible human health risks, ~~but rather a range that high-end exposures might fall within~~including estimates that might fall into the high end of those possible.

In addition to the variability, there is also uncertainty associated with the exposure factors that were used in this BHHRA.

The following exposure factor uncertainties have been identified and analyzed further to determine the potential effects on the risk estimates:

~~7.2.5.1~~6.2.5.1 Exposure Parameters for Sediment Exposure Scenarios

The beach and in-water sediment exposure parameters used in this BHHRA were conservative estimates of potential uses for the Study Area.

Beach areas that are accessible to the general public were identified as potential human use areas, even though it is not known whether recreational beach use actually occurs at these locations. Even if beach use occurs, the extent to which the beach is used and the nature of the contact with sediments/beach is unknown. Future changes in land use may make some beach areas more or less accessible for humans, which increases uncertainty about future exposure. For in-water sediment, every ½-river mile segment on each side of the navigation channel was considered a potential exposure area for all in-water sediment exposure scenarios, regardless of the feasibility or practicality of use of the area. Information from this approach can be used to inform the public about relative risks throughout the river and can help focus the feasibility study, but likely over-estimates risk estimates for in-water sediment.

The exposure duration, frequency, and intake parameters for both beach and in-water sediment also have associated uncertainties. The scenarios assume exposure to the same beach or ½-river mile segment for an entire childhood, or 25 to 70 year exposure duration for adults, depending on the receptor. Frequency of exposure ranges from 94 days/year to 250 days/year. Default intake parameters for soil exposure were generally used; however, the adherence factor (dermal contact with sediment) for ~~recreational children~~a child recreational beach user was more than 10 times greater than the default for soil.

Another uncertainty associated with exposure parameters for sediment is the dermal absorption factor, which does not exist for all COPCs. Per EPA guidance (2004), only those compounds or classes of compounds for which dermal absorption factors exist were evaluated quantitatively for the dermal contact exposure pathway. For compounds without dermal absorption factors, which for the sediment COPCs are certain metals and perchlorate, dermal intake was assumed to be zero. However,

dermal absorption factors exist for the chemicals and chemical groups that are likely to pose the greatest concern for risk from dermal contact. So although the lack of dermal absorption factors for all COPCs may underestimate risk from dermal contact with sediment for certain metals and perchlorate, this uncertainty would not change the conclusions of this BHHRA.

Most of the uncertainties associated with the sediment exposure parameters are likely to overestimate the risks associated with direct exposure to sediment. However, all of the beach sediment exposure scenarios were below or within the target risk range of 1 x 10^{-4} to 1 x 10^{-6}, and with the exception of two segments specifically for the tribal fisher RME scenario, all of the in-water sediment exposure scenarios were also below or within the target risk range of 1 x 10^{-4} to 1 x 10^{-6}. For the tribal fisher RME scenario, the exposure parameters are especially conservative as it is unlikely that an individual would fish the same ½-river mile river segment for five days every week of every year for 70 years.

~~7.2.5.2~~6.2.5.2 Exposure Parameters ~~For~~ for Surface Water and Groundwater Seep Exposure Scenarios

Transients were assumed to be exposed to surface water through ingestion and dermal contact. Tap water ingestion rates were used to represent exposure to surface water via ingestion for transients. However, tap water ingestion rates are an estimate of ingestion of a drinking water source, and the use of untreated water from the Lower Willamette as a source of drinking water by transients on an ongoing basis ~~is highly unlikely~~for two years is assumed to be health protective. The tap water ingestion rate used in the risk evaluation was 2 L/day for the transient and assumes surface water will be ingested every day for two years. In addition, it was assumed that transients bathe directly in the Lower Willamette two days per week throughout the entire year for two years.

For the recreational beach users, exposure to surface water was assumed to occur through incidental ingestion and dermal contact while swimming in the Lower Willamette. The incidental ingestion rate of 50 milliliters per day (ml/day) used in this BHHRA is that recommended by EPA for a swimming scenario. The exposure scenario assumes that adults frequent the same quiescent water area 26 times per year for 30 years, and that children frequent the same area 94 times per year for six years.

In addition to the direct contact scenarios mentioned above, risks were assessed from exposure to surface water as a hypothetical future domestic water source. This scenario assumes untreated surface water is used as a domestic water source ~~drunk and bathed in~~ 350 days a year for 30 years (adult resident) or six years (child resident)~~, using tap water ingestion rates. As with the transient scenario, this scenario is equally unlikely for residents in the area~~. The LWR within the Study Area is not currently used as a domestic water source, ~~nor are there any future plans to use the LWR within the Study Area as a domestic water source~~but could be used as such in the future.

Another exposure parameter resulting in uncertainty for the surface water and groundwater exposure parameters is the absorbed dose per event. This parameter was derived per EPA guidance (2004) using chemical-specific factors, but the factors for some of the COPCs fall outside of the predictive domain. Specifically, the dermal permeability coefficient (K_p) falls outside of the effective predictive domain (EPD) for a number of PAHs, including the following COPCs:

- Benzo(a)anthracene
- Benzo(a)pyrene
- Benzo(b)fluoranthene
- Indeno(1,2,3-cd)pyrene
- Dibenzo(a,h)anthracene

EPA guidance (EPA 2004) states that "Although the methodology [for predicting the absorbed dose per event] can be used to predict dermal exposures and risk to contaminants in water outside the EPD, there appears to be greater uncertainty for these contaminants." The range of uncertainty associated with the Kp value can be several orders of magnitude. For instance, the predicted Kp value recommended by EPA (2004) for benzo(a)pyrene is 0.7 centimeters per hour (cm/hr), while the range of predicted Kp values presented by EPA (2004) is 0.024 cm/hr (95% lower confidence level) to 20 cm/hr (95% upper confidence level). This uncertainty could result in over-estimation or under-estimation of risk from exposure to surface water. With the exception of arsenic, the only exceedances of 1×10^{-6} risk from surface water scenarios are the result of dermal exposure to PAHs in surface water. However, all of the surface water exposure scenarios were below or within the target risk range of
1×10^{-4} to 1×10^{-6}.

~~7.2.5.3~~6.2.5.3 Exposure Parameters for Tissue Ingestion Scenarios

The exposure parameters for tissue ingestion were designed to provide a conservative estimate of risk. Fish tissue ingestion rates were developed ~~were developed~~ using fish consumption data from a national study of fish consumption (CSFII, USDA), from a creel survey of Columbia Slough fishers north of the Study Area, and from the CRITFC Columbia River Fish Consumption ~~Study~~Survey (CRITFC) study. ~~with variable exposure factors and environmental data that are not site-specific, or that are derived from anecdotal evidence.~~ The CRITFC Fish Consumption Survey provides fish consumption data for the Columbia River Basin for four of the six tribes who are parties to the Consent Decree for the Portland Harbor site. In addition, although the Columbia Slough Study was not done in Portland Harbor ~~and it may underestimate fish consumption because of the way the fish consumption data were collected~~, the Columbia Slough is within one-half mile of the northern part of the Portland Harbor

site, so fishers in the Portland Harbor site may have similar fishing practices and fish consumption rates as those fishing in the Slough.

Site-specific fish consumption information is not available for the fisher scenarios. As a result, nationwide fish consumption data were used to calculate target fish tissue levels. A ~~limited~~ consumption study conducted for the Columbia Slough was also used. The 99th percentile rate from the nationwide Continuing Survey of Food by Individuals, CSFII (United States Department of Agriculture [USDA] 1998) of 142 g/day (as calculated in USEPA Estimated Per Capita Fish Consumption in the United States, freshwater and estuarine fish and shellfish) was used as one ingestion rate~~as the highest (142 g/day) ingestion rate~~ for adult fishers in the BHHRA. The 90th percentile rate of 17.5 g/day from the same study was used ~~as the high (17.5 g/day)~~ also used as one of the ingestion rates for adult fishers in the BHHRA. Concerns have been expressed regarding the methodology used by EPA in this study to establish the fish consumption rates, which are also recommended as default AWQC subsistence fish consumption rates in EPA's WQC Human Health Methodology guidance (EPA 2000d). Criticisms of these rates have been raised because they are based on per capita consumption rates from the general population – that is, "fish consumption" rates that are estimated based on the combined consumption information from fish consumers and fish non-consumers alike. For example, the 90th percentile rate for fish consumers is 200 g/day, while the 90th percentile rate including data regarding fish non-consumers is about 18 g/day. Similarly, the 99th percentile value for fish consumers is about 506 g/day, while the 99th percentile is approximately 142 g/day when data including the lack of fish in the diet of non-consumers are added. There is a large difference in the percentiles of the dataset when information from people who do not consume fish are included. The consumer-only ingestion rates likely overestimate actual ingestion rates because people who do consume fish but did not on the 2 days of the study (e.g., many infrequent consumers) are not included in consumers only rate. At the same time, EPA guidance (1989) recommends using the 95th percentile, or even the 90th percentile, for RME contact values. ~~So, the use of high-end percentiles for all three ingestion rates in the BHHRA provides conservative estimates of reasonable maximum and central tendency exposures.~~ The 95th UCL rate from the Columbia Slough study was used as the ~~higher ingestion~~73 g/day rate for adult consumers in the BHHRA. The Columbia Slough Study was a creel survey. As a result, ~~it provides a very rough estimate of fish consumption rates~~the consumption rates used in the BHHRA~~, which~~ may overestimate or underestimate actual fish consumption rates in the Study Area. This is due to many reasons, including but not limited to:

- Willingness of anglers to participate
- Communication. If a substantial number of anglers consist of 1st or 2nd generation ethnic minorities, then language may be a barrier.
- Discrepancy between individuals who catch fish and those who prepare meals. Men generally fish but women generally prepare seafood and are much more familiar with the mass of seafood consumed.

- Difficulty in translating from the items inspected in an angler's basket to portion sizes and amounts consumed, since this requires assumptions about edible portions and cleaning factors.
- Lack of a random or representative sample. Interviewers can only speak with who they encounter.
- Timing and seasonality of interviews.
- Weather conditions may bias the results of any day's interviews.

~~All three of the ingestion rates used for adult fishers in the BHHRA are higher than average fish ingestion rates reported from the respective studies.~~ In addition to the uncertainties behind the rates of fish consumption, it was assumed that the frequency of consumption occurred at the same ingestion rate ~~every day of every year~~ for 30 years for the adult fisher scenarios. ~~Furthermore, 100% of the fish consumed was assumed to be caught within a 1 mile stretch on both sides of the river for bass and within a 3 mile stretch on both sides of the river for crappie, carp and bullhead trout over 30 years.~~ Furthermore, 100% of the fish consumed was assumed to be caught within a 1 mile stretch on both sides of the river for bass and within a 3 mile stretch on both sides of the river for crappie, carp and bullhead trout ~~at the same location~~ over 30 years for localized exposures.. ~~, and no~~No reduction in concentrations of contaminants during food preparation and cooking was assumed, although reductions can occur depending on cooking and methods of preparation.

For the tribal fish consumption scenario, the 95th percentile rate from the CRITFC Fish Consumption Survey (CRITFC 1994) was used. The CRITFC Fish Consumption Survey was performed by interviewing four of the six tribes who are natural resource trustees for the Site. It is not clear how this would impact the fish consumption rate for tribal populations used in the BHHRA, which was based up on the CRITFC Fish Consumption Survey. Also, some published articles have suggested that the fish consumption rates in the CRITFC Fish Consumption Survey are biased low for tribal members because:

- Tribal members who have a traditional lifestyle (and likely a higher consumption rate) would have been unlikely to travel to the tribal offices that were used for administering the CRITFC fish consumption interviews.
- The fish consumption rates for some tribal members that were perceived as being outliers (consumption rates were too high) were dropped from the CRITFC data before the consumption rates were calculated.
- Current fish consumption rates may be suppressed and, therefore, do not reflect the potential of the higher consumption rates if fishery resources improved or if ~~COC~~ contaminant concentrations in the water body decrease.

While the tribal fish consumption rates may or may not be biased low, there were additional conservative assumptions incorporated in the tribal fish consumption scenario. For example, fish consumption by an adult tribal fisher was assumed to occur at the same rate every day of every year for 70 years. As with the fisher

scenarios, it was assumed that 100% of the fish consumed was caught at the same location for 70 years, and no reduction in concentration of contaminants occurred during food preparation or cooking. The~~e same~~ CRITFC Fish Consumption Survey that was used as the basis for the tribal fish ingestion rate also indicated that none of the respondents fished the Willamette River for resident fish and at most, approximately 4% fished the Willamette River for anadromous fish. However, future use of the site by tribal members may change. Tribal members who have a traditional lifestyle and were unlikely to travel to tribal offices for the CRITFC Fish Consumption Survey also may be unlikely to travel to Portland Harbor to fish. It is unknown to what extent future tribal fishing habits may change if fishery resources improved or if COC concentrations in the water body decrease. ODEQ is proceeding with development of state water quality limits based on a tribal ingestion rate of 175 g/day.

The information suggesting that shellfish consumption may occur at the Study Area comes from a community project sponsored by the Linnton Community Center, as discussed in Section 3.3.6. However, it is not known to what extent shellfish consumption occurs~~, as there is no documentation of ongoing shellfish consumption by humans occurring in the Study Area~~. Because site-specific shellfish ingestion rates are not available, nationwide CSFII (USDA 1998) shellfish consumption data were used to calculate target tissue levels for clams and crayfish. The 95th percentile rate for shellfish consumption for freshwater and estuarine habitats combined from the nationwide survey was ~~used as the~~ the source of the~~high ingestion rate (~~18 g/day~~)~~ ingestion rate, and the mean rate from the nationwide survey was ~~used as the medium ingestion rate (~~the source of the 3.3 g/day~~). ~~ ingestion rate. As with the fish ingestion rates for adult consumers, these shellfish ingestion rates are based on per capita consumption rates from the general population – that is, consumption rates that include shellfish consumers and non-consumers alike. Consumer-only rates were not calculated in the EPA document for shellfish alone, but it is likely that they are higher for consumers~~ -~~only compared to the rate based on both consumers and non-consumers. In the nationwide survey, shrimp, which is not found within the Study Area, accounted for more than 80% of the shellfish consumed. Crayfish accounted for less than 1% of the shellfish consumed, and freshwater clams were not included in the nationwide survey. ~~It~~ It is not known to what extent fishers ~~would~~ substitute alternative local types of shellfish~~. if the shellfish in the survey were not available~~. However, for freshwater habitat only, which is the same as the Study Area, the mean nationwide shellfish consumption rate is 0.01 g/day; upper percentiles for freshwater shellfish consumption rates are not available (EPA 2002b).

~~Shellfish consumption was assumed to occur at the same rate every day of every year for 30 years.~~ Daily shellfish consumption rates used in this BHHRA represent mathematical artifacts to account for annual consumption rates. The daily consumption rates for shellfish represent approximately two and a half 8-ounce meals per month (18 g/day ingestion rate), and just less than one 8-ounce meal every two months (3.3 g/day ingestion rate). As with fish, 100 percent of the shellfish was assumed to be caught from the same one-mile stretch of river, o-n the same side of the

river, for the 30 years, and no losses in chemical concentration were assumed from food preparation or cooking. It is unlikely that the Study Area supports ~~shellfish~~ *Corbicula* populations large enough to supply the quantity of tissue needed to satisfy the~~se hypothetical~~ ingestion rates used in the BHHRA. During the Round 2 sampling event, the maximum mass of clam tissue data collected at a given sampling location was only 217.57 grams. At 18 g/day, this location would be depleted of clam tissue within 13 days. However, following EPA direction, bivalve consumption is treated as a potential future exposure pathway at the rates used in the BHHRA.

Most of the uncertainties associated with the fish and shellfish exposure parameters provide a conservative~~, health protective~~ estimate of the risks associated with fish and shellfish consumption. Because noncancer hazards and cancer ~~some of the~~risks associated with consumption of fish and shellfish ~~consumption scenarios~~ exceeded the NCP target noncancer hazard quotient of one and the cancer risk range of 1×10^{-4} to 1×10^{-6} as well as the point of departure of 1×10^{-6}, the uncertainties associated with fish and shellfish consumption could affect the decisions made in the FS. The upper and lower bound magnitude of uncertainty associated with exposure parameters for tissue ingestion scenarios was estimated for the BHHRA based on the data presented above, and is discussed in Attachment ~~F5~~F6.

~~7.2.5.4~~6.2.5.4 Assumptions about a Multi~~ple~~ Species Diet

Uncertainties exist in the assumptions about the multi~~ple~~ species diet composition. The non-tribal multi~~ple~~ species diet assumes equal proportions of all four resident fish species. The tribal multi~~ple~~ species diet consists of equal proportions of the four resident fish species, as well as dietary percentages of salmon, lamprey, and sturgeon that come from the CRITFC Fish Consumption Survey (CRITFC 1994). Variations from these compositions would result in different risk estimates. Because the risks from consumption of the individual species that make up the multi~~ple~~ species diet were evaluated separately, the range of risks from fish consumption scenarios encompasses the potential variations in the multi~~ple~~ species diet. The range of the magnitude of these risks was between 1 and 8. The derivation of these risk ranges is further discussed in Attachment ~~F5~~F6. The magnitude in the difference of risk estimates based on diet composition shows that this uncertainty could result in over or under-estimation of actual risks from a multi-species diet.

~~7.2.6~~6.2.6 Exposure Point Concentrations

The EPC is supposed to represent the arithmetic average of the concentration of a ~~chemical~~ contaminant that will be contacted over the exposure duration; however, as a protective approach, a~~n~~ UCL on the arithmetic average is recommended for use as the EPC (EPA 1989). Given the uncertainties and variability associated with environmental data, a high amount of uncertainty is associated with calculating a representative EPC. The following EPC uncertainties have been identified and were analyzed further in the BHHRA to determine the potential effects on the risk estimates.

~~7.2.6.1~~6.2.6.1 Using 5-10 Samples to Calculate the 95% UCL on the Mean

Using less than ten sample results to calculate a 95% UCL on the mean increases the uncertainty associated with the 95% UCL for certain calculation methods. EPCs for a number of exposure areas throughout the Study Area were based upon the 95% UCL on the mean concentration calculated using less than 10 samples. These EPCs are discussed and listed in Attachment F2 text and tables. They include EPCs for in-water sediment, surface water, and tissue. Calculating the 95% UCL on the mean using less than 10 samples could overestimate or underestimate actual exposures. The Study Area-wide fish tissue EPCs that were calculated as 95% UCL on the mean concentrations, using less than 10 samples, included the Study Area-wide EPCs for whole body brown bullhead and fillet common carp. The maximum EPCs for the individual exposure points for whole body brown bullhead and fillet common carp were up to two times higher than the Study Area-wide EPCs, as discussed in Attachment ~~F5~~F6.

If maximum detected concentrations had been used as EPCs in place of 95% UCL on the mean concentrations for exposure areas with less than 10 samples, exposures would have likely resulted in an overestimate of actual risks.

~~7.2.6.2~~6.2.6.2 Nondetects Greater than Maximum Detected Concentrations

~~Nondetect~~ Individual non-detected analytical results ~~chemicals~~ for which the detection limit was greater than the maximum detected concentration in a given exposure area were removed from the dataset prior to 95% UCL calculations. These sample identifications, detection limits, and associated maximum concentrations are discussed and listed by media and exposure area in Attachment F2 text and tables. A nondetect concentration means the actual concentration of the chemical could be as high as the detection limit, or it could be not present. However, if a detection limit exceeds the maximum detected concentration in a given exposure area, it is unknown whether the actual concentration is closer to zero or closer to the detection limit. Removal of these data prior to 95% UCL calculations decreases the need for assumptions about what the actual concentration may be, but it also decreases overall sample size for a given chemical and exposure area.

As discussed in Section 5.2.5, PCBs are the primary contributor to the cumulative risks for all of the fish tissue consumption scenarios ~~were primarily driven by PCBs ,~~ and dioxins are the secondary contributor. There were no cases for which nondetect concentrations exceeded the maximum detected concentration of PCBs and dioxins in fish tissue. It follows that the cases where nondetect concentrations exceeded the maximum detected concentrations did not impact the cumulative risk estimates. PCBs and dioxins were also the primary contributor to cumulative risk for shellfish tissue consumption and there were no cases where nondetect concentrations exceeded the maximum detected concentration of PCBs and dioxins in shellfish tissue. For surface water and in-water sediment the ratio of the nondetect concentrations exceeding the

maximum detected concentrations were within two orders of magnitude. If the actual concentrations were closer to the detection limit, the risk estimates would still be less than ~~-~~1 x 10^{-6}.

~~7.2.6.3~~6.2.6.3 Using the Maximum Concentration to Represent Exposure

For cases with less than five detected samples for a given analyte and exposure area, the sample size was not sufficient to calculate a 95% UCL on the mean concentration for an EPC, and the maximum concentration was used. This includes EPCs calculated to represent Study Area-wide exposure. Using maximum detected concentrations of infrequently detected contaminants ~~chemicals~~ to represent individual exposure areas, and especially Study Area-wide exposure, results in an extremely conservative estimate of risk for the Study Area. In general, use of 95% UCL on the mean concentrations or maximum concentrations provided a protective approach and likely resulted in overestimates of the actual risks, especially for ongoing, repeated, long-term exposures. Use of the maximum concentration to represent exposure occurred for all media, and occurred most frequently for the fish and shellfish consumption scenarios. Contaminants and exposure points for which the maximum detected concentration was used instead of a 95% UCL on the mean are presented in the exposure point concentration tables in Section 3. In some cases, the maximum concentration for a ~~chemical~~ contaminant was anomalously high, and may not be representative of tissue concentrations resulting from exposure to CERCLA-related contamination within the Study Area.

Generally, the ratios between the maximum and minimum detected concentrations are less than 3. For in-water sediments, the ratios are less than 4. When comparisons are made within an exposure area for biota, the majority of the ratios of the 95% UCL/maximum EPCs to the mean are equal to or less than 2, and the remaining ratios are less than 4. A more in-depth analysis of scenarios for which using the maximum concentration to represent exposure significantly affected the result of the risk estimate, and consequently which chemicals were designated as ~~COCs~~ contaminants ~~chemicals~~ potentially posing unacceptable risks for a scenario, is provided in Attachment ~~F5~~F6.

The conservatism of using the maximum detected concentration as the EPC for exposure areas with less than 5 detected results impacts the conclusions of this BHHRA.

~~7.2.6.4~~6.2.6.4 Possible Effects of Preparation and Cooking Methods~~.~~

Cooking and preparation methods of fish tissue can modify the amount of contaminant ingested by fish consumers. The EPA (1997b) states that “cleaning and cooking techniques may reduce the levels of some chemical pollutants in the fish”. PCBs, which were found to have the greatest contribution to the cumulative cancer risks and the highest noncancer HQs, tend to concentrate in fatty tissues. Therefore, trimming away fatty tissues, including the skin, ~~will~~ may reduce the exposure to

PCBs. The concentrations of PCBs in raw fillet tissue have been shown to decrease by approximately 50% by removing the skin (EPA 2000c). Cooking can also reduce the concentrations of PCBs ~~from approximately~~ up to 87%, depending on the method (Wilson et al. 1998). However, one study showed a net gain in PCB concentrations after cooking (EPA 2000c).

As per EPA directive, dose modifications to account for cooking or tissue preparation were not used in determining EPCs for fish ingestion~~, likely resulting in conservative estimates of exposure from tissue~~. If included, the risk estimates may have been reduced by up to approximately 90% for some contaminants~~chemicals~~. Since PCBs contribute to the majority of risks from fish consumption, this uncertainty could significantly impact the results of this BHHRA. For other contaminants~~chemicals~~, particularly mercury, which accumulates in the muscle tissue of fish, cooking is not known to reduce the concentrations in tissue; however, mercury does not contribute to the cumulative cancer risks. ~~Therefore, not accounting for cooking or tissue preparation likely overestimates the cancer risk estimates from fish consumption.~~

~~7.2.6.5~~6.2.6.5 Assumptions about Arsenic Speciation

Arsenic in tissue was analyzed only as total arsenic. Toxicity data are only available for inorganic arsenic. The Columbia River Basin Fish Contaminant Survey (EPA 2002c) determined that a "value of 10% is expected to result in a health protective estimate of the potential health effects from arsenic in fish". Therefore, the EPC for inorganic arsenic was estimated as 10% of the total arsenic detected in tissue. In previous fish tissue studies in the lower Columbia and Willamette Rivers, the percent of inorganic arsenic relative to total arsenic ranged from 0.1% to 26.6% with an average percent inorganic arsenic of 5.3% in the resident fish samples from the Willamette River (Tetra Tech 1995, EVS 2000).

In clams, inorganic arsenic was found to range as high as 50% of total arsenic in tissue collected in the Duwamish River. However, the Duwamish River is an estuary while Portland Harbor is a freshwater river, so the species of clams in the Duwamish River are different from those in Portland Harbor. Since the actual percent of arsenic that is inorganic in clam tissue from the Study Area is unknown, this results in uncertainty in the estimate of inorganic arsenic EPCs for clam. The clam tissue data collected from the Study Area in Rounds 1 through 3 was evaluated to determine whether a higher percentage of inorganic arsenic might have a significant effect on overall risk from the consumption of clam tissue. The analysis found:

- All of the arsenic concentrations in clam tissue are within a factor of 2 of each other (i.e., the maximum concentration is approximately 2 times higher than the minimum concentration). In addition, the arsenic concentrations in clams are normally distributed. Both of these facts support the conclusion that the arsenic in clams is due to ubiquitous concentrations, not localized sources.
- Due to the narrow range of arsenic concentrations, the risks from consumption of clams are within a factor of 2 throughout the Study Area.

- If inorganic arsenic is assumed to be 50% of the total arsenic rather than the assumption of 10% used in the BHHRA, the cumulative risks from consumption of clams only increase by a factor of 1.1 to 1.3 because there are other contaminants ~~chemicals~~ that are ~~driving~~ primary contributors to risks from consumption of clams.

Given all of the other uncertainties associated with risks from clam consumption, the inorganic arsenic assumption is a minor uncertainty with minimal effect on the overall risk estimates.

Although arsenic resulted in risks greater than 1×10^{-6} for some of the fish consumption scenarios, the contribution of arsenic to the cumulative risk was insignificant relative to that from PCBs. Therefore, the assumptions about inorganic arsenic are not likely to impact the conclusions of this BHHRA.

~~7.2.6.6~~6.2.6.6 Polychlorinated Biphenyls

PCBs were analyzed as Aroclors in some media and as individual PCB congeners in others. This introduces some uncertainty when comparing cumulative risk across media. Congener analysis may provide a more accurate measure of PCBs in environmental samples than does the Aroclor analysis. Although most PCBs may have originally entered the environment as technical Aroclor mixtures, environmental processes, such as weathering and bioaccumulation, may have led to changes in the congener distributions in environmental media such that they no longer closely match the technical Aroclor mixtures used as standards in the laboratory analysis, leading to inaccuracies in quantitation.

The results for PCBs in whole body tissue samples analyzed for both PCBs as Aroclors and as individual PCB congeners were qualitatively compared to evaluate ~~the significance of~~ correlations ~~in order to evaluate the uncertainty~~ associated with the use of Aroclor data. ~~The correlation of the PCB Aroclor and PCB congener data were significant (compared to a probability value of 0.05) for all species evaluated (common carp, smallmouth bass, black crappie, brown bullhead, and crayfish).~~ Windward (2005) analyzed fish tissue from the Lower Duwamish Waterway as PCB Aroclors and as individual PCB congeners. The PCB Aroclor data and PCB congener data were significantly correlated for both fillet and whole body tissue. It should be noted that the Lower Duwamish Waterway is not freshwater, and different species were assessed in the Lower Duwamish study compared to Portland Harbor. - There is less uncertainty associated with using PCB congener data to calculate EPCs; however, these correlations suggest that PCB Aroclor data may be used in the place of congener data if congener data are not available.

When available, PCB congener data were included in cumulative risk sums for tissue because differences in bioaccumulation, in addition to weathering, results in even greater uncertainty in the PCB Aroclor analysis for tissue. However, for fillet tissue, Round 1 samples were analyzed for PCB Aroclors only, and Round 3 samples, which

were collected for smallmouth bass and common carp, were analyzed for PCB congeners only. Because PCB congener data are available for smallmouth bass and common carp fillet tissue, cumulative risks for exposure to fillet tissue from ingestion include only the most recent tissue data for these two species. This introduces uncertainty to the cumulative risk estimates for exposure to fillet tissue when comparing risks across all four resident species.

PCB Aroclor data were included in cumulative risk sums for sediment because the PCB Aroclor dataset is larger than the congener dataset.

PCB congener data were included in the risk evaluation for surface water because the PCB Aroclor data was derived from the results of the congener analysis for the samples used in the risk characterization of this BHHRA. Total PCB congeners did not screen in as COPCs for any surface water scenarios. If PCB Aroclor data from the surface water dataset were used in the COPC screening, PCBs would still not be considered a COPC for any surface water scenarios.

When PCB congener data were used, the total PCB concentration was adjusted by subtracting the concentrations of coplanar PCBs from the total PCB concentration. This was done for purposes of estimating cancer risks because the coplanar PCBs were evaluated separately for the cancer endpoint.

~~7.2.6.7~~6.2.6.7 Bioavailability of Chemicals

The toxicity values used in the risk assessment are generally based on laboratory studies in which the chemical is administered in a controlled setting via food or water. The actual absorption from environmental media may be lower than that observed in the laboratory. Studies have shown that conditions in environmental media (e.g., pH, organic carbon content) can affect the bioavailability of a chemical (Ruby et al. 1999, Pu et al. 2003, Saghir et al. 2007). If the bioavailability of a chemical in a given environmental medium is less than that in the laboratory study used to derive the toxicity value, the risk assessment will overestimate the risks associated with exposure to that chemical in that medium. A committee of the National Research Council recommended that consideration of bioavailability be incorporated in decision-making at sites (National Academy of Sciences 2003). While site-specific information on the bioavailability of ~~COCs~~ chemicals in sediment is not available, it is important to recognize that there is uncertainty associated with not incorporating bioavailability into the risk estimates, especially related to sediment-associated ~~COCs~~chemicals. ~~According to these studies, the magnitude of uncertainty could be as much as a factor of ten.~~

~~7.2.6.8~~6.2.6.8 Smallmouth Bass Exposure Areas

Smallmouth bass exposure areas were on a river mile basis. Uncertainties associated with the home range of smallmouth bass are discussed in ~~Section 7~~~~Section 6~~Section 6.1.~~12~~13. In Round 1, samples were composited on a per river mile basis (e.g., RM 2,

RM 3). In Round 3, samples were composited on a per river mile basis, per side of river (e.g., RM 2E, RM 2W). The Round 1 and Round 3 results were combined and included in the EPC calculations for each river mile exposure area. Although studies have shown that smallmouth bass migrate from one side of the river to another in the lower Willamette (ODFW 2005), it is possible that some smallmouth bass may have a home range that is limited to a single side of the river.

Figure ~~7~~6-1 displays the ratios of concentrations of DDT, DDE, DDD, cPAH, dioxin/furan TEQ, and PCB congeners detected in composite smallmouth bass samples collected at the east side of the river mile compared to concentrations for those detected in composite samples collected at the west side of the river mile. At RM 8, 9, and 10, ~~T~~the ratios are all less than ~~5~~1, indicating concentrations on the east side of the river are generally less than concentrations on the west side of the river. For the remaining river miles, some ratios exceed one. ~~with the exception of the ratio of PCB congeners detected in smallmouth bass tissue collected at the east and west side of RM 11, for which the ratio is approximately one order of magnitude.~~ East to west side concentration ratios for PCBs at river mile 11 are highest of any river mile evaluated. It should be noted, as previously discussed in ~~Section 7~~~~Section 6~~Section 6.1.1~~4~~3, that a fish from RM 11W was included in the composite for RM 11E due to a mislabeling of the sample. Due to the low number of samples for each exposure area, the maximum detected concentration from either side of the river is almost always used as the 95% UCL/max EPC for the river mile exposure areas anyway, which eliminates the possibility of underestimating risk for a given river mile based on whether or not smallmouth bass migrate across the river. Furthermore, the river mile exposure area was determined based on the smallmouth bass home range. In addition, the area over which fishing occurs should also be considered. Given the exposure duration of 30 to 70 years, it is likely that fish would be collected over an area greater than a single river mile for localized exposures. ~~Therefore, the characterization of risk for bass in this risk assessment is a health protective estimate that is unlikely to underestimate risks~~T.~~T~~herefore, ~~uncertainties associated with exposure areas for smallmouth bass likely overestimate risks and may impact the conclusions of this BHHRA when considering risks on a river mile basis~~the characterization of risk for bass in this risk assessment is a health protective estimate that is unlikely to underestimate risks.

~~7.2.6.9~~6.2.6.9 Surface Water EPCs for Recreational Beach Users

For recreational exposures to surface water, data from only the low water sampling event was used, in order to represent surface water conditions during the time of year when most frequent recreational use occurs (i.e. summer months). There is some uncertainty in the representativeness of this dataset for surface water conditions for recreational users.

Transient exposure to surface water can occur throughout the year, so data from sampling events during three seasons of the year were used for this scenario and can be used to assess the representativeness of the single low water sampling event.

Arsenic was the only surface water COPC detected in recreational exposure areas. The Study Area-wide average total arsenic concentration for transient exposure to surface water, using year-round data, is 0.48 µg/l. The Study Area-wide average total arsenic concentration for recreational beach user exposure to surface water, using low flow data, is 0.51 µg/l. Given the similarity of these results, the uncertainty associated with the recreational beach user surface water dataset should not impact the conclusions of this BHHRA.

~~7.3~~6.3 TOXICITY ASSESSMENT

The results of animal studies are often used to predict the potential human health effects of a chemical. Extrapolation of toxicological data from animal studies to humans is one of the largest sources of uncertainty in evaluating toxicity factors. Much of the toxicity information used in this BHHRA comes from EPA's Integrated Risk Information System (IRIS), which states the following on its website:

> In general IRIS values cannot be validly used to accurately predict the incidence of human disease or the type of effects that chemical exposures have on humans. This is due to the numerous uncertainties involved in risk assessment, including those associated with extrapolations from animal data to humans and from high experimental doses to lower environmental exposures. The organs affected and the type of adverse effect resulting from chemical exposure may differ between study animals and humans. In addition, many factors besides exposure to a chemical influence the occurrence and extent of human disease~~.~~ (EPA ~~2009b~~2010b, http://www.epa.gov/iris/limits.htm).

Because of these uncertainties, toxicological data parameters are usually conservative to be more protective of human health due to safety factors EPA uses when estimating toxicity values. The safety factors used by EPA typically range from two to three orders of magnitude (100 to 1,000 times), depending on various aspects of the animal study. As a result, actual risks within the Study Area could be lower than the potential risk estimates calculated in this BHHRA. In addition to the uncertainty already included in the toxicity values, the following toxicity value uncertainties have been identified.

~~7.3.1~~6.3.1 Early Life Exposure to Carcinogens

In 2005, EPA finalized the Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens (EPA 2005b). The guidance provides a process to evaluate risks from early-life exposure to carcinogens with a mutagenic mode of action. The only exposure scenarios with early-life exposures (i.e., child populations) are recreational beach users and fish consumption. Of these, the only scenario with potential exposure to chemicals with a mutagenic mode of action is the recreational beach user scenario for exposure to PAHs.

This BHHRA did not evaluate risks using the new EPA guidance as the exposure factors for the specific age classes ~~have not been determined~~in the separate child and adult scenarios. However, the guidance was used to assess risks associated with exposure to PAHs in the combined adult/child scenarios. Therefore, the combined adult/child scenario accounts for the additional potency associated with early life exposures ~~applies a 10-fold weighting to exposures occurring under the age of two and a 3-fold weighting to exposures occurring between the age of two and the age of 16. Assuming that most beach use would likely occur above the age of two, the risks for the child recreational beach user from carcinogenic PAHs would be approximately 3 times higher than those in this BHHRA. The highest risk for the child recreational beach user from exposure to benzo(a)pyrene in beach sediment is 5 x 10^{-6}. The highest risk from total carcinogenic PAHs is 1 x 10^{-6}. Even if this risk were 3 times higher, the risk would be within the target risk range of 10^{-6} to 10^{-4}. However, it should be noted that the exposure parameters for the frequency and duration of exposure were extremely conservative for this exposure scenario~~.

~~7.3.2~~6.3.2 Lack of Toxicity Values for Delta-hexachlorocyclohexane, Thallium, ~~and~~ Titanium

Delta-HCH was detected in tissue and in-water sediment. An SF or RfD toxicity value could not be identified for delta-HCH according to the hierarchy of sources of toxicity values recommended for use at Superfund sites (EPA 2003b). Also, an STSC review concluded that the other hexachlorocyclohexane isomers could not be used as surrogates for delta-HCH due to differences in toxicity (EPA 2002d). Potential risk from delta-HCH was not quantitatively evaluated because of the lack of availability of toxicity data for the chemical.

Thallium was detected in in-water sediment and surface water, and ~~T~~titanium was detected in in-water sediment ~~and transition zone water~~. Thallium and titanium ~~is a~~ are naturally occurring elements, and although thallium may have a wide spectrum of effects on humans and animals (EPA 2009a)~~,~~ titanium has been characterized as having extremely low toxicity (Friberg et al 1986). An SF or RfD toxicity value could not be identified for titanium according to the hierarchy of sources of toxicity values recommended for use at Superfund sites (EPA 2003b), and consultation with EPA indicated no surrogate toxicity value was available. Therefore potential risk from exposure to titanium was not quantitatively evaluated in this BHHRA.

~~7.3.3~~6.3.3 Use of Toxicity Values From Surrogate Chemicals for Some Chemicals that Lack Toxicity Values

For some chemicals, if a RfD or SF toxicity value was not available from the recommended hierarchy, a structurally similar chemical was identified as a surrogate. The RfD or SF for the surrogate was selected as the toxicity value and the surrogate chemical was indicated in Section 4. Uncertainty exists in using surrogate chemicals to represent the toxicity of chemicals for which toxicity values are not available.

Using surrogate toxicity values could over- or under-estimate risk for a specific chemical.

Based on the results of the BHHRA, the chemicals that exceeded the minimum target cancer risks of 1 x 10^{-6} or hazard quotient of 1 did not rely on surrogate toxicity values. Therefore, the use of surrogate toxicity values should not impact the conclusions of this BHHRA.

~~7.3.4~~6.3.4 Toxicity Values for Chromium

Chromium was analyzed as total chromium in all media. Toxicity values exist for trivalent and hexavalent chromium only. ~~Hexavalent chromium is not considered carcinogenic for oral or dermal exposures.~~ A reference dose for hexavalent chromium is 0.003 mg/kg-day versus 1.5 mg/kg-day for trivalent chromium, which is a factor of 500 times higher. The toxicity values for trivalent chromium were used in the toxicity assessment for the Study Area because hexavalent chromium reduces to trivalent chromium in ~~aerobic conditions~~an aqueous environmental medium if an appropriate reducing agent is available, and thus trivalent chromium is more prevalent in the environment (ATSDR 2008). Likewise, screening values for trivalent chromium were used in the selection of total chromium as a COPC for in-water sediment, beach sediment, the groundwater seep, and surface water. This is an uncertainty because the trivalent chromium screening level is for insoluble salts.

For fish consumption, the highest HQ from chromium was 0.004, so even if a portion of the chromium were present as hexavalent chromium, the HQ would likely still be less than 1. ~~For groundwater, there is a hexavalent chromium plume near RM 7 that is discharging to surface water; however, the screening performed in Section 6 of TZW loading to surface water indicated no exceedances for chromium.~~ Therefore, use of toxicity values for trivalent chromium should not impact the conclusions of this BHHRA.

Additionally, that EPA currently considers the carcinogenic potential of hexavalent chromium via oral exposure as "cannot be determined." A Tier 3 source of toxicity criteria, the New Jersey Dept. of Environmental Protection, has derived quantitative dose-response criteria for evaluating the cancer risks associated with oral exposures to hexavalent chromium, which is the value used in the BHHRA.

~~7.3.5~~6.3.5 Toxicity Values for Polychlorinated Biphenyls and Applicability to Environmental Data

The toxicity values for PCBs were applied to both PCB congeners (not including coplanar congeners) and Aroclors. The RfD for PCBs is based on an immunotoxicity endpoint for Aroclor 1254 (EPA ~~2009b~~2010b). Several other Aroclors have been detected in media within the Study Area, indicating the mixture of PCBs differs from

that used in the study to develop the RfD. The cancer SF for PCBs was derived for PCB mixtures based on administered doses of Aroclors to rats. The PCB mixtures used in the studies included the coplanar PCB congeners (i.e., dioxin-like PCBs). These coplanar PCBs may have contributed significantly to the carcinogenicity observed in the study. The cancer risk from coplanar PCB congeners was evaluated separately, so including both the total PCB and coplanar PCB congener risks in the cumulative cancer risk results in an overestimate of the cancer risks. Although the potential double counting of PCB mass was corrected for in the PCB adjusted values (mass of dioxin-like PCB was subtracted), there was no correction for the potential double counting of toxicity of dioxin-like PCBs in the PCB TEQ cancer risk estimate and as part of the PCB adjusted value cancer risk estimate.

Based on the dose-response data from studies in rats, PCBs are classified as probable human carcinogens. However, the human carcinogenicity data are inadequate for classification of PCBs as human carcinogens. Several cohort studies have been conducted that analyzed cancer mortality in workers exposed to PCBs. The studies did not find a conclusive association between PCB exposure and cancer; however they were limited by small sample sizes, brief follow-up periods, and confounding exposures to other potential carcinogens. Therefore, using a cancer SF based on the dose-response observed in rats adds further uncertainties to the cancer risk estimates from PCBs as a dose-response has not been observed in humans.

In addition to the uncertainties with toxicity values for total PCBs, there are uncertainties with the toxicity values for the PCB TEQ, which is evaluated using toxicity values for dioxin and dioxin-like compounds (e.g., dioxin-like PCBs). In their 2001 evaluation of the EPA dioxin reassessment, members of the EPA's Science Advisory Board (SAB) did not reach consensus on the classification of 2,3,7,8-TCDD as a carcinogen (EPA 2001d). The National Academy of Sciences (NAS 2006) discussed the primary uncertainties with the toxicity values for dioxin and dioxin-like compounds as follows:

- The estimation of risks at doses below the range of existing reliable data may result in an overestimate of risk. An estimate of risk for typical human exposures to dioxin and dioxin like compounds would be lower in a sublinear extrapolation model than in the linear model that was used to derive the 2,3,7,8-TCDD SF.

- The issue of appropriately assessing the toxicity of various mixtures of these compounds in the environment. The relative concentrations may change over an exposure period, even though the potency of the individual congeners remains constant. The estimated risk in a given sample depends on both potency and concentration.

The above uncertainties apply to risks from dioxins and furans, as well as risks from dioxin-like PCBs.

6.3.6 Adjustment of Oral Toxicity Values for Dermal Absorption

To evaluate dermal exposures in this BHHRA, an adjustment to the oral toxicity factor to account for the estimated absorbed dose was applied, as discussed in Section 4.7 of this BHHRA.

As recommended by EPA guidance (EPA 2004), an adjustment to the oral toxicity factor to account for the estimated absorbed dose was applied in this BHHRA when the following conditions are met:

- The toxicity value derived from the critical study is based on an administered dose (e.g., through diet or by gavage)
- A scientifically defensible database demonstrates the GI absorption of the chemical is less than 50% in a medium similar to the one used in the critical study.

If both conditions are not met, then a default oral absorption value of 100% is used so that no adjustment for GI absorption is made to evaluate toxicity from dermal exposures.

The EPA (2004) recommends the adjustment of oral toxicity values to reflect dermal absorption using a cutoff value of 50% GI absorption to reflect the intrinsic variability in the analysis of the absorption studies. The cutoff value of 50% GI absorption obviates the need for small adjustments in the oral toxicity value that are not supported by the level of accuracy in the critical studies that are the source of the toxicity values.

The EPA (2004) guidance states that ~~the~~ scientific literature indicates that organic chemicals are generally well absorbed across the GI tract. For inorganic chemicals, the literature indicates a wide range of GI absorption values. However, if ~~the~~ EPA (2004) guidance does not provide a GI absorption value for an inorganic COPC, then the default GI absorption value of 100% was used. The EPA (2004) guidance states that this assumption of 100% absorption may contribute to underestimation of dermal risk for those inorganics that are poorly absorbed. The extent of this underestimation is proportional to the actual GI absorption, which would not exceed 50%. The inorganic COPCs for which the default value of 100% GI absorption was used includes~~were~~ the following metals: aluminum, arsenic, boron, cobalt, copper, iron, molybdenum, selenium, thallium, and zinc.

~~7.4~~6.4 RISK CHARACTERIZATION

Uncertainties arise during risk characterization due to the methods used in calculating, summing, and presenting risks. The following subsections address uncertainties associated with the risk characterization of this BHHRA.

6.4.1 Endpoint-specific Hazard Indices

~~Another uncertainty for non-cancer effects that was not discussed in the draft HHRA relates to the calculation of endpoint-specific HIs.~~ In deriving ~~these~~endpoint-specific HIs, only one health endpoint is used for each chemical, even though most chemicals have a myriad of health effects as exposures increase. As an example, a majority of the non-cancer impacts from the site are from PCBs and total TEQ. The endpoint used for deriving the RfD for PCBs is immunotoxicity, while the endpoint used for deriving the RfD for dioxin/furan TEQ and PCB TEQs is reproduction. ~~In Table 5-144 (Child, Fish Consumption, Single-Species Diet, Common Carp, 95 percent UCL/ Maximum Exposure Scenario, Highest Ingestion Rate (60 g/day)), the endpoint-specific HI for total TEQ is 500, calculated using the RfD for 2,3,7,8-TCDD, which is based on a reproductive endpoint. A review of the toxicity data in the ATSDR Toxicological Profile for PCBs shows that a dose of 0.02 mg/kg/day in monkeys results in a "serious LOAEL (Lowest Observed Adverse Effect Level) for reproduction."~~ If the reproductive endpoint for PCBs based upon the lowest observed adverse effects level (LOAEL) of 0.02 mg/kg/day is used with the same Uncertainty Factor as the immunological endpoint to derive an RfD for a reproduction endpoint for PCBs, the RfD for reproductive effects will be 4 times the RfD for immunological effects. Using this ratio, the endpoint-specific HI for reproduction for this exposure scenario for PCBs would be 5,000/4 = 1,250. The total HI for reproduction effects, combining HIs for total TEQ (500) and non-dioxin-like PCBs (1,250), would increase from 500 to 1,750. For the chemicals that have the largest non-cancer contribution in the HHRA, ~~the Uncertainty Section should discuss the~~there is a possibility of under-predicting non-cancer health effects by using only one endpoint per chemical.

~~7.4.1~~6.4.2 Risks from Cumulative or Overlapping Scenarios

Where multiple exposure scenarios exist for a given population (i.e., recreational beach users are potentially exposed to both beach sediment and surface water), the risks for each of the exposure scenarios that are considered potentially complete and significant for a given population were summed to estimate the cumulative risks for that population (see Tables 5-~~182~~ 199 and 5-~~183~~200). In calculating the cumulative risks, the maximum cancer risk for each RME scenario was used. This provides a ~~highly~~ conservative approach, as the same individual may not have the maximum exposure under more than one exposure scenario. However, due to the fact that risks from one scenario are usually orders of magnitude higher than any other scenario for a given receptor, risks from potential cumulative scenarios should not impact the conclusions of this BHHRA. However, the possible magnitude of uncertainty associated with risks from cumulative or overlapping scenarios is discussed further in Attachment ~~F5~~F6.

In addition to cumulative exposure scenarios for a given population, an individual may be part of multiple populations (i.e., a dockside worker that is also a non-tribal fisher) and thus could have overlapping exposure scenarios. Because there are numerous possible combinations of overlapping scenarios due to variations in

exposure points and exposure assumptions, a model was not developed to quantitatively evaluate overlapping scenarios in this BHHRA. However, because the risk from tissue ingestion is typically at least 10 times higher than other exposure pathways, if an individual consumes fish, the contribution from other exposure scenarios is not likely to contribute significantly to the overall risks for that individual. This BHHRA presents the risks for all of the exposure scenarios, so the risks for a given overlapping scenario could be calculated simply by summing the risks for each of the exposure scenarios that make up the overlapping scenario.

This BHHRA assessed potential risks from exposure to media within the Study Area. Upland sites were not included in this BHHRA. If exposure to upland sites were incorporated with exposures to media within the study, the overall estimate of cumulative risk would likely be higher than the risk estimates in this BHHRA.

~~7.4.2~~6.4.3 Risks from Background

Concentrations of arsenic and mercury in samples collected within the Study Area were found to result in risks greater than 1 x 10^{-6} or an HQ of 1 for at least one of the exposure scenarios evaluated in this BHHRA. However, metals are naturally occurring chemicals and may be present in tissue, water or sediment due to background concentrations. For beach sediment, the exposure point concentrations ranged from 0.7 mg/kg to 9.9 mg/kg and are consistent with the default background soil concentration for arsenic of 7 mg/kg used by DEQ (DEQ 2007). Risks from background concentrations of arsenic in beach sediment and surface water are discussed in Section 5 of this BHHRA. In addition to naturally occurring metals, anthropogenic background may contribute to the overall risks.

Neither natural nor anthropogenic background tissue concentrations were established for the Study Area. Natural and anthropogenic sources of both metals and organic chemicals are known to contribute to COC concentrations in abiotic media and biota in the Study Area. ~~In some cases, background concentrations correspond to risk estimates above the target risk thresholds established by EPA (i.e., cancer risk of 10^{-6} to 10^{-4}.~~

Although background tissue concentrations for the Study Area were not established, in some cases, regional tissue concentrations correspond to risk estimates above the target risk thresholds established by EPA (i.e. cancer risk of 10^{-6} to 10^{-4})[10]. ~~This increases the uncertainty in estimating risks from fish or shellfish ingestion that are attributable to hazardous substance releases within the Study Area.~~ For example, in the Columbia River Basin Fish Contaminant Survey, HIs were greater than 100 and cancer risks were as high as 2 x 10^{-2} for the highest tribal fish consumption rate (389 g/day) (EPA 2002c). In this study, the fish species collected included five anadromous species (Pacific lamprey, smelt, coho salmon, fall and spring Chinook

[10] Regional tissue concentrations are discussed in the Risk Management Recommendations document for the Portland Harbor, provided by the LWG to EPA under separate cover.

salmon, steelhead) and six resident species (largescale sucker, bridgelip sucker, mountain whitefish, rainbow trout, white sturgeon, walleye). All samples were composites; the size of the individual fish varied with species. However, concentrations of certain contaminants are higher in tissue collected within the Study Area than in the regional tissue, the sources of the regional tissue concentrations are unknown, and regional efforts are underway to reduce contaminant concentrations in tissue.

~~The presence of PCBs in fish above the EPA target fish tissue concentration in the Willamette River Basin was evaluated using a watershed-scale model (Hope 2008). The model results suggested that atmospheric sources of PCBs could have yielded the concentrations observed in fish tissue. If the model results are correct, atmospheric sources of PCBs alone result in tissue concentrations that exceed the target risk level of 1 x 10^{-6} for fish consumption rates higher than 16 meals per month.~~

While risks were presented in this BHHRA without accounting for contributions from background, it is important to recognize that background concentrations may result in unacceptable risks based on the exposure assumptions used in this BHHRA. The proportion of the concentrations that are not due to releases from sources in the Study Area cannot be controlled by remedial actions in the Study Area. This could prevent remedial actions in the Study Area from achieving acceptable risk levels.

~~7.4.3~~6.4.4 Risks from Lead Exposure

Because the maximum EPCs for lead are greater than the protective fish tissue concentrations associated with an acceptable probability of exceeding protective blood lead levels in the fetus of a pregnant woman ingesting tissue from the Study Area, lead is considered a chemical potentially posing unacceptable risk~~COC~~ for fish tissue. However, this maximum EPC is orders of magnitude greater than all other fish EPCs and may be attributable to lead in the gut of the fish.

Protective tissue concentrations were estimated using the EPA Adult Lead Methodology (ALM) (EPA 2003c), based on agreements with the EPA to follow the same methodology used in the CRITFC (1994) ~~study~~ survey to assess tissue exposures from lead. The ALM focuses on potential impacts to the fetus of a pregnant worker, and therefore, is only appropriate when considering fish consumption by pregnant women. The ALM was developed based on exposure to lead in soil and may not be appropriate to use for fish consumption. Furthermore, the ALM is highly sensitive to the bioavailability of ingested lead. For purposes of developing the protective tissue concentrations, the default bioavailability of lead in soil was used. It is not known whether this is an appropriate assumption for lead in tissue.

While lead was identified as a ~~chemical~~ contaminant -potentially posing unacceptable risk~~COC~~ for fish tissue, there is considerable uncertainty associated with that decision. The identification of lead as a ~~chemical~~contaminant potentially posing

unacceptable risk~~COC~~ was based on the maximum EPC, which may not be due to CERCLA activities, and is not representative of Study Area-wide lead concentrations. Furthermore, the identification of lead as a ~~chemical~~contaminant potentially posing unacceptable risk~~COC~~ was based on the ALM, which was not developed for fish consumption.

For in-water sediment, blood lead levels were also estimated using the ALM. As discussed above, the methodology focuses on potential impacts to the fetus of a pregnant worker, and therefore, is only appropriate when evaluating exposures by pregnant women. Because lead was not identified as a ~~chemical~~contaminant potentially posing unacceptable risk~~COC~~ for in-water sediment, the use of the ALM to evaluate risks from lead exposure for in-water sediment is not likely to impact the conclusions of this BHHRA.

~~7.4.4~~6.4.5 Future Risks

This BHHRA estimated current and future risks for exposure within the Study Area, based on known and reasonably foreseeable future uses of the Study Area. In addition, this BHHRA assessed hypothetical scenarios at EPA's request. However, the LWR is a highly dynamic, industrialized water way, and if the land uses in certain areas of the Study Area were to change in the future in a manner that was not foreseen in this BHHRA, the assumptions and scenarios used to evaluate risks for the Study Area may not be applicable to risks from new exposures. Nevertheless, due to the conservative nature of the assumptions used in this BHHRA, the risk estimates in this BHHRA may still be protective of future uses of the Study Area that were not evaluated. The uncertainty related to future risks could result in either higher or lower risk estimates for the Study Area.

~~7.5~~6.5 OVERALL ASSESSMENT OF UNCERTAINTY

A summary of the uncertainties and a qualitative classification of their magnitude, their impact on the health protectiveness of the assessment, and their significance to risk management decisions are presented in Table ~~7~~6-1. For each of the uncertainties identified and discussed in this section, Table ~~7~~6-1 provides a qualitative assessment (using High, Medium, and Low as descriptors) for each of these properties. In addition, the table presents whether an uncertainty is more likely to over-estimate or under-estimate actual risks from the Study Area. While there are numerous uncertainties identified for this BHHRA, and the cumulative effect of these uncertainties could be significant to the conclusions of the BHHRA, some of these uncertainties would be expected to have more of a significant effect on risk management decisions than other uncertainties. These are identified with a "High" descriptor under the "Significance to Risk Management" column in Table ~~7~~6-1.

Risk assessments typically include conservative assumptions to minimize the chances of underestimating exposure and/or risks of adverse effects to human health, and

therefore potentially underestimating the need for remedial actions. In this BHHRA, conservative assumptions were incorporated into the identification of exposure scenarios, the selection of exposure assumptions, the development of EPCs, and the use of toxicity values. ~~In estimating the risks in this BHHRA, the conservative assumptions were multiplied together, which magnifies the conservatism in the risk estimates.~~

Only a portion of the uncertainties in this BHHRA are quantifiable. Further analysis of the data and review of pertinent published literature provided a possible range of values for some of the uncertainties presented above. The magnitude of these ranges are provided in Attachment ~~F5~~F6 and discussed in this Section. ~~Table 7-1 also presents possible ranges for the magnitude of difference in values associated with a given uncertainty.~~

While it is not probable that the maximum values of the uncertainties apply for every tissue consumption exposure scenario and ~~chemical~~contaminant , this magnitude of uncertainty indicates that risks may actually be less than 1 x 10^{-4} or HI of 1 for certain scenarios.

~~The cumulative effects of the numerous conservative assumptions made during this BHHRA are risk estimates that are likely higher, and potentially significantly higher, than actual risks that may exist within the Study Area.~~ While conservative, the results of the BHHRA are intended to show the relative risks associated with the exposure scenarios, and which contaminants ~~chemicals~~ are contributing the highest percentage of the calculated risks.

~~8.0~~7.0 SUMMARY

The overall objective of this BHHRA was to evaluate whether exposure to contaminants ~~chemicals~~ in sediment, surface water, groundwater seeps, or biota may result in unacceptable risks to human health. ~~In addition, surface water data were evaluated as a potential source of contamination for biota that are consumed by humans, and TZW data were evaluated as a potential source to untreated surface water that is hypothetically used as a domestic water source.~~ The results of this BHHRA will be used in developing remedial action objectives and assist in risk management decisions for the Site. The results of this BHHRA have been used in developing risk management recommendations for the Site, submitted to the EPA under separate cover.

The populations evaluated in the risk characterization portion of the BHHRA were identified based on human activities that are known to occur now and/or which could occur in the future within the Study Area, as described in the Programmatic Work Plan, or were directed by EPA for evaluation in this BHHRA. The following are the populations and associated exposure scenarios that were quantitatively evaluated in this BHHRA:

- Dockside Worker – Direct exposure to beach sediment
- In-water Worker – Direct exposure to in-water sediment
- Recreational Beach User – Direct exposure to beach sediment and surface water
- Transient – Direct exposure to beach sediment, surface water, and groundwater seep
- Diver – Direct exposure to in-water sediment and surface water
- Tribal Fisher – Direct exposure to beach sediment or in-water sediment, and fish consumption
- Fisher – Direct exposure to beach sediment or in-water sediment, fish consumption, and shellfish consumption
- ~~Hypothetical future resident~~Domestic Water ~~u~~User – Hypothetical direct exposure to untreated surface water used as a domestic water source
- Infants - Consumption of human milk was quantitatively assessed~~included~~ as a complete exposure pathway for all adult receptor populations exposed to~~that were assessed quantitatively for~~ bioaccumulative chemicals that were identified as COPCs for a given scenario (i.e., PCBs, dioxin/furans, and DDX).

~~8.1~~7.1 SUMMARY OF RISKS

Cancer risks and noncancer hazards were calculated for each of the exposure scenarios listed above for potential exposure to the contaminants ~~chemicals~~ selected as COPCs. The following sections present a summary of the risks for each of the media quantitatively evaluated in this BHHRA, and a discussion of the relative magnitude of the risk estimates for each media.

~~8.1.1~~7.1.1 Summary by Exposure Scenario

This section summarizes the risks for each of the media evaluated for potential risks in this BHHRA (beach sediment, in-water sediment, surface water, groundwater seep, fish tissue, and shellfish tissue). Table 5-196 presents a tabular summary of the risk estimates by exposure scenario. Figures 5-1 through 5-21 illustrate the contaminants contributing to risk for each exposure scenario by exposure point, and comparisons of risk across exposure points. ~~In estimating the risks in this BHHRA, the health protective assumptions regarding fish consumption were multiplied together, which magnifies the overall conservatism in the risk estimates. The cumulative effects of the numerous conservative assumptions made during this BHHRA are risk estimates that are potentially significantly higher than actual risks that may exist within the Study Area.~~

~~8.1.1.1~~7.1.1.1 Fish Consumption

Fish consumption risks were calculated for the adult and child non-tribal fish consumers, based on three different ingestion rates representing a range of potential ~~high end~~ consumption scenarios. Fish consumption risks were also evaluated for both single species- and multi-species diets (common carp, black crappie, brown bullhead, and smallmouth bass) based on consumption of either whole body or fillet with skin tissue. Fish consumption was assumed to occur at the same ingestion rate ~~, every day of every year,~~ for 30 years for an adult and for 6 years for a child. It was assumed that all fish consumed were resident fish caught within the Study Area (from RM 2 to 11 for smallmouth bass, between RM 0 to 12 for carp, from RM 3 to 9 for brown bullhead and black crappie) or within a single exposure area (w~~within a one mile area on both sides of the river for bass and within a 3 mile stretch of both sides of the river for crappie, carp and bullhead troutw~~within a one mile area on both sides of the river for bass and within a 3 mile stretch of both sides of the river for crappie, carp and bullhead trout)~~for spatial scales smaller than the Study Area~~.

Fish consumption risks were also evaluated for adult and child tribal fishers based on an upper-bound ingestion rate for a multi-species diet consisting of resident fish species (common carp, black crappie, brown bullhead, and smallmouth bass) as well as sturgeon, lamprey, and salmon. Risks from the tribal fish diet were based on consumption of either whole body or fillet with skin tissue. Fish consumption was assumed to occur at the same ingestion rate~~, every day of every year,~~ for 70 years for

an adult and for 6 years for a child. It was assumed that all fish consumed were caught within the Study Area.

Consumption of individual species by the non-tribal fisher resulted in cumulative cancer risks ranging from ~~7 x 10^{-6} to 6 x 10^{-2} for the adult fisher and from~~ 3 x 10^{-6} to ~~2~~ 7 x 10^{-2} for the scenarios including adult fisher, child fisher, combined adult and child fisher, or breastfeeding infant of an adult fisher consuming fish. The cumulative HIs range from 0.5 to 5,000 for the child and adult non-tribal fish consumers. The highest ~~endpoint-specific~~ HI ~~s ranged from 3 to 3~~was 60,000 for the breastfeeding infant of a non-tribal fish consumer~~the adult fisher and from 5 to 5,000 for the child consumer~~. Risks from fish consumption by non-tribal fishers are primarily from exposure to PCBs.

Consumption of fish by the tribal fisher resulted in cumulative cancer risks ranging from ~~2 x 10^{-3} to 1 x 10^{-2} for the tribal adult fisher and from~~ 4 x 10^{-4} to ~~2~~ 2 x 10^{-3}~~^{2}~~ for the tribal adult consumer, tribal child consumer, and breastfeeding infant of tribal adult consumer.~~-~~ The highest ~~endpoint-specific~~ HI~~s ranged from 40 to~~ was ~~200~~ 400 for the tribal adult fisher ~~and, from 80 to 400~~ 800 for the tribal child consumer, and 9,000 for a breastfeeding infant of a tribal adult consuming fish. Risks from fish consumption by tribal fishers are primarily from exposure to PCBs.

There were multiple uncertainties associated with the fish consumption scenarios of which the following were of primary significance: lack of site-specific fish consumption information, the small area assumed for exclusive collection of fish or shellfish consumed, ~~use of maximum detected concentrations as EPCs,~~ fish consumption rates, tissue type and fish species consumed, cooking and preparation methods, and contributions from background. Round 1 fillet tissue samples were not analyzed for PCB, dioxin, or furan congeners. Therefore, the risks from consumption of black crappie and bullhead fillet tissue, which were only analyzed in Round 1, likely underestimate the actual risks. However, a range of risks was calculated for fish consumption scenarios, which included samples that were analyzed for congeners, so the lack of analysis of contaminants ~~chemicals~~ in certain samples should not impact the conclusions of this BHHRA.

~~8.1.1.2~~7.1.1.2 Shellfish Consumption

~~It is not known to what extent shellfish consumption actually occurs, and there is no documentation of ongoing shellfish consumption by humans occurring in the Study Area.~~Current and potential future shellfish consumption rates for the site are not known. However, both crayfish and clams were evaluated for consumption risks. Two different ingestion rates based on the nationwide survey for shellfish consumption for freshwater and estuarine habitats combined were used to calculate risks from shellfish consumption. Shellfish consumption was assumed to occur at the same ingestion rate~~, every day of every year,~~ for 30 years. It was assumed that all shellfish consumed were caught within the Study Area or within a single exposure area for spatial scales smaller than the Study Area. Cumulative cancer risks from

consumption of shellfish ranged from 9 x 10^{-7} to 7 x 10^{-4}. The cumulative HIs range from 0.06 to 40 for shellfish consumption. The highest HI was 800 for the breastfeeding infant of a shellfish consumer. ~~HIs for endpoint-specific noncarcinogenic risks ranged from 1 to 30 for consumption of shellfish.~~

In addition to the uncertainty of whether shellfish consumption actually occurs on an ongoing basis, there were other uncertainties associated with the shellfish consumption scenarios of which the following were of primary significance: spatial scale of EPCs, ~~use of maximum detected concentrations as EPCs,~~ shellfish consumption rates, shellfish species consumed, cooking and preparation methods, and contributions from background.

~~8.1.1.3~~7.1.1.3 Direct Exposure to In-~~water~~ Water Sediment

Risks from in-water sediment exposure were estimated separately for each of the ½-mile river segment exposure areas on each side of the river, and for Study Area-wide exposure. Each ½-river mile segment was considered a potential exposure area, regardless of the ~~feasibility or practicality of~~ use of the area. In-water sediment within the navigation channel was not included in the risk evaluation. Risks from in-water sediment exposure were evaluated for exposures by in-water workers, tribal fishers, fishers, and divers.

The cumulative cancer risks for all of the CT scenarios for direct exposure to in-water sediment were below 1 x 10^{-4}, and only the tribal fisher CT scenario had cancer risks above 1 x 10^{-6}. For the RME scenarios, cumulative cancer risks were greater than 1 x 10^{-6} but were below 1 x 10^{-4}, with the exception of cancer risks above 1 x 10^{-4} for in-water sediment by a tribal fisher at exposure areas RM 6W (risk is 2 x 10^{-4} due primarily to PAHs) and RM 7W (risk is 3 x 10^{-4} due primarily to dioxins). ~~None of the scenarios resulted in endpoint-specific HIs exceeding 1.~~ The highest HI is 3.

There were multiple uncertainties associated with the direct exposure to in-water sediment scenarios of which the following were of primary significance: degree of sediment contact that occurs during fishing scenarios, spatial scale of in-water sediment EPCs, exposure parameters, bioavailability of contaminants ~~chemicals~~ in sediment, and contributions from background. The uncertainties associated with exposure parameters and contributions from background were not quantified in this BHHRA. ~~The magnitude of uncertainty associated with the bioavailability of contaminants chemicals in sediment could be as much as a factor of ten. Given that uncertainty associated with the bioavailability of contaminants chemicals in sediment could be as much as a factor of ten, it is probable that actual cancer risks are lower than the risk estimates, which did not account for bioavailability.~~

~~8.1.1.4~~7.1.1.4 Direct Exposure to Beach Sediment

Beaches were identified as potential human use areas associated with industrial upland sites (dockside workers), recreation (recreational users or fishers), and/or

trespassing or transient use (transients). Even if such beach use occurs, the extent to which the beach is used and the nature of the contact with sediments/beach is uncertain. However, health protective assumptions were included in the risk analysis of this exposure pathway to provide an estimate of potential risks.

The only CT scenarios for exposure to beach sediment resulting in risks above 1 x 10^{-6} were the dockside worker (6 x 10^{-6}) and tribal fisher and child recreational beach user scenarios (2 x 10^{-6}). The cumulative cancer risks for all of the CT scenarios were below 1 x 10^{-4}. The RME scenarios for exposure to beach sediment resulting in cumulative cancer risks above 1 x 10^{-6} include: dockside worker, adult and child recreational beach user, tribal fisher and fisher. The maximum cancer risk from RME scenarios was 9 x 10^{-5} for the dockside worker exposure to beach sediment. None of the RME scenarios for exposure to beach sediment resulted in risks greater than 1 x 10^{-4}. None of the scenarios resulted in ~~endpoint-specific~~ HIs exceeding 1. Risks above 1 x 10^{-6} resulting from exposures to beach sediment are due primarily to arsenic, which is likely present at naturally occurring background concentrations, and benzo(a)pyrene.

There were multiple uncertainties associated with the direct exposure to beach sediment scenarios of which the following were of primary significance: spatial scale of beach sediment EPCs, exposure parameters, bioavailability of contaminants ~~chemicals~~ in sediment, and contributions from background. The uncertainties associated with exposure parameters and contributions from background were not quantified in the BHHRA. ~~The magnitude of uncertainty associated with the bioavailability of chemicals in sediment could be as much as a factor of ten. Given that uncertainty associated with the bioavailability of chemicals in sediment could be as much as a factor of ten, it is probable that actual cancer risks are lower than the risk estimates, which did not account for bioavailability.~~

~~8.1.1.5~~7.1.1.5 Direct Exposure to Surface Water

Risks were evaluated for direct surface water exposures by transients, divers and adult and child recreational beach users. ~~None of the~~The ~~evaluated~~ scenarios result~~inged~~ in cumulative cancer risks greater than 1 x 10^{-6}~~, with the exception of the~~ were the diver in wet suit ~~at RM 6W~~ (1 x 10^{-5} ~~due primarily to PAHs~~) and the diver in dry ~~w~~suit (2 x 10^{-6}) at RM 6W due primarily to cPAHs.~~, where risks were below 1 x 10^{-4}~~. None of the direct surface water exposure scenarios resulted in HIs exceeding 1. ~~None~~

~~of the evaluated scenarios resulted in endpoint-specific HIs exceeding 1.~~

Surface water within the Study Area is not currently used as a domestic water source, nor are there plans to use surface water within the Study Area as a domestic water source in the future. However, risks were also evaluated for hypothetical exposure to untreated surface water used as a domestic water source by ~~hypothetical~~ future residents. ~~Cumulative~~ The maximum cumulative cancer risk for hypothetical

exposure to untreated surface water was~~between 10^{-4} and 10^{-6} for both adult and child residents due to arsenic, which is likely present at naturally occurring background concentrations~~ 9×10^{-4}, due primarily to cPAHs, and benzo(a)pyrene specifically. The child RME scenario for hypothetical exposure to surface water as a domestic water source was the only scenario with an exceedance of an HI of 1. The exceedance occurred at RM 8.5, primarily from exposure to MCPP (HQ for MCPP was 2).~~None of the evaluated scenarios resulted in endpoint-specific HIs exceeding 1.~~

~~8.1.1.6~~7.1.1.6 Direct Exposure to Groundwater Seeps

Risks from exposures to groundwater seeps were evaluated for exposure by a transient for only one exposure point. The transient exposure scenario did not result in cumulative cancer risks greater than 1×10^{-6} or HIs greater than 1.

~~8.1.2~~7.1.2 Comparison of Risks Between Exposure Scenarios

A comparison of risk ranges across media can help focus risk management decisions by identifying the media contributing most to the overall risk to human health at the Study Area. As discussed in Sections 5, the magnitude of risk varies greatly across the different scenarios. Figures ~~8~~7-1 and ~~8~~7-2 display the ranges of total cumulative cancer risk and endpoint-specific HIs, respectively, for each media type, based on mean exposure assumptions for each media evaluated in the BHHRA. As illustrated in Figures ~~8~~7-1 and ~~8~~7-2, the risk ranges for the scenarios assessing consumption of fish and shellfish tissue are orders of magnitude higher than risks for others scenarios, and exceed a cumulative cancer risk of 1×10^{-4} and ~~an endpoint-specific~~a HI of 1. Figures ~~8~~7-3 and ~~8~~7-4 display the ranges of total cumulative cancer risk and ~~endpoint-specific~~cumulative HIs, respectively, based on RME assumptions, for each media type evaluated in the BHHRA. As illustrated in Figures ~~8~~7-3 and ~~8~~7-4, the risk ranges for scenarios assessing consumption of fish and shellfish tissue are orders of magnitude higher than risks for other scenarios. The only scenarios that exceed a cumulative cancer risk of 1×10^{-4} or ~~an endpoint-specific~~ a HI of 1 are the tissue consumption scenarios and the scenario for direct contact with in-water sediment by tribal and high frequency fishers.

~~8.1.3~~7.1.3 Contaminants ~~Chemicals of Concern~~Potentially Posing Unacceptable Risks

Contaminants ~~Chemicals~~ were identified as ~~preliminary COCs~~potentially posing unacceptable risks if they resulted in a cancer risk greater than 1×10^{-6} or an HQ greater than 1 under any of the exposure scenarios for any of the exposure point concentrations evaluated in this BHHRA, regardless of the uncertainties. Given the uncertainties in the analytical data discussed in ~~Section 7~~Section 6, the preliminary COCs were assessed to select the final COCs for this BHHRA.

~~Uncertainties associated with the analytical data for individual chemicals were considered in the selection of the final COCs. Specifically, if chemicals were~~

~~identified as preliminary COCs based only the use of N-qualified data as EPCs, the chemicals were not identified as final COCs~~Four of the contaminants identified as potentially posing unacceptable risks (alpha-, beta, and gamma-hexachlorocyclohexane and heptachlor) were only detected in fish tissue as N-qualified data. Due to retention time issues in the analytical methods used for the Round 1 tissue samples, some of the pesticide tissue data were N-qualified, indicating that the identity of the chemical could not be confirmed. In subsequent sampling events, different analytical methods were used so that the identification of pesticides was not an issue in tissue samples collected in Rounds 2 and 3. EPA guidance (1989) does not recommend the use of data where there are uncertainties in the identification of contaminants~~chemicals~~, as is the case in the N-qualified data. Therefore, if a chemical was identified as ~~a preliminary COC~~potentially posing unacceptable risks based only on the use of N-qualified data, that chemical ~~was not selected as a final COC~~is not recommended for further evaluation for potential risks to human health.

The ~~final COCs~~contaminants potentially posing unacceptable risks ~~for~~to human health~~, which are~~ based on the results of this BHHRA~~, including consideration of the uncertainties associated with the analytical data,~~ that are recommended for further evaluation for potential risks to human health are presented in Table ~~8~~7-1.

~~8.2~~7.2 ~~RISK DRIVERS~~PRIMARY CONTRIBUTORS TO RISK

In this BHHRA, there are certain exposure scenarios and ~~chemicals~~ contaminants that result in risks that are orders of magnitude higher than risks from other exposure scenarios and contaminants ~~chemicals~~ within the Study Area, and that exceed risk levels that generally warrant remedial action under CERCLA. ~~Consistent with EPA guidance (1999), the exposure scenarios and chemicals that are driving a need for remedial action are referred to as "risk drivers".~~ One role of the BHHRA is to identify those contaminants that pose the greatest risks to current and future receptors, along with the media and exposures routes associated with those risks. This information is used to inform response actions. This section presents the ~~rationale for the identification of the exposure scenarios and chemicals that are the risk drivers~~primary contributors to ~~for~~ human health risk at the Site~~, many of which are risk drivers~~. The exposure scenarios and chemicals ~~selected as risk drivers~~discussed here represent a subset of the scenarios and contaminants ~~chemicals~~ evaluated ~~and COCs identified~~ in this BHHRA.

The ~~selection of risk drivers~~focus on primary contributors to risk can assist~~s~~ with the development of the FS by focusing on those scenarios and contaminants ~~chemicals~~ associated with the greatest overall risk in the Study Area. ~~This is of particular importance in cases in which it is not possible for remedial actions to achieve certain specified target risk levels for all scenarios and chemicals and in cases where the remediation of risk drivers~~the primary contributors to risk ~~may address risk from exposure to other chemicals as well.~~ While ~~risk drivers should~~these scenarios and contaminants may be the focus of the remedial

analyses, other exposure scenarios and ~~COCs~~ contaminants ~~chemicals not selected as risk drivers~~potentially posing unacceptable risks may still be considered in remedial decisions for the Site.

Only those exposure scenarios and contaminants ~~chemicals~~ that resulted in a cancer risk greater than 1×10^{-6} or an HQ greater than 1 were considered ~~in the selection of~~ in identifying the primary contributors to risk~~risk drivers~~. Additional considerations in the selection of ~~risk drivers~~contributors included:

- The relative percentage of each contaminant's ~~chemical's~~ contribution to the total human health risk consistent with assumptions on exposure areas.
- Uncertainties associated with the exposure scenarios, such as the likelihood of future risk scenarios, number of assumptions made in estimating exposure, or level of uncertainty in estimates of exposure variables.
- Frequency of detection, both on a localized basis and Study Area-wide.
- Comparison of risks within the Study Area to risks based on measured regional contaminant ~~chemical~~ concentrations for similar exposure scenarios, indicating background sources of chemicals in the region.
- Magnitude of risk exceedance above EPA's target range for managing cancer risk of 10^{-4} to 10^{-6} and noncancer hazard of one.

The ~~risk drivers selected~~chemicals potentially posing unacceptable risks and the primary contributors to risk based on the above criteria for the exposure scenarios evaluated in this BHHRA are discussed below.

~~8.2.1~~7.2.1 Fish Consumption Scenarios

Twenty ~~three~~ six COCs (PCBs, dioxins, six metals, Bis 2-ethylhexyl phthalate (BEHP), PAHs, hexachlorobenzene, and seven pesticides) were identified as ~~risk driversprimary contributors to risk~~potentially posing unacceptable risks for the fish-consumption scenarios (i.e., both fisher and tribal fisher) based on exceedances of a cancer risk of 1×10^{-6} or HQ of 1:

- PCBs: Total PCBs resulted in cancer risk estimates exceeding 1×10^{-4} and/or HQs exceeding 1 for fish consumption. Total PCB TEQ also resulted in cancer risk estimates exceeding 1×10^{-4} and/or HQs exceeding 1 for fish consumption. PCBs resulted in risk estimates that exceeded a cancer risk of 1×10^{-4} and/or HQ of 1 for both localized and Study Area-wide exposures. PCBs are considered a ~~risk driver~~primary contributor to risk for the fish consumption pathway because of the magnitude of the risk exceedances above the EPA target range for managing risk, spatial scale of the risk exceedances, and relative contribution to cumulative risk.

- Dioxins/furans: Total dioxin TEQ resulted in cancer risk estimates exceeding 1×10^{-4} and/or HQs exceeding 1 for fish consumption. Total dioxin TEQ resulted in risk estimates that exceeded a cancer risk of 1×10^{-4} and/or HQ of

1 for both localized and Study Area-wide exposures. Dioxins are considered a primary contributor to risk ~~risk driver~~ for the fish consumption pathway because of the magnitude of the risk exceedances, spatial scale of the risk exceedances, and relative contribution to cumulative risk.

- Metals: Antimony, arsenic, mercury, selenium, and zinc were associated with one or more fish consumption exposure scenarios that resulted in a risk estimate that exceeded a cancer risk of 1×10^{-6} or HQ of 1.
    - Arsenic resulted in cancer risk estimates that exceeded a cancer risk of 1×10^{-4} for Study Area-wide exposures.
    - Antimony exceeded an HQ of 1 at RM 10 for consumption of whole body smallmouth bass tissue only due to a single smallmouth bass sample with the anomalously high result discussed in ~~Section 7~~Section 6.~~2.6.3~~1.14.
    - Lead was identified as a ~~COC chemical~~contaminant potentially posing unacceptable risk based on exceedance of protective tissue concentrations derived using blood lead models. The risk exceedances for lead from fish consumption are due to only a single sample of smallmouth bass whole body tissue collected at RM 10 with the anomalously high result discussed in ~~Section 7~~Section 6.1.14~~.2.6.3.~~
    - Mercury resulted in risk estimates that exceeded a HQ of 1 for both localized and Study Area-wide exposures.
    - Selenium exceeded an HQ of 1 at RM 11 only for consumption of smallmouth bass fillet tissue, due to a single sample. Due to a limited number of detected concentrations of antimony and selenium (i.e., 5 detects out of 32 samples and 1 detect out of 23 samples, respectively), antimony and selenium also resulted in HQs greater than 1 Study Area-~~-~~wide.
    - Zinc slightly exceeded an HQ of 1 (HQ = 2) for fish consumption based on a single sample of whole body common carp tissue collected from RM 4 to RM 8.

~~Metals are not considered primary contributors to risk~~risk drivers for the fish consumption pathway because of the low relative contribution to the cumulative risks for this pathway. Also, with the exception of arsenic and mercury, metals were identified as COCs based on a limited number of detected concentrations. Arsenic and mercury concentrations in fish tissue may be due in part to naturally occurring (i.e., background) concentrations in sediment.

- BEHP: BEHP resulted in cancer risk estimates greater than 1×10^{-6} for consumption of whole body smallmouth bass and brown bullhead, based on both a localized and Study Area-wide basis, for all ingestion rates. BEHP resulted in cancer risk estimates greater than 1×10^{-4} and HQs greater than 1 at RM 4 for consumption of smallmouth bass at the ~~higher (~~73 g/day~~)~~ and ~~highest (~~142 g/day~~)~~ ingestion rates. ~~BEHP is not considered a primary~~

~~contributor to risk~~risk driver for the fish consumption pathway because of the limited number of detected concentrations and the potential for sources of phthalates in whole body tissue (i.e., the gut) not related to sediment exposures.

- PAHs: Benzo(a)anthracene, benzo(a)pyrene, dibenzo(a)anthracene, and total carcinogenic PAHs were identified as a ~~chemical~~contaminant potentially posing unacceptable risk~~COCs~~ for fish tissue consumption based on cancer risk estimates exceeding 1×10^{-6}. Cancer risk estimates for total carcinogenic PAH exceeded 1×10^{-6} for all ingestion rates for consumption of smallmouth bass and only the ~~higher (~~73 g/day~~)~~ and ~~highest (~~142 g/day ingestion rates for consumption of common carp. No cancer risk estimates exceeded 1×10^{-4}. For consumption of smallmouth bass, cancer risk estimates for total carcinogenic PAHs exceeded 1×10^{-6} for five rive mile segments and ~~for~~ Study Area-wide. For consumption of common carp, cancer risk estimates for total carcinogenic PAHs exceeded 1×10^{-6} for two fishing zones and ~~for~~ Study Area-wide. PAHs account for less than 1% of the cumulative cancer risks where they were detected. ~~Therefore, PAHs are not considered primary contributors to risk~~a risk driver ~~for the fish consumption pathway because of the low relative contribution to the cumulative risks.~~

- Pesticides: Aldrin, dieldrin, heptachlor epoxide, total chlordane, total DDD, total DDE, and total DDT were associated with one or more fish consumption exposure scenarios that resulted in a risk estimate that exceeded a cancer risk of 1×10^{-6} or HQ of 1. These pesticides did not result in cancer risks greater than 1×10^{-4}.
    - Aldrin was identified as a ~~chemical~~contaminant potentially posing unacceptable risk~~COC~~ based on cancer risk estimates slightly above 1×10^{-6}, at only the ~~highest (~~142 g/day~~)~~ ingestion rate for consumption of common carp (localized and Study Area-wide). Aldrin only contributes approximately 0.01% to the total Study Area-wide risk for the whole body common carp diet.
    - Dieldrin was identified as a ~~chemical~~contaminant potentially posing unacceptable risk~~COC~~ based on an exceedance of 1×10^{-6} for consumption of all fish species (smallmouth bass, common carp, black crappie, and brown bullhead), all ingestion rates, and on a localized and Study Area-wide basis. For the multi-species whole body tissue diet, dieldrin contributes to less than 1% of the site-wide risk from tissue consumption.
    - Heptachlor epoxide was identified as a ~~chemical~~contaminant potentially posing unacceptable risk~~COC~~ based on cancer risk estimates slightly above 1×10^{-6}, at only the ~~highest (~~142 g/day~~)~~ ingestion rate for consumption of common carp, and for one fishing zone (RM 0 to RM 4). For this fishing zone, heptachlor epoxide

contributes to 0.1% of cumulative risk from consuming whole body common carp.

- Total chlordane was identified as a ~~chemical~~contaminant potentially posing unacceptable risk~~COC~~ based on an exceedance of 1 x 10^{-6} for consumption of all fish species (smallmouth bass, common carp, black crappie, and brown bullhead), all ingestion rates, and on a localized and Study Area-wide basis.
- DDD was identified as a ~~chemical~~contaminant potentially posing unacceptable risk~~COC~~ based on an exceedance of 1 x 10^{-6} for consumption of all fish species (smallmouth bass, common carp, black crappie, and brown bullhead), all ingestion rates, and on a localized and Study Area-wide basis.
- DDE was identified as a ~~chemical~~contaminant potentially posing unacceptable risk~~COC~~ based on an exceedance of 1 x 10^{-6} for consumption of all fish species (smallmouth bass, common carp, black crappie, and brown bullhead), all ingestion rates, and on a localized and Study Area-wide basis. DDE also resulted in an HQ slightly greater than 1 at RM 7 for smallmouth bass.
- DDT was identified as a ~~chemical~~contaminant potentially posing unacceptable risk~~COC~~ based on an exceedance of 1 x 10^{-6} for consumption of all fish species (smallmouth bass, common carp, black crappie, and brown bullhead), all ingestion rates, and on a localized and Study Area-wide basis.

~~Pesticides are not considered a primary contributors to risk~~risk driver for the fish consumption pathway because of the low relative contribution to the cumulative risks, as well as the limited number of detects in many cases.

Based on the magnitude of risk, the relative contribution to risk, and the frequency of detection, PCBs and dioxins/furans are considered the primary contributors to risk~~only risk drivers~~ for fish consumption scenarios. The risks for PCBs and dioxins/furans exceed a cancer risk of 1 x 10^{-4} or an HQ of 1 for both the mean and maximum exposure scenarios for both localized and Study Area-wide exposures. Figure 7-5 illustrates the relative percentages of cancer risks for individual contaminants ~~chemicals~~ contributing to total cumulative risk for consumption of fish tissue by an adult fisher, based on Study Area-wide EPCs for a multi-species diet. Separate charts are shown for diets based on whole body fish consumption and fillet tissue consumption. As illustrated in the pie charts in Figure ~~8~~7-5, PCBs are the primary contributor to risk ~~primary risk driver~~ for fish consumption and dioxins are a secondary risk contributor ~~to risk~~driver for fish consumption of both whole body and fillet tissue diets. A similar pattern is shown in Figure ~~8~~7-6, which illustrates the relative percentage of cancer risk for consumption of fish tissue by an adult tribal fisher, based on Study Area-wide EPCs for a multi-species diet for both whole body and fillet tissue consumption. For both the fisher and tribal fisher, and for both whole body and fillet tissue diets, PCBs contribute over 90% of the overall cancer risk and result in an HQ

that is up to 57 times higher~~approximately 80 times higher~~ than any other HQ from whole body tissue consumption, and up to 153 times higher than any other HQ from fillet tissue consumption by adults.

The contributions of background concentrations ~~of COCs~~ to these risk estimates may exceed the risk levels that generally warrant remedial action under CERCLA. While background concentrations have not been established for fish tissue, ~~A~~as discussed in ~~Section 7~~Section 6.4.2, ~~background~~ regional tissue concentrations may be associated with unacceptable risks from fish consumption, especially at higher ingestion rates. On a regional level, PCBs and dioxins/furans have been detected in fish tissue collected in the Willamette and Columbia Rivers, outside of the Study Area. In a risk assessment for the mid-Willamette (EVS 2000), PCBs were found to result in an HQ greater than 1 for both the ~~high and low ingestion rates (~~142 g/day and 17.5 g/day~~)~~ ingestion rates, and a cancer risk greater than 1 x 10^{-4} for the ~~high~~ 142 g/day ingestion rate. Dioxins and furans were also found to result in a cancer risk greater than 1 x 10^{-4} for the ~~high~~ 142 g/day ingestion rate (non-cancer endpoints were not evaluated for dioxins and furans). In the Columbia River Basin Fish Contaminant Survey (EPA 2002c), PCBs were found to result in cancer risks greater than 1 x 10^{-4} and HQs greater than 1 for the ~~high and low ingestions rate (~~142 g/day and 7.5 g/day~~)~~[11] ingestion rates for the general public consumption of resident fish. Dioxins and furans were also found to result in a cancer risk greater than 1 x 10^{-4} for the ~~high~~ 142 g/day ingestion rate (non-cancer endpoints were not evaluated for dioxins and furans). While the concentrations in the Study Area are higher than the regional tissue concentrations, the sources of PCBs and dioxins and furans in regional tissue data are unknown, and efforts are underway to reduce regional tissue concentrations, the regional tissue data indicate that CERCLA actions alone may not be adequate to achieve a target risk level of 1 x 10^{-6} for some of the assumptions evaluated in this BHHRA.

~~•~~7.2.2 Shellfish Consumption Scenarios

~~Nineteen~~ Seventeen contaminants ~~chemicals~~ were identified as potentially posing unacceptable risk ~~COC~~s ~~were identified~~ for shellfish consumption, based on exceedances of the cumulative cancer risk of 1 x 10^{-6} or HQ of 1, including PCBs, dioxins, arsenic, PAHs, pentachlorophenol, and five pesticides:

- PCBs: Total PCBs resulted in cancer risk estimates exceeding 1 x 10^{-4} and/or HQs exceeding 1 for shellfish consumption. Total PCB TEQ also resulted in cancer risk estimates exceeding 1 x 10^{-4} and/or HQs exceeding 1 for shellfish consumption. PCBs resulted in risk estimates that exceeded a cancer risk of 1 x 10^{-4} and/or HQ of 1 for both localized and Study Area-wide exposures.

[11] The low ingestion rate used in the Columbia River Basin Fish Contaminant ~~Study~~ Survey is lower than the lowest ingestion rate used in this BHHRA~~(~~, which was 17.5 g/day~~)~~.

PCBs are considered a primary contributor to risk~~risk driver~~ for the shellfish consumption pathway because of the magnitude of the risk exceedances, spatial scale of the risk exceedances, the relative contribution to cumulative risk, and the frequency of detection.

- Dioxins/furans: Total dioxin TEQ resulted in cancer risk estimates exceeding 1 x 10^{-4} and/or HQs exceeding 1 for shellfish consumption. Dioxins and furans resulted in risk estimates that exceeded a cancer risk of 1 x 10^{-4} and/or HQ of 1 for both localized and Study Area-wide exposures. Dioxins are considered a primary contributor to risk~~risk driver~~ for the shellfish consumption pathway because of the magnitude of the risk exceedances, spatial scale of the risk exceedances, the relative contribution to cumulative risk, and the frequency of detection.

- Arsenic: Arsenic was identified as a ~~chemical~~contaminant potentially posing unacceptable risk~~COC~~ based on cancer risk estimates that exceeded 1 x 10^{-6} for both clams and crayfish, at both ingestion rates, and on a localized and Study Area-wide scale. No cancer risk estimates exceeded 1 x 10^{-4}. ~~Arsenic is not considered a primary contributor to risk~~risk driver for the site based on the low relative magnitude of the risk exceedances and contribution to cumulative risk.~~ Though arsenic was identified as a ~~chemical~~contaminant potentially posing unacceptable risk~~COC~~ on both a localized and Study Area-wide spatial scale, the concentrations in shellfish tissue may be due in part to naturally occurring background concentrations.

- cPAHs: cPAHs were identified as a ~~chemical~~contaminant potentially posing unacceptable risk~~COC~~ based on cancer risk estimates that exceeded 1 x 10^{-6} for both clams and crayfish, at both ingestion rates, and on a localized and Study Area-wide scale. Cancer risk estimates for total cPAHs across all exposure areas and exposure scenarios ranged from 2 x 10^{-8} to 5 x 10^{-4}, and exceeded 1 x 10^{-4} for the ~~highest (~~18 g/day~~)~~ ingestion rate for clams collected at locations RM 5~~-~~W and RM 6~~-~~W. cPAHs are considered a primary contributor to risk~~risk driver~~ for the shellfish consumption pathway at those locations because of the magnitude of the risk exceedances and relative contribution to cumulative risk.

- Pentachlorophenol: Pentachlorophenol was only detected in one out of 41 shellfish samples, which was a crayfish composite sample collected near RM 8. This one detection of pentachlorophenol resulted in a cancer risk estimate within the range of 1 x 10^{-6} to 1 x 10^{-4}.~~ Pentachlorophenol is not considered a primary contributor to risk~~ risk driver because it was detected in only one the 41 shellfish samples in which it was analyzed and has a low contribution to cumulative risk.~~

- Pesticides: Aldrin, dieldrin, total DDD, total DDE, and total DDT were associated with one or more shellfish consumption exposure scenarios that resulted in a risk estimate that exceeded a cancer risk of 1 x 10^{-6} or HQ of 1. These pesticides were not associated with shellfish consumption scenarios that resulted in a cancer risk estimate above 1 x 10^{-4}.
    - Aldrin was identified as a ~~chemical~~contaminant potentially posing unacceptable risk~~COC~~ based on cancer risk estimates above 1 x 10^{-6} for ingestion of clam tissue, for the ~~highest (~~18 g/day~~)~~ ingestion rate only, and for one location (near RM 8-W) and Study Area-wide.
    - Dieldrin was identified as a ~~chemical~~contaminant potentially posing unacceptable risk~~COC~~ based on cancer risk estimates above 1 x 10^{-6} for ingestion of clam tissue, for the ~~highest (~~18 g/day~~)~~ ingestion rate only, and for one location (near RM 8-W) and Study Area-wide.
    - Total DDD was identified as a ~~chemical~~contaminant potentially posing unacceptable risk~~COC~~ based on cancer risk estimates above 1 x 10^{-6} for ingestion of clam tissue, for the ~~highest (~~18 g/day~~)~~ ingestion rate only, and for one location (near RM 6-W) and Study Area-wide.
    - Total DDE was identified as a ~~chemical~~contaminant potentially posing unacceptable risk~~COC~~ based on cancer risk estimates above 1 x 10^{-6} for ingestion of clam tissue, for the ~~highest (~~18 g/day~~)~~ ingestion rate only, and for three locations (near RM 6-W, RM 7-W, and RM 8-W).
    - Total DDT was identified as a ~~chemical~~contaminant potentially posing unacceptable risk ~~COC was identified as a COC~~ based on cancer risk estimates above 1 x 10^{-6} for ingestion of clam tissue, for the ~~highest (~~18 g/day~~)~~ ingestion rate only, and for only two locations (near RM 6 W and RM 7-W).

  ~~Pesticides are not considered primary contributors to risk~~risk drivers for the ~~shellfish consumption pathway because of the low relative contribution to the cumulative and limited number of detects.~~

Based on the magnitude of risk, the relative contribution to risk, and the frequency of detection, PCBs, dioxins/furans, and cPAHs are considered the primary contributors to risk~~risk drivers~~ for shellfish consumption. PCBs and dioxins/furans contribute approximately 58% of the cumulative cancer risk for clam consumption and approximately 91% for crayfish consumption for the Study Area. Total cPAHs contribute approximately 35% of the cumulative cancer risk for clam consumption (for undepurated samples) and approximately 5% for crayfish consumption for the Study Area. PCBs and dioxins/furans are considered primary contributors to risk ~~risk drivers~~ on a Study Area-wide basis. cPAHs are considered primary contributors to risk~~risk drivers~~ on a localized basis (RM 5-W and RM 6-W). PCBs are the primary ~~primary~~ contributors to risk~~risk driver~~ and dioxins/furans are the secondary contributors to risk~~risk driver~~ for shellfish consumption.

7.2.3 In-Water Sediment Scenarios

The contaminants ~~chemicals~~ potentially posing unacceptable risk~~COCs~~ identified for

in-water sediment are PAHs (primarily benzo[a]pyrene), arsenic, PCBs, and dioxins. PAHs and dioxins were identified as contaminants ~~chemicals~~ potentially posing unacceptable risk~~COCs~~ for all of the in-water sediment scenarios, and arsenic and PCBs were identified as contaminants ~~chemicals~~ potentially posing unacceptable risk~~COCs~~ for tribal fisher and high frequency fisher scenarios only. The contribution of the ~~COCs~~ contaminants ~~chemicals~~ to the cumulative cancer risks varied by river mile. Risks from cPAHs across all exposure areas and exposure scenarios ranged from 1×10^{-10} to 2×10^{-4}. For the entire Study Area, total cPAHs and dioxins/furans through direct contact with sediment each contributed approximately 50% of the cumulative cancer risk. As previously discussed, cumulative cancer risks associated with arsenic may be due in part to naturally occurring background sediment concentrations. Cumulative cancer risks above 1×10^{-6} for PCBs are associated with only four ½-mile river segments, and for dioxins are associated with only two ½-mile river segments. Cumulative cancer risks above 1×10^{-6} for PAHs are associated with ~~22~~ twenty-two ½-mile river segments. Carcinogenic PAHs are considered the primary contributors to risk~~risk driver~~ ~~chemical~~ contaminant for in-water sediment on a Study Area-wide basis due to relative magnitude of the cumulative risk and the number of the risk exceedances. PCBs and dioxins are considered primary contributors to risk~~risk drivers~~ on a localized basis (RM 8.5-W [PCBs] and RM 7-W [dioxins]).

~~8.2.2~~7.2.4 Beach Sediment Scenarios

The contaminants potentially posing unacceptable risk~~COCs~~ identified for beach sediment are PAHs (primarily benzo[a]pyrene) and arsenic. Risks above 1×10^{-6} resulting from exposure to arsenic in beach sediment are likely due in part to naturally occurring background concentrations of arsenic. If the contribution of naturally occurring background concentrations of arsenic is subtracted from the cumulative risk, then the primary contributor to risk~~only risk driver~~ for beach sediment is benzo(a)pyrene. Risks above 1×10^{-6} resulting from exposure to benzo(a)pyrene was limited to a few locations, with the maximum cumulative cancer risk associated with beach location 06B025. Therefore, direct exposure to beach sediment containing benzo(a)pyrene at beach 06B025 is considered a primary contributor to risk~~risk driver~~ for beach sediment.

~~8.2.3~~7.2.5 Surface Water Scenarios

The primary contributor to risk~~risk driver~~ for direct contact with surface water is exposure to PAHs in surface water by divers at RM 6.0 W, because this is the only scenario and location with risk exceedance of 1×10^{-6} or HI greater than 1. However, risk management during remedy selection should consider the limited spatial scale and high degree of uncertainty associated with the diver exposure assumptions.

Risks were also evaluated for hypothetical exposure to untreated surface water used as a domestic water source by future residents. Cumulative cancer risks were ~~between~~ up to 3×10^{-4} ~~and 10^{-6}~~ for ~~both~~ adults, and up to 7×10^{-4} for child residents

primarily due to ~~arsenic, which is likely present in surface water at naturally occurring background concentrations~~benzo(a)pyrene. The only HIs that were greater than 1 were for a child resident under the RME scenario at Multnomah Channel and RM 8.5, due primarily to ingestion of MCPP in surface water.~~None of the evaluated scenarios resulted in cumulative HIs exceeding 1.~~ Because this is a hypothetical scenario, it is not considered a primary contributor to risk~~risk driver~~ for the Study Area.

~~8.2.4~~7.2.6 Summary of ~~Risk Drivers~~Primary Contributors to Risk

As per EPA guidance for the role of risk assessment in remedy selection under CERCLA (EPA 1991a), EPA uses the general risk range of 1×10^{-6} to 1×10^{-4} as a "target range" within which the EPA manages risk during the remedy selection. Furthermore, if the cumulative cancer risk to an individual based on RME assumptions is less than 1×10^{-4} and the non-cancer HQ is less than 1, remedial action generally is not warranted at a site (EPA 1991a). DEQ guidance sets an acceptable risk level of 1×10^{-6} for individual chemicals and 1×10^{-5} for cumulative risks (OAR 340-122-0115). While ~~primary contributors to risk~~~~risk~~chemicals potentially posing unacceptable risks~~ drivers~~ were ~~selected~~ identified ~~for those exposure scenarios and chemicals~~based on exceeding a cancer risk of 1×10^{-6} or HQ of 1, the only exposure scenarios with cancer risks exceeding 1×10^{-4} or HQ greater than 1 are fish consumption and shellfish consumption and direct exposure to in-water sediment for two ½-river mile segments.

The primary exposure scenario ~~driving~~ contributing to risk for the Study Area is fish consumption, and the ~~COCs~~ contaminants ~~chemicals driv~~contributing to that risk are PCBs and dioxins/furans. PCBs and dioxins/furans both resulted in cancer risks greater than 1×10^{-4} and HQs greater than 1 for fish consumption for both localized and Study Area-wide exposures. PCBs and dioxins/furans contribute approximately 98% of the cumulative cancer risk for fish consumption. Regionally, fish consumption also results in risk estimates exceeding cumulative risks of 1×10^{-4} or HQ of 1 based on data collected from the Willamette and Columbia Rivers outside of the Study Area (EVS 2000, EPA 2002c). In those studies, both PCBs and dioxins/furans resulted in cancer risks greater than 1×10^{-4} and/or HQs greater than 1 for fish consumption. The concentrations of PCBs in regional tissue are lower than in the Study Area, and the sources of PCBs in regional tissue are unknown. The secondary exposure scenario ~~driving~~ contributing to risk is consumption of shellfish; however, ~~as previously discussed,~~ it is not known ~~whether~~ to what extent shellfish consumption actually occurs on an ongoing basis within the Study Area.

The identification of the primary contributors to human health risks~~selection of risk drivers~~ can help provide focus to the FS by identifying a smaller number of chemicals and exposure scenarios that have the largest contribution to overall risk.

To provide context for the significance of the remedial actions to the protection of human health, the uncertainties associated with the exposure assumptions ~~for risk drivers~~ and potential contribution of background sources of contaminants ~~chemicals~~ to the Study Area should be considered when evaluating ~~risk drivers~~ primary contributors to human health risks during the FS.

~~9.0~~8.0 CONCLUSIONS

A summary of chemicals contributing to risk by exposure scenario is provided in Table 7-1, and risk ranges by exposure scenario are presented in Table 5-203. The following presents the major findings of this BHHRA:

- Fish consumption is the exposure scenario that is considered the ~~main~~ primary contributor to risk~~risk driver~~ for this site. Risks resulting from the consumption of fish are generally orders of magnitude higher than risks resulting from direct contact with sediment, surface water, or groundwater seeps. Risks from fish consumption are within or above the cumulative cancer risk range of 1×10^{-6} to 1×10^{-4} and exceed an HI of 1 for most exposure scenarios evaluated, including both RME and CT assumptions. Risk estimates for shellfish consumption scenarios were also within or above the cumulative cancer risk range of 1×10^{-6} to 1×10^{-4} and exceeded an HI of 1 for most exposure scenarios evaluated, including both RME and CT assumptions. The evaluation of shellfish consumption was completed at the direction of EPA. With the exception of two ½-mile river segments for the tribal fisher scenario and one location for the hypothetical use of untreated surface water as a drinking water source by a future resident, ~~direct contact with sediment, surface water, and seeps results~~ all of the direct contact scenarios result in risks within or below the EPA target cancer risk range of 1×10^{-6} to 1×10^{-4}. The direct contact scenarios also result in non-cancer hazards below the target HI of 1, with the exception of one ½-river mile segment for in-water sediment and one location for hypothetical use of untreated surface water as a drinking water source.~~Risk estimates for shellfish consumption scenarios were also within or above the cumulative cancer risk range of 10^{-6} to 10^{-4} and exceeded a HI of 1 for most exposure scenarios evaluated, including both RME and CT assumptions. However, there is no information documenting whether shellfish consumption actually occurs on an ongoing basis within the Study Area. The evaluation of shellfish consumption was completed at the direction of EPA.~~

- For fish consumption, which is the pathway with the highest risk estimates, PCBs are the primary contributor to risk~~risk driver for fish consumption~~, and dioxins/furans are the secondary ~~risk driver~~contributor to risk ~~for fish consumption~~.

- The uncertainties associated with the tissue consumption scenarios should be considered during the FS. The fish tissue consumption risks in this BHHRA incorporate assumptions that may under-~~,~~ or more likely over-estimate the actual risks.

  ~~While it is not probable that the maximum values of the uncertainties apply for every tissue consumption exposure scenario and chemical, this magnitude~~

~~of uncertainty needs to be considered relative to the maximum cancer risks and noncancer hazards presented in this BHHRA and indicates that risks may actually be less than 10^{-4} (excess cancer risk) or HI of 1 for certain scenarios.~~

~~On a regional basis, risks from exposure to bioaccumulatives in tissue exceed EPA target risk levels. For example, the PCB concentrations detected in resident fish from the Willamette and Columbia Rivers are approximately 20 to 100 times higher than the EPA target fish tissue concentration, which is based on a target risk level of 10^{-6}, when adjusted for the ingestion rates used in this BHHRA.~~

- The contribution of background sources ~~of COCs~~ is an important consideration in risk management decisions. For example, arsenic concentrations in beach sediment contribute approximately 50% of cumulative risk from exposure from this medium for the highest-risk scenarios, yet arsenic concentrations detected in beach sediment within the Study Area are comparable to Oregon DEQ-established background levels.

The results of the BHHRA will be used to produce risk-based PRGs and AOPCs for the FS, as well as to develop risk management recommendations for the Site. In addition, the BHHRA may be consulted by risk managers as they deliberate practical risk management objectives during the course of the FS.

~~10.0~~9.0 REFERENCES

Adolfson Associates, Inc. (Adolfson). 1996. Technical Memorandum on the Results of the 1995 Fish Consumption and Recreational Use Surveys, Amendment Number 1. April 19, 1996.

ATSDR. 1996. Toxicological Profile for Endrin. Accessed online October 2008 at http://www.atsdr.cdc.gov/toxprofiles/tp89.html.

ATSDR. 2002. Public Health Assessment, Initial Release: Portland Harbor, Portland, Multnomah County, Oregon. January 15, 2002.

ATSDR. 2006. Final Release: Public Health Assessment, Portland Harbor, Portland, Multnomah County, Oregon, EPA Facility ID: OR0001297969. March 22, 2006.

ATSDR. 2008. Toxicological Profile for Chromium. Accessed online November 2008 at http://www.atsdr.cdc.gov/toxprofiles/tp7.html.

Burch, Dee (President of Advanced American). 2008. Personal communication, telephone call, with Don Larson, Business Development Coordinator, Kennedy/Jenks Consultants, Portland, OR. July 14, 2008.

Cal EPA. 2008. Toxicity Criteria Database, September 2008. Office of Environmental Health Hazard Assessment. Accessed October 2008 at http://www.oehha.org/risk/pdf/TCDBalpha100108.pdf.

Centers for Disease Control (CDC). 1991. Preventing lead poisoning in young children: a statement by the Centers for Disease Control. Atlanta, Georgia: US Department of Health and Human Services, Public Health Service.

City of Portland. 2006a. Comprehensive Plan Goals and Policies. City of Portland Bureau of Planning, Portland, OR. July 2006.

City of Portland. 2006b. River Concept. City of Portland Bureau of Planning, Portland, OR. April 26, 2006.

City of Portland. 2008. Water Management and Conservation Plan, Final Draft Report. Portland Water Bureau. Portland, OR, March 2008.

Columbia River Inter-Tribal Fish Commission (CRITFC). 1994. A Fish Consumption Survey of the Umatilla, Nez Perce, Yakama, and Warm Springs Tribes of the Columbia River Basin, Technical Report 94-3. Columbia River Inter-Tribal Fish Commission, Portland, OR. October 1994.

DEQ. 2000a. Guidance for Conduct of Deterministic Human Health Risk Assessments. Oregon Department of Environmental Quality. May 2000.

DEQ. 2000b. Portland Harbor RI/FS Work Plan, DRAFT. Oregon Department of Environmental Quality. 31 March 2000.

DEQ. 2003. Risk-Based Decision Making for the Remediation of Petroleum-Contaminated Sites. Land Quality Division, Environmental Tanks and Cleanup Program. Portland, OR. September 22, 2003.

DEQ. 2007. Guidance for Assessing Bioaccumulative Chemicals of Concern in Sediment. DEQ Environmental Cleanup Program. Portland, OR. April 2007.

DEQ. 2010. Human Health Risk Assessment Guidance. DEQ Environmental Cleanup Program. Portland, OR. October 2010.

EPA. 1989. Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual (Part A), Interim Final. Office of Solid Waste and Emergency Response, EPA/540/1-89/002. December 1989.

EPA. 1991a. Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions. Office of Solid Waste and Emergency Response. OSWER Directive 9355.0-30. April 1991.

EPA. 1991b. Risk Assessment Guidance for Superfund, Volume I. Human Health Evaluation Manual, Supplemental Guidance, Standard Default Exposure Factors, Interim Final. Office of Emergency and Remedial Response: OSWER Directive: 9285.6-03.

EPA. 1993. Provisional Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons. Office of Health and Environmental Assessment, EPA/600/R-93/089. July 1993.

EPA. 1994. Memorandum: OSWER Directive: Revised Interim Soil Lead Guidance For CERCLA Sites and R~~E~~CRA Corrective Action Facilities. Office of Solid Waste and Emergency Response. Washington, D.C.

EPA. 1997a. *Exposure Factors Handbook*. Office of Research and Development, Volume I-General Factors, EPA/600/P-95/002Fa, Office of Research and Development, Washington, DC 20460.

EPA. 1997b. Should I Eat the Fish I Catch? A guide to healthy eating of the fish you catch. EPA 823-B-97-009. Office of Science and Technology. September 1997.

EPA. 1998. Memorandum: OSWER Directive: Clarification to the 1994 Revised Interim Soil Lead (Pb) Guidance for CERCLA Sites and RCRA Corrective Action Facilities (August 1998). Office of Solid Waste and Emergency Response. EPA/540/F-98/030.

EPA. 1999. A Guide to Preparing Superfund Proposed Plans, Records of Decision, and Other Remedy Selection Decision Documents. EPA Office of Solid Waste and Emergency Response. EPA 540-R-98-031. July 1999.

EPA. 2000a. EPA Region 10 Supplemental Human Health Risk Assessment Guidance, Office of Environmental Assessment, Soil Ingestion Rates. January 25, 2000.

EPA. 2000b. Estimated Per Capita Fish Consumption in the United States. EPA-821-R-00-025.

EPA. 2000c. Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, Volume 1, Fish Sampling and Analysis, Third Edition. Office of Water. EPA 823-B-00-007. November 2000.

EPA. 2000d. Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health. EPA-822-B-00-004. October 2000.

EPA. 2000e. Data Quality Objectives Process for Hazardous Waste Site Investigations. EPA QA/G-4HW. Final. EPA Office of Environmental Information. EPA/600/R-00/007. January 2000.

EPA. 2001a. Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual (Part D, Standardized Planning, Reporting, and Review of Superfund Risk Assessments), Final. Office of Emergency and Remedial Response, Publication 9285.7-47. December 2001.

EPA. 2001b. Trichloroethylene Health Risk Assessment: Synthesis and Characterization, August 2001, EPA/600/P-01/0002A – External Review Draft.

EPA. 2001c. Risk Assessment Guidance for Superfund, Volume 3, Part A: Process for Conducting Probabilistic Risk Assessment. Office of Emergency and Remedial Response. EPA 540-R-02-002. December 2001.

EPA. 2001d. Dioxin Reassessment-An SAB Review of the Office of Research and Development's Reassessment of Dioxin. Review of the Revised Sections (Dose Response Modeling, Integrated Summary, Risk Characterization, and Toxicity Equivalency Factors) of the EPA's Reassessment of Dioxin by the Dioxin Reassessment Review Subcommittee of the EPA Science Advisory Board (SAB). EPA-SAB-EC-01-006. Science Advisory Board, Washington, DC. May 2001.

EPA. 2002a. Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. Office of Emergency and Remedial Response. OSWER 9285.6-10. December 2002.

EPA. 2002b. Estimated Per Capita Fish Consumption in the United States. EPA 821-C-02-003. August 2002.

EPA. 2002c. Columbia River Basin Fish Contaminant Survey, 1996-1998. EPA 910-R-02-006. August 12, 2002.

EPA. 2002d. Feasibility for Derivation of Provisional Toxicity Values for delta-Hexachlorocyclohexane (CASRN 319-86-8). SRC SF 01-019a-c/10-17-02.

EPA. 2002e. Blood Lead Concentrations of U.S. Adult Females: Summary Statistics from Phases 1 and 2 of the National Health and Nutrition Evaluation Survey (NHANES III). EPA OSWER #9285.7-52 March 2002.

EPA. 2003a. National Primary Drinking Water Standards. Office of Water (4606M). Maximum Contaminant Levels. EPA 816-F-03-016. June 2003.

EPA. 2003b. OSWER Directive 9285.7-53. Human Health Toxicity Values in Superfund Risk Assessments. December 5, 2003.

EPA. 2003c. Recommendations of the Technical Review Workgroup for Lead for an Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil. EPA-540-R-03-001. January 2003.

EPA. 2004. Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment), Final. Office of Emergency and Remedial Response. EPA/540/R/99/005. July 2004.

EPA. 2005a. Guidelines for Carcinogen Risk Assessment. Risk Assessment Forum. Washington, D.C. EPA/630/P-03/001F. March 2005.

EPA. 2005b. Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens. Risk Assessment Forum. Washington, D.C. EPA/630/R-03/003F. March 2005.

EPA, Region 10. 2007a. Internal Memorandum from Michael Cox regarding Recommendations for Human Health Risk-based Chemical Screening and Related Issues at EPA Region 10 CERCLA and RCRA Sites. April 17, 2007.

EPA. 2007b. ProUCL Version 4.00.02 User Guide. EPA/600/R-07/038. April 2007.

EPA 2007c. Guidance for Evaluating the Oral Bioavailability of Metals in Soil for Use in Human Health Risk Assessment. OSWER 9285.7-80. May 2007.

EPA. 2007d. User's Guide for the Integrated Exposure Uptake Biokinetic Model for Lead in Children (IEUBK), Windows version 1.1. EPA 9285.7-42. May 2007.

EPA. 2008a. Region 6 Human Health Medium-Specific Screening Levels. http://www.epa.gov/region6/6pd/rcra_c/pd-n/screen.htm. Screening Levels last updated on March 8, 2008.

EPA 2008b. Region 10 Memorandum regarding Portland Harbor Superfund Site; Administrative Order on Consent for Remedial Investigation and Feasibility Study; Docket No. CERCLA-10-2001-0240. Comprehensive Round 2 Site Characterization and Data Gaps Analysis Report. Dated January 15, 2008.

EPA. 2008c. Region 10 Memorandum regarding Proposed Commercial Diver Exposure Scenario for the Portland Harbor Risk Assessment. September 15, 2008.

~~EPA 2009a. Regional Screening Levels for Chemical Contaminants at Superfund Sites. Dated April 19, 2009. http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm. Screening Levels last updated on April 19, 2009.~~

EPA 2009a. Toxicological Review of Thallium and Compounds (CAS No. 7440-28-0) In Support of Summary Information on the Integrated Risk Information System (IRIS). EPA/635/R-08/001F.

~~EPA. 2009b. Integrated Risk Information System (IRIS). Accessed November 2008 at http://www.epa.gov/iris/.~~

~~EPA. 2009c. National Recommended Water Quality Criteria. EPA Office of Water. Office of Science and Technology. U.S. Environmental Protection Agency.~~

EPA 2010a. Regional Screening Levels for Chemical Contaminants at Superfund Sites. Dated May 2010. http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm. Screening Levels last updated on April 19, 2009.

EPA. 2010b. Integrated Risk Information System (IRIS). Accessed November 2010 at http://www.epa.gov/iris/.

EVS Environment Consultants, Inc. (EVS). 2000. Human health risk assessment of chemical contaminants in four fish species from the Middle Willamette River, November 21, 2000. Salem, OR: Oregon Department of Environmental Quality. (Willamette River Basin Studies: Human Health Technical Study; EVS Project No. 2/839-01).

Friberg, L., Nordberg, G.F., Kessler, E. and Vouk, V.B. (eds). Handbook of the Toxicology of Metals. 2nd ed. Vols I, II.: Amsterdam: Elsevier Science Publishers B.V., 1986.

Grooms, M. 2008. Personal communication (email of February 12, 2008 to T. Pinit, Kennedy/Jenks Consultants, Portland, OR, regarding crayfish catch reports). Oregon Department of Fish and Wildlife, Portland, OR.

Groundwater Solutions, Inc. (GSI) 2003. Technical Memorandum: Results of Seep Reconnaissance Survey River Mile 2 – 10.5, Lower Willamette River. USEPA Docket No: CERCLA-10-2001-0240.

Hartman, Bud (President of Pan Fish Association, Portland, OR). 2002. Personal communications, telephone call with Bill Williams, Senior Scientist, Kennedy/Jenks Consultants, Portland, OR. March 19, 2002.

Hope, B. 2008. A Model for the Presence of Polychlorinated Biphenyls (PCBs) in the Willamette River Basin (Oregon). Environ. Sci. Technol. 2008, 42, 5998-6006.

Hutton, Jesse (President of Northwest Underwater Construction, LLC). 2008. Personal communication, telephone call with Taku Fuji, Senior Scientist, and Levi Fernandes, Engineer, Kennedy/Jenks Consultants, Portland, OR. July 11, 2008.

Integral Consulting, Inc. 2004. Round 2 Quality Assurance Project Plan Addendum 1: Surface Water. Prepared for The Lower Willamette Group. Portland, OR.

Integral Consulting, Inc., Kennedy/Jenks Consultants. 2004. Round 2 Quality Assurance Project Plan Addendum 3: Groundwater Pathway Assessment Pilot Study. Prepared for The Lower Willamette Group. Portland, OR.

Integral Consulting, Inc., Windward Environmental, LLC. 2004. Round 2 Quality Assurance Project Plan. Prepared for The Lower Willamette Group. Portland, OR.

Integral Consulting, Inc., Windward Environmental, LLC, Kennedy/Jenks Consultants, Anchor Environmental, LLC, Groundwater Solutions, Inc. 2004. Portland Harbor RI/FS Programmatic Work Plan. Prepared for The Lower Willamette Group. Portland, OR.

~~Integral Consulting, Inc. 2006. Portland Harbor RI/FS Round 2 Groundwater Pathway Assessment Transition Zone Water Site Characterization Summary Report. Prepared for The Lower Willamette Group. Integral Consulting, Inc.~~

Integral Consulting, Inc. 2007. Round 2 Quality Assurance Project Plan Addendum 9: Fish and Invertebrate Tissue and Collocated Sediment Sampling for Round 3B. Prepared for The Lower Willamette Group. Integral Consulting, Inc., Portland, OR.

Integral Consulting, Inc., Windward Environmental, LLC, Kennedy/Jenks Consultants, Anchor Environmental, LLC. 2007. Portland Harbor RI/FS Comprehensive Round 2 Site Characterization Summary and Data Gaps Analysis Report. Prepared for The Lower Willamette Group. Portland, OR. February 22, 2007.

Integral Consulting, Inc., 2008. Round 3B Fish and Invertebrate Tissue And Collocated Sediment Data Report Addendum 1: Lead and Antimony Results For Smallmouth Bass Sample LW3-SB010E-C00B. Prepared for the Lower Willamette Group. Portland, OR. September 26, 2008.

Johns, Mike (Vice President of Operations for Advanced American Construction). 2008. Personal communication, telephone call, with Don Larson, Business Development Coordinator, Kennedy/Jenks Consultants, Portland, OR. July 16, 2008.

Kennedy/Jenks Consultants, Integral Consulting, Inc., Windward Environmental, LLC. 2004. Portland Harbor RI/FS Technical Memorandum Guidelines for Data Reporting, Data Averaging, and Treatment of Non-detected Values for the Round I Database. Prepared for The Lower Willamette Group. Kennedy/Jenks Consultants, Portland, OR; Integral Consulting, Inc., Mercer Island, WA; Windward Environmental, LLC, Seattle, WA.

Kennedy/Jenks Consultants. 2004a. Human Health Toxicity Values. Interim Deliverable. Prepared for The Lower Willamette Group. Kennedy/Jenks Consultants, Portland, OR.

Kennedy/Jenks Consultants. 2004b. Round I Tissue Exposure Point Concentrations. Interim Deliverable. Prepared for The Lower Willamette Group. Kennedy/Jenks Consultants, Portland, OR.

Kennedy/Jenks Consultants. 2004c. Salmon, Lamprey, and Sturgeon Tissue Exposure Point Concentrations for Oregon Department of Human Services. Prepared for The Lower Willamette Group. Kennedy/Jenks Consultants, Portland, OR.

Kennedy/Jenks Consultants. 2006. Portland Harbor RI/FS Technical Memorandum Human Health Risk Assessment: Exposure Point Concentration Calculation Approach and Summary of Exposure Factors. Prepared for The Lower Willamette Group. Kennedy/Jenks Consultants, Portland, OR.

National Academy of Sciences (NAS). 2003. Bioavailability of Contaminants in Soils and Sediments: Processes, Tools, and Applications. National Academies Press. Washington D.C.

National Academy of Sciences (NAS). 2006. Health Risks from Dioxin and Related Compounds, Evaluation of the EPA Reassessment. National Academies Press. Washington D.C.

National Library of Medicine (NLM). 2004. Hazardous Substances Data Bank (HSDB).

Oregon Department of Human Services (ODHS). 2007. Environmental Toxicology Program. Fish Advisories: Consumption Guidelines. Accessed January, 2007. http://oregon.gov/DHS/ph/envtox/fishconsumption.shtml#table

Oregon Fish and Wildlife Department (ODFW). 2005. Biology, Behavior, and Resources of Resident and Anadromous Fish in the Lower Willamette River. Final Report of Research, 2000-2004 . Thomas A. Friesen, editor. March 2005.

Pu X; Carlson G; Lee L. 2003. Oral bioavailability of pentachlorophenol from soils of varying characteristics using a rat model. Journal of Toxicology and Environmental Health, Part A. 2003, Nov 14; 1966(21):2001-13.

Ruby, MV; R Schoof; W Brattin; M Goldade; G Post; M Harnois; DE Mosby; SW Casteel; W Berti; M Carpenter; D Edwards; D Cragin; W Chappell. 1999. Advances in evaluating the oral bioavailability of inorganics in soil for use in human health risk assessment. Environmental Science and Technology; 33 (21). 1999. 3697-3705.

Saghir SA; Bartels MJ; Budinsky RA; Harris EE; Clark AJ; Staley JL; Chai Y; Davis JW. 2007. Effect of organic carbon content, clay type, and aging on the oral bioavailability of hexachlorobenzene in rats. Environmental Toxicology and Chemistry. 2007, Nov; 26(11):2420-9.

Siipola, M. Personal communication (telephone conversation on November 9, 2004 with Laura Kennedy, Kennedy/Jenks Consultants). U.S. Army Corps of Engineers, Portland, OR.

Steele, Ralph (Owner of Lure-em Tackle Shop, Portland, OR). 2002. Personal communication, telephone call with Bill Williams, Senior Scientist, Kennedy/Jenks Consultants, Portland, OR. April 8, 2002.

Striplin Environmental Associates, Inc. 2002. Round 1 Quality Assurance Project Plan Final Report. Prepared for The Lower Willamette Group. Striplin Environmental Associates, Inc., Olympia, WA.

Tetra Tech. 1995. Willamette River Basin Water Quality Study. Summary and Synthesis of Study Findings. Final Report 97-094. Prepared for Oregon Department of Environmental Quality, Portland, OR. Tetra Tech, Inc., Redmond, WA. 119 pp.

United States Department of Agriculture (USDA). 1998. Continuing Survey of Food by Individuals, CSFII 1994-1996. Agricultural Research Service.

Van den Berg, M., et al. 2006. The 2005 World Health Organization Re-evaluation of Human and Mammalian Toxic Equivalency Factors for Dioxins and Dioxin-like Compounds. Toxicol Sci. 2006 Jul 7, 16829543. World Health Organization Collaborating Centre for Research on Environmental Health Risk Assessment and Institute for Risk Assessment Sciences, Faculties of Veterinary Medicine, Science and University Medical Center, Universiteit Utrecht, PO Box 80177, 3508 TD Utrecht, The Netherlands.

Wagner, P. 2004. Personal Communication: letter dated June 6, 2004 to Amanda Guay, Oregon Department of Human Services. Linnton Community Center.

Wallner-Kersanach, S. E. Lobo, E. M. da Silva. 1994. Depuration Effects on Trace Metals in *Anomalocardia brasiliana* (Gmelin, 1791). Bull. Environ. Contam. Toxicol. (1994) 52:840-847.

Washington Department of Ecology (Ecology). 2007. Washington State Toxics Monitoring Program: Contaminants in Fish Tissue from Freshwater Environments in 2004 and 2005. Publication No. 07-03-024. June 2007.

Washington Department of Health (WDOH). 2005. Analysis of Chemical Contaminant Levels in Store-Bought Fish from Washington State. *Proceedings of the 2005 National Forum on Contaminants in Fish*. Baltimore, MD. Powerpoint presentation accessed online at http://www.epa.gov/fishadvisories/forum/2005/index.htm.

Wilson et al. 1998. The effect of cooking practices on the concentration of DDT and PCB compounds in the edible tissue of fish. J. Expo. Anal. Environ. Epidemiol. Jul-Sep;8(3):423-40.

Windward. 2005. Lower Duwamish Waterway Remedial Investigation, Fish and Crab Data Report Addendum: PCB Congener Data, MS/MSD Analyses, and DDT Confirmation Final. Prepared for Lower Duwamish Waterway Group, Windward Environmental LLC, Seattle, WA. October 2005.

Windward. 2009. Portland Harbor RI/FS bioaccumulation modeling report. Draft. WW09-0003. Prepared for Lower Willamette Group. May 29, 2009. Windward Environmental LLC, Seattle, WA.

TAB 16

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10
1200 Sixth Avenue, Suite 900
Seattle, WA 98101-3140

OFFICE OF
ENVIRONMENTAL
CLEANUP

June 22, 2012

Mr. Bob Wyatt
Chairman, Lower Willamette Group
c/o Northwest Natural
220 Northwest Second Avenue
Portland, Oregon 97209

Re: Portland Harbor Superfund Site, Administrative Order on Consent for Remedial Investigation and Feasibility Study; Docket No. CERCLA-10-2001-0240
Directed Modifications and Additional Comments on Baseline Human Health Risk Assessment dated May 2, 2011

Dear Mr. Wyatt;

EPA and its partners have reviewed the revised draft Baseline Human Health Risk Assessment (BHHRA) submitted to EPA on May 2, 2011. In certain respects, the technical computations in the revised BHHRA are correct and the second draft document is an improvement from the previous submittal. The second draft too showed an attempt to address most of EPA's comments and concerns on previous versions. However, the second draft did not fully reflect EPA's directions for changes and there were still significant deficiencies with key elements of the BHHRA.

In accordance with Paragraph 1, Section IX. of the Administrative Order on Consent, EPA determined it was necessary to modify the BHHRA extensively. Attached to this letter are EPA's modifications to the text and required changes to the tables and figures of the BHHRA. The LWG is directed to incorporate EPA's modified text. In addition, EPA has included directed comments in the attachment titled "Modifications to tables and figures" that the LWG must also fully incorporate into the BHHRA before EPA can approve the BHHRA.

Some but not all of the deficiencies with the May draft are listed below:

1. The discussion of the process used to evaluate risks to humans and the conclusions were not clearly presented and, in fact, there were several instances of incorrect or misleading information. For example, the BHHRA repeatedly stated that the exposure assessment assumed someone ate fish every day of the year for 30 years. The LWG is fully aware that such a statement is not accurate. Consumption rates are average lifetime intake doses mathematically averaged to give an average daily rate. EPA commented on this issue in our February 9, 2010 comment letter; however, the LWG failed to address it.

2. There were several instances where the BHHRA does not fully reflect EPA's directions for change, directions given years before and reiterated in our comments to previous versions. For example, EPA's February 2010 comment on Section 3.4, page 31 was:

> In this section and subsequently throughout the risk assessment, replace the term "95% UCL/max EPC" with "RME EPC." The repeated references to a "mean" EPC relative to one based on a 95 percent UCL or maximum concentration is misleading. The text in the second paragraph incorrectly states that exposure point concentrations would be calculated differently for central tendency (CTE) and reasonable maximum (RME) exposures. Consistent with EPA guidance (1992, 2000), the EPC should represent an estimate of the arithmetic average concentration for a contaminant based on a set of site sampling data. Because of the uncertainty associated with estimating the true average concentration at a site, the 95 percent UCL of the arithmetic mean should be used for this variable. The 95 percent UCL provides reasonable confidence that the true site average will not be underestimated. The average concentration, defined as the 95 percent UCL, should be used for both CTE and RME evaluations. The RME evaluation should be distinguished from CTE by accounting for variability in such variables as exposure frequency and intake rates.

However, the LWG did not make the change, claiming that the EPCs were described in a factual manner. Use of the term 95% UCL/Max Scenario is incorrect and needs to be changed throughout the document. RME and CT are not defined based solely on calculation of EPC. Actually, EPC should be the same for both the RME and CT. Since the LWG used different EPCs for the RME and CT calculations, EPA is requiring the removal of the CT evaluations for the consumption scenarios in the BHHRA. Further, reference to RME and CT in the BHHRA were not consistent with those agreed to in the Programmatic Work Plan. EPA has modified the BHHRA to reflect those agreements and adequately describe the RME and CT.

3. There were many instances in the BHHRA where the only explanation the LWG provides for why something is done was that EPA directed or otherwise required it be done. While it may be true EPA directed changes, the LWG is fully aware of the technical basis for the direction and should have included such technical basis in the report. The LWG's failure to fully explain the basis for how the risk assessment was done is not consistent with EPA guidance nor is the report complete and transparent without it. Therefore, EPA had to modify the report to provide the rational for the directions in the text of the BHHRA for clarity and relevance for the assessment.

4. Overall, the BHHRA did not present the process and information in a clear and transparent manner that would allow anyone outside those intimately involved in the development of this assessment to follow and understand. Thus, EPA had to extensively modify the report to make the report understandable to the general public.

In accordance with Paragraph 1, Section XIX. of the AOC, written notice is being given that EPA has determined that the LWG failed to produce a BHHRA of acceptable quality, or otherwise failed to perform in accordance with the requirements of the Order by failing to fully correct all deficiencies and incorporate and integrate all information and comments supplied by EPA on prior versions of the BHHRA.

EPA project managers are willing to coordinate and discuss questions the LWG has with the required changes to the BHHRA, as appropriate. The LWG must provide a draft final BHHRA incorporating all of EPA's modfications (correcting formatting and other typographical errors) and directed comments no later than 30 days from receipt of this letter.

If you have any questions regarding this letter, please contact Chip Humphrey at (503) 326-2678, or humphrey.chip@epa.gov, Kristine Koch at (206) 553-6705, or koch.kristine@epa.gov. All legal inquiries should be directed to Lori Cora at (206) 553-1115, or cora.lori@epa.gov.

Sincerely,

for Chip Humphrey
Remedial Project Manager

Kristine Koch
Remedial Project Manager

encl. (sent via email)

cc: Mr. Jim Anderson
Oregon Department of Environmental Quality

Mr. Rob Neely
National Oceanic and Atmospheric Administration

Mr. Ted Buerger
U.S. Fish and Wildlife Service

Mr. Brian Cunninghame
Confederated Tribes of the Warm Springs Reservation of Oregon

Ms. Rose Longoria
Confederated Tribes and Bands of the Yakama Nation

Mr. Michael Karnosh
Confederated Tribes of the Grand Ronde Community of Oregon

Mr. Tom Downey
Confederated Tribes of the Siletz Indians

Mr. Audie Huber
Confederated Tribes of the Umatilla Indian Reservation

Ms. Erin Madden
Nez Perce Tribe

Mr. Greg Ulirsch
ATSDR

Mr. Kurt Burkholder
Oregon Department of Justice

Mr. Todd Hudson
Oregon Health Authority

Mr. Rick Keppler
Oregon Department of Fish and Wildlife

Enclosure
EPA comments on Draft BHHRA
Required Modifications to Text, Tables and Figures
June 22, 2012

Globally remove all references to Draft in the BHHRA (e.g., headers) and to document being under review by EPA and partners (e.g., footers and cover pages).

Delete the text from Attachment F2, as it was incorporated into Section 2 of the main text. Attachment F2 is now just the tables.

Combine Tables 2-1 and 2-2 into a single Table 2-1 titled "BHHRA Data Summarized by Matrix," and Tables 2-3 and 2-4 into a single Table 2-2 titled "Summary of BHHRA Sediment Data."

Revise the names of Section 3 tables, from "Mean and 95% UCL and Maximum Exposures" to "Central Tendency and Reasonable Maximum Exposures." Alternately, simply naming the tables "Exposure Point Concentration Summary" is acceptable.

Delete all tables in Section 5 for fish consumption based on "Mean concentration" as shown in the revised List of Tables. The remaining fish consumption tables are renamed as follows:

> Change "17.5 g/day consumption rate" to "Recreational Fishers, Central Tendency Exposure"
> Change "73 g/day consumption rate" to "Recreational Fishers, Reasonable Maximum Exposure"
> Change "142 g/day consumption rate" to "Subsistence Fishers, Reasonable Maximum Exposure"

The revised convention of referring to the consumption rates of 17.5 g/day and 73 g/day as CT and RME for recreational fishers, and 142 g/day as RME for subsistence fishers should be also be applied to the figures and maps. All references to fish consumption scenarios using an exposure concentration based on the simple mean should be deleted. This convention should also be applied to the tables in Attachment F3. Note that some of the river mile designations in the tables in Attachment F3 are incorrectly formatted as subscripts.

Replace tables 5-199 through 5-203 with the cumulative risk tables provided in the enclosed Cumulative Risk Estimates Excel file. These tables need to be numbered and incorporated into the main text, as identified.

Add PDBEs to the former Table 5-204 as a chemical potentially posing unacceptable risk.

Global changes: Delete chemicals that are not used in the sums. Noncancer hazard should be presented in decimal format rather than scientific notation. In all footnotes, delete "RME = 95% UCL/Maximum Exposure." Change "Oral contact" to "Ingestion."

When describing the numerical values of tissue consumption rates, change “ingestion rate” to “consumption rate” in tables, figures, and maps.

In tables presenting EPCs and risk/hazard estimates associated with fish consumption, the term “F” needs to be defined as “fillet” in the footnotes.

Table 6-2: Please use a consistent number format.

Maps:

Dredging and capping areas are not relevant to the BHHRA, and should be deleted from all figures. The legends in maps presenting cancer risk and/or noncancer hazard should identify risk and hazard as greater than 1E-6 or 1, not “exceedances.” Change “scenarios” to “evaluations.” The Hazard Index should be presented in decimal format to clearly distinguish it from cancer risks. Note that the hazard values presented represent a hazard index, not a hazard quotient.

Delete the phrase “95% UCL/maximum exposure point concentrations” from the legend in all of the maps presenting fish/shellfish consumption risks and hazards.

Map 2-7: The sampling locations should be identified.

Map 2-8: Delete “untreated” from the title.

Delete Maps 5-2-1 and 5-2-2. We are unaware of any possible mechanism by which receptors can be exposed only to that portion of arsenic concentrations greater than background. Thus, the values presented on this figure are not associated with any plausible exposure scenario.

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PORTLAND HARBOR RI/FS

~~DRAFT~~ FINAL REMEDIAL INVESTIGATION REPORT

APPENDIX F

BASELINE HUMAN HEALTH RISK ASSESSMENT

~~DRAFT~~ FINAL

This draft document has been provided to EPA at EPA's request to facilitate EPA's comment process on the document in order for LWG to finalize the BHHRA~~.~~. The comments or changes (including redlines) on this document may not reflect LWG positions or the final resolution of the EPA comments.

~~May 2~~, ~~2011~~2012

TABLE OF CONTENTS

LIST OF ATTACHMENTS

LIST OF TABLES

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LIST OF FIGURES

LIST OF MAPS

LIST OF ACRONYMS

ACG	analytical concentration goal
ADAF	age-dependent adjustment factor
ALM	Adult Lead Methodology
AOPC	Area of Potential Concern
ATSDR	Agency for Toxic Substances and Disease Registry
AWQC	Ambient Water Quality Criteria
BEHP	Bis 2-ethylhexyl phthalate
BERA	baseline ecological risk assessment
BHHRA	baseline human health risk assessment
Cal EPA	California Environmental Protection Agency
CDC	Centers for Disease Control
CDI	chronic daily intake
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cm	centimeter
cm/hr	centimeters per hour
CNS	central nervous system
COI	contaminant[1] of interest
COPC	contaminant1~~1111111111111111111111111111111111111111111111111111~~ of potential concern
CRITFC	Columbia River Inter-tribal Fish Commission
CSM	conceptual site model
CT	central tendency
DA_{event}	absorbed dose per event
DDD	dichlorodiphenyldichloroethane
DDE	dichlorodiphenyldichloroethylene
DDT	dichlorodiphenyltrichloroethane
delta-HCH	delta-hexachlorocyclohexane
DEQ	Oregon Department of Environmental Quality
DL	detection limit
DQO	data quality objective
E	east
EPA	United States Environmental Protection Agency
EPC	exposure point concentration
EPD	effective predictive domain
FS	feasibility study
g/day	grams per day
GI	gastrointestinal
GSI	Groundwater Solutions, Inc.

[1] Prior deliverables and some of the tables and figures attached to this document may use the te~~rm~~ RM "Chemical of Interest" or "Chemical of Potential Concern", which as the same meaning as "Contaminant of Interest" or "Contaminant of Potential Concern", respectively, and refers to "contaminants" as defined in 42 USC 9601(33).

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HEAST	Health Effects Assessment Summary Table
HHRA	human health risk assessment
HI	hazard index
HQ	hazard quotient
IEUBK	Integrated Exposure Uptake Biokinetic model3
IRAF	Infant Risk Adjustment Factor
IRIS	Integrated Risk Information System
ISA	initial study area
K_p	dermal permeability coefficient
L~~l~~/day	liters per day
LADI	lifetime average daily intake
LOAEL	lowest observed adverse effects level
LWG	Lower Willamette Group
LWR	Lower Willamette River
µg/dL~~l~~	microgram per deciliter
µg/kg	microgram per kilogram
µg/~~l~~L	microgram per liter
MCL	Maximum Contaminant Level
MCPP	2-(4-Chloro-2-methylphenoxy)propanoic acid
mg/kg	milligram per kilogram
ml/day	milliliters per day
ml/hr	milliliters per hour
MRL	method reporting limit
NHANES	National Health and Nutrition Evaluation Survey
NLM	National Library of Medicine
OAR	Oregon Administrative Rules
ODFW	Oregon Department of Fish and Wildlife
ODHS	Oregon Department of Human Services
pg/g	picograms per gram
PAH	polycyclic aromatic hydrocarbon
PBDE	polybrominated diphenyl ether
PCB	polychlorinated biphenyl
PEF	potency equivalency factor
PPRTV	Provisional Peer Reviewed Toxicity Value
PRG	preliminary remediation goal
RBC	risk-based concentration
RfD	reference dose
RG	remediation goal
RI/FS	remedial investigation/feasibility study
RM	river mile
RME	reasonable maximum exposure
RSL	Regional Screening Level
SCRA	site characterization and risk assessment
SF	slope factor
STSC	Superfund Health Risk Technical Support Center

SVOC	semi-volatile organic compound
TCDD	tetrachlorodibenzo-p-dioxin
TEF	toxic equivalency factor
TEQ	toxic equivalent
TZW	transition zone water
UCL	upper confidence limit
~~95% percent UCL/max 95% percent UCL or maximum~~	
USDA	United States Department of Agriculture
VOC	volatile organic compound
W	west
WHO	World Health Organization
XAD	XAD-2 Infiltrex™ 300 system

GLOSSARY

Term	Definition
bioaccumulation	the accumulation of a substance in an organism
bioconcentration factor	the concentration of a chemical in the tissues of an organism divided by the concentration in water
central tendency	a measure of the middle or expected value of a dataset
contaminant of concern	the subset of contaminants[2] of potential concern with exposure concentrations that exceed EPA target risk levels
contaminant of interest	contaminant[2] detected in the Study Area for all exposure media (i.e., surface water, transition zone water, sediment, and tissue)
contaminant of potential concern	the subset of contaminants[2] of interest with maximum detected concentrations that are greater than screening levels
composite sample	an analytical sample created by mixing together two or more individual samples; tissue composite samples are composed of two or more individual organisms, and sediment composite samples are composed of two or more individual sediment grab samples
conceptual site model	a description of the links and relationships between chemical sources, routes of release or transport, exposure pathways, and the human receptors at a site
congener	a specific chemical within a group of structurally related chemicals (e.g., PCB congeners)
human health risk assessment	a process to evaluate the likelihood that adverse effects to human health might occur or are occurring as a result of exposure to one or more contaminants
dose	the quantity of a contaminant taken in or absorbed at any one time, expressed on a body weight-specific basis; units are generally expressed as mg/kg bw/day
empirical data	data quantified in a laboratory
exposure assessment	the part of a risk assessment that characterizes the chemical exposure of a receptor

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[2] Prior deliverables and some of the tables and figures attached to this document may use the terms “chemical of concern”, “chemical of interest”, or “chemical of potential concern”, which has the same meaning as “contaminant of concern”, “contaminant of interest”, or “contaminant of potential concern”, respectively, and refers to “contaminants” as defined in 42 USC 9601(33).

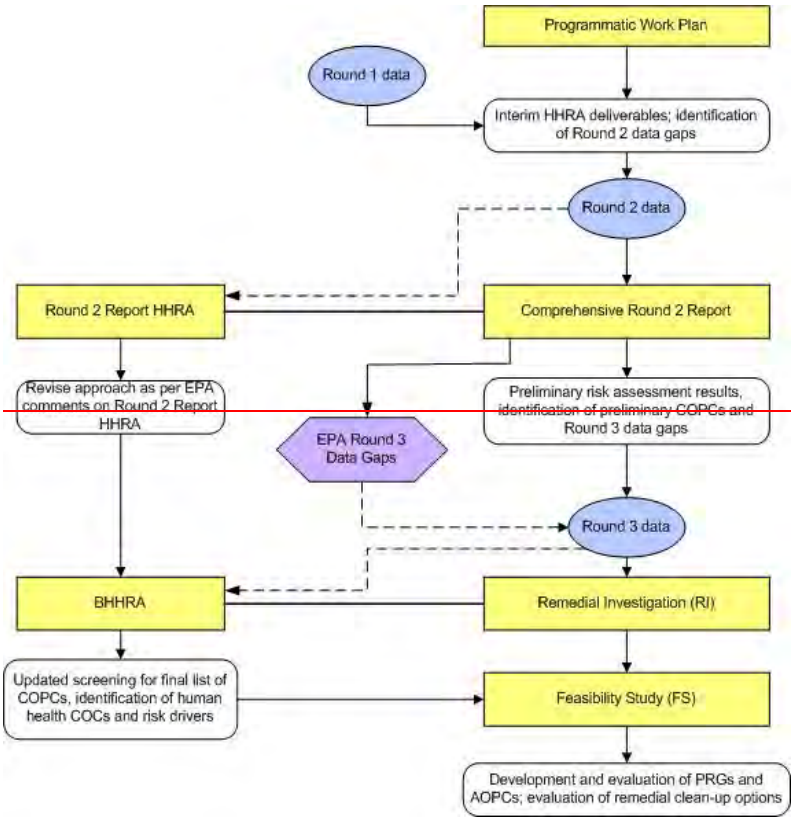
Term	Definition
exposure pathway	physical route by which a contaminant moves from a source to a human receptor
exposure point	the location or circumstances in which a human receptor is assumed to contact a contaminant
exposure point concentration	the value that represents the estimated concentration of a contaminant at the exposure point
exposure area	size of the area through which a receptor might come in contact with a contaminant as determined by human uses
hazard quotient	the quotient of the exposure level of a chemical divided by the toxicity value based on noncarcinogenic effects (i.e., reference dose)
predicted data	data not quantified in a laboratory but estimated using a model
reasonable maximum exposure	the maximum exposure reasonably expected to occur in a population
receptor	The exposed individual relative to the exposure pathway considered
risk	the likelihood that a specific human receptor experiences a particular adverse effect from exposure to contaminants from a hazardous waste site; the severity of risk increases if the severity of the adverse effect increases or if the chance of the adverse effect occurring increases. Specifically for carcinogenic effects, risk is estimated as the incremental probability of an individual developing cancer over a lifetime as a result of exposure to a potential carcinogen. Specifically for noncarcinogenic (systemic) effects, risk is not expressed as a probability but rather is evaluated by comparing an exposure level over a period of time to a reference dose derived for a similar exposure period.
risk characterization	a part of the risk assessment process in which exposure and effects data are integrated in order to evaluate the likelihood of associated adverse effects
slope factor	toxicity value for evaluating the probability of an individual developing cancer from exposure to contaminant levels over a lifetime
Study Area	the portion of the Lower Willamette River that extends from River Mile 1.9 to River Mile 11.8
toxic equivalency factor	numerical values developed by the World Health Organization that quantify the toxicity of dioxin, furan, and dioxin-like PCB congeners relative to 2,3,7,8-tetrachlorodibenzodioxin

Term	Definition
transition zone water	Pore water associated with the upper layer of the sediment column; may contain both groundwater and surface water
uncertainty	a component of risk resulting from imperfect knowledge of the degree of hazard or of its spatial and temporal distribution
upper confidence limit on the mean	a high-end statistical measure of central tendency
variability	a component of risk resulting from true heterogeneity in exposure variables or responses, such as dose-response differences within a population or differences in contaminant levels in the environment

EXECUTIVE SUMMARY

The baseline human health risk assessment (BHHRA) was conducted as part of the Remedial Investigation Report (RI Report) for the Portland Harbor Superfund Site (Site). . The BHHRA is an analysis of potential adverse health effects (current or future) caused by hazardous substance releases from a site in the absence of any actions to control or mitigate these releases. The results of the BHHRA are used to develop remedial action objectives and to assist in risk management decisions for the Site. .Figure ES-1 presents an overview of how the development and production of the BHHRA fits in with the overall Remedial Investigation/Feasibility Study (RI/FS) process for the Portland Harbor Superfund Site. .

Figure ES-1 Portland Harbor RI/FS Process and BHHRA



The general objective of the BHHRA is to assess the potential risks to human health from exposure to site-related chemicals present in or entering into environmental

This draft document has been provided to EPA at EPA's request to facilitate EPA's comment process on the document in order for LWG to finalize the BHHRA. The comments or changes (including redlines) on this document may not reflect LWG positions or the final resolution of the EPA comments.

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media (i.e., water or sediment) or bioaccumulating in the food chain, to assist in determining the need for remedial action, to assist in providing a basis for determining concentrations of chemicals that can remain in place and still be protective of public health, and to assist in providing a basis for comparing the effectiveness of various remedial alternatives. . Specifically, this included evaluating whether exposure to chemicals in sediment, surface water, groundwater seeps, or biota may result in unacceptable risks to human health.

The BHHRA followed the approach that was documented in the Programmatic Work Plan (Integral et al. 2004) and subsequent interim deliverables. . It also reflects numerous discussions, directives, and agreements on risk assessment techniques for the Site with or from the United States Environmental Protection Agency (EPA), Oregon Department of Environmental Quality (DEQ), Oregon Department of Human Services (ODHS), and Native American Tribes. . To minimize the chances of underestimating risks, the BHHRA incorporated conservative (i.e. health-protective) assumptions into the identification of exposure scenarios, the estimates of exposure, and the use of toxicity values. .

Industrial use of Portland Harbor and adjacent areas of the Lower Willamette River (LWR) has been extensive. . Portland Harbor generally refers to a heavily industrialized reach of the LWR between river mile (RM) 0 and RM 11.8, the extent of the navigation channel. . The approximate 10-mile portion of Portland Harbor from RM 1.9 to 11.8 is referred to as the Study Area, which is the focus of the BHHRA. . Potential human uses of Portland Harbor were considered in identifying the exposure scenarios and exposure media for evaluation in the BHHRA.

ES.1 BHHRA DATASET

The BHHRA dataset includes those data used for direct human health exposure pathways that were quantitatively evaluated in the risk characterization sections of the document: surface sediment (0 to 30.5 centimeter (cm) in depth), surface water, groundwater seep water, clam and crayfish tissue, and fish tissue. . Other matrices included in the site characterization and risk assessment (SCRA) dataset (e.g., subsurface sediment) were not evaluated in the BHHRA because they were not relevant to the exposure scenarios evaluated. . Although the BHHRA focused on the Study Area, data from outside the Study Area, from downstream to RM 1.0, including Multnomah Channel, and upstream to RM 12.2, were also used to assess risk, per an agreement with EPA. The following summarizes the data used by medium in the BHHRA . datasetby medium:

- Beach sediment: Composite beach sediment samples that were collected from designated human use areas within the Study Area were included in the BHHRA dataset.

- In-water sediment: In-water sediment (i.e., not beach sediment) samples that were collected from the top 30.5 cm in depth between the bank and the navigation channel were included in the BHHRA dadataset.
- Surface water: All Round 2 and Round 3 surface water data collected within the Study Area and in Multnomah Channel were included in the BHHRA dataset. .
- Groundwater seep: Data from Outfall 22B, which discharges in a potential human use area, were included in the BHHRA dataset. . Samples collected from this outfall as part of a stormwater sampling event were excluded from the BHHRA groundwater seep dataset.
- Fish tissue: Composite samples, both whole body and fillet with skin (fillet without skin samples were analyzed for mercury only), of target resident fish species (smallmouth bass, brown bullhead, black crappie, and common carp) were included in the BHHRA dataset. . Composite samples of adult Chinook salmon (whole body, fillet with skin, and fillet without skin), adult lamprey (whole body only), and sturgeon (fillet without skin only) were also included in the BHHRA dataset.
- Shellfish tissue: Field-collected composite samples of crayfish and clam tissue (depurated and undepurated) were included in the BHHRA dataset. .

ES.2 BHHRA EXPOSURE SCENARIOS

The risk characterization in the BHHRA evaluated the following exposure scenarios, as provided in the approved Programmatic Work Plan and subsequent agreements with or directives from the EPA related to the BHHRA approach:

	Beach Sediment: Ingestion and dermal absorption	**In-water Sediment:** Ingestion and dermal absorption	**Surface Water:** Ingestion and dermal Absorption	**Groundwater Seeps:** Ingestion and dermal absorption	**Fish/ Shellfish:** Ingestion	**Infant Consumption of Human Milk**
Workers	●	●	-	-	-	●
Transients	●	-	●	●	-	
Beach Users	●	-	●	-	-	
Fishers	●	●	-	-	●	●
Divers	–	●	●	-	-	●
Domestic Users	-	-	●	-	-	

- ~~Dockside worker – direct exposure to (i.e., ingestion of and dermal contact with) beach sediment, infant ingestion of human breast milk.~~
- ~~In-water worker – direct exposure to in-water sediment, infant ingestion of human breast milk.~~
- ~~Transient – direct exposure to beach sediment, surface water (for bathing and drinking water scenarios), and groundwater seeps.~~
- ~~Adult and child recreational beach user – direct exposure to beach sediment and surface water (for swimming scenarios).~~
- ~~Tribal fisher – direct exposure to beach sediment or in-water sediment, fish consumption, and infant ingestion of human breast milk.~~
- ~~Fisher – direct exposure to beach sediment or in-water sediment, fish consumption, shellfish consumption, and infant ingestion of human breast milk.~~
- ~~Diver – direct exposure to in-water sediment and surface water, infant ingestion of human breast milk.~~
- ~~Domestic water user – hypothetical~~ direct exposure to untreated surface water ~~hypothetically used as a drinking water source in the future.~~

~~Exposures to beach sediment were assessed per beach, and exposures to groundwater seeps were assessed per seep. .~~Exposures to in-water sediment, surface water, and fish and shellfish tissue were assessed on both localized and Study Area-wide scales. ~~.~~Details of each exposure scenario and associated exposure parameters are provided in Section 3 of this BHHRA.~~

~~Of these scenarios, the following were evaluated at the direction of EPA: .~~clam tissue ingestion, fish ingestion for single-species diets, exposure to in-water sediment and surface water by commercial divers, and hypothetical exposure to untreated surface water by a domestic user. ~~.~~Even though surface water in the LWR within Portland Harbor is not currently used as a domestic water source, under OAR 340-041-0340 Table 340A, domestic water supply is a designated beneficial use of the Willamette River, with adequate pretreatment. ~~.~~Divers and clam consumption by fishers were not included in the original Programmatic Work Plan but were included in the BHHRA as directed by EPA. ~~.~~Asian clams (*Corbicula* sp.) are the only clam species that were found in the Study Area during sampling events and, in addition to crayfish, were evaluated for shellfish consumption in the BHHRA. ~~.~~Although harvest and possession of Asian clams is illegal in the State of Oregon, conversations with transients indicated shellfish (both crayfish and clams) are eaten by them (Wagner 2004). ~~.~~In addition, crayfish are commercially harvested in the Willamette River, although the extent of this harvest within the Portland Harbor Superfund Site is not known.~~

ES.3 BHHRA EXPOSURE ASSESSMENT

The exposure assessment incorporated the reasonable maximum exposure (RME) approach described by EPA (1989). . The RME is intended to be a conservative exposure level that is still within the range of possible exposures. . Consistent with EPA (1989), the exposure assessment also used evaluated a central tendency (CT) values, which is intended to represent average exposures, for certain exposure assumptions. . For some exposure scenarios, such as fish consumption, exposure assumptions were directed by EPA. . Exposure point concentrations (EPCs) were calculated for each exposure area for as the 95% percent upper confidence limit on the arithmetic mean (95% percent UCL) for the RME evaluations and the arithmetic mean for the CTE evaluations for each exposure area. . In some exposure areas,certain instances the maximum concentration was used as the EPC instead of the 95% percent UCL. . These instances included those exposure areas where there are an insufficient number of samples to calculate a 95 percent UCL, and when the calculated UCL was greater than the maximum detected concentration. . Therefore, the EPCs are referred to as the 95% UCL/max and mean throughout the BHHRA.

EPCs for sediment, surface water, and tissue were also calculated for individual exposure areas and on a Study Area-wide basis. . The spatial scale of the individual exposure areas and the resulting data included in the calculation of those EPCs were predetermined through discussions with EPA based on assumptions about potential human uses as well as the species' home ranges in the case of tissue EPCs. . Exposure areas were designated throughout the Study Area based on the predetermined spatial scales. .

Assumptions about each population evaluated in the BHHRA were used to select exposure parameters to calculate the pathway-specific chemical intakes. . Site-specific values are not available for all populations and pathways. . Therefore, default values were used where site-specific values are not available. . Where default values are not available, best professional judgment based on knowledge of human uses of the Study Area or requirements from EPA were used. . Uncertainties that are inherent in exposure assessment are attributed to both variability in the population assessed and also the degree of knowledge associated with exposure assumptions. These uncertainties associated with the exposure assessment impact the risk estimates (EPA 1989).

ES.4 BHHRA TOXICITY ASSESSMENT

Toxicity values provide a quantitative estimate of the potential for adverse effects resulting from exposure to a chemical. . Cancer and noncancer toxicity values are used in human health risk assessments to quantify the likelihood of adverse effects occurring at different levels of exposure to a chemical. . Toxicity values are often based on the results of animal studies, and the extrapolation of toxicological data from animal studies to humans can be one of the largest sources of uncertainty in a

~~risk assessment. .Modifying factors, which typically range from two to three orders of magnitude (100 to 1,000 times), are often used by EPA in deriving toxicity values for human health given the level of confidence in the toxicological data, the intra-species differences (i.e., animal to human), and the inter-species differences to account for sensitive human subpopulations. .~~

~~Some toxicity values are based on exposure to chemical mixtures and not to individual chemicals. .This is because these chemicals are commonly present as mixtures in the environment, and the individual components of the mixtures have similar modes of toxicity (such as dioxins). .The chemicals that were evaluated in the BHHRA for toxicity as mixtures include: .chlordanes, dichlorodiphenyldichloroethane (DDD), dichlorodiphenyldichloroethylene (DDE), and dichlorodiphenyltrichloroethane (DDT);), endosulfan; .polychlorinated biphenyls (PCBs); and dioxins and furans. .~~

~~ES.5 BHHRA RISK CHARACTERIZATION~~

~~Consistent with DEQ (DEQ 2000a) and EPA guidance (EPA 1989), noncarcinogenic and carcinogenic effects were evaluated separately in the BHHRA. .To characterize potential noncarcinogenic effects, comparisons were made between projected intakes of substances and toxicity values. .To characterize potential carcinogenic effects, projected intakes and chemical-specific, dose-response data were used to estimate the probability that an individual will develop cancer over a lifetime.~~

~~Hazard quotients (HQs) were calculated for noncarcinogenic contaminants of potential concern (COPCs) to estimate the potential for noncarcinogenic effects. . The HQs were then summed to yield cumulative hazard indices (HIs) for each exposure area and for the entire Study Area. .Estimated HIs were compared to a target HI of 1. .For exposure areas exceeding a cumulative HI of 1, endpoint-specific HIs were then calculated and compared to a target HI of 1, below which remedial action at a Superfund site is generally not warranted (EPA 1991a)adverse health effects are not expected. .~~

~~Table ES-1 shows the ranges of cancer risks and HIs for each receptor and medium. . The exposure pathway with the highest range of HI estimates is consumption of fish tissue. .For the most part, exposure scenarios other than fish and shellfish consumption did not exceed a target HI of 1. .The ranges of HI estimates are due to the evaluation of different exposure areas, RME and CT scenarios for sediment and water, and multiple ingestion rates and diets for tissue consumption. .For example, the range of HI estimates for tissue encompass results for both adult and child consumers, results from three different ingestion rates for each receptor, and results from five different diet compositions.~~

~~Potential cancer risks were calculated for carcinogenic COPCs. .This calculated risk is expressed as the probability of an individual developing cancer over a lifetime as a~~

result of exposure to the potential carcinogen, and is a health protective estimate of the incremental probability of excess individual lifetime cancer risk. . Estimated total cancer risks (summed across all chemicals) were compared to a 1 x x 10^{-4} to 1 x x 10^{-6} risk range, which is the "target range" within which the EPA strives to manage risk as a part of the Superfund program (EPA 1991a). . The DEQ target risk levels are 1 x x 10^{-6} for individual carcinogens and 1 x x 10^{-5} for total cancer risks.

As shown below in Table ES-1, the exposure pathway with the highest range of cancer risk estimates is consumption of fish tissue. . For the most part, exposure scenarios other than fish and shellfish consumption were within or below the target risk range of 1 x x 10^{-4} to 1 x x 10^{-6}. . The ranges of cancer risk estimates are due to the evaluation of different exposure areas, RME and CT scenarios for sediment and water, and multiple ingestion rates and diets for tissue consumption. Round 1 fillet tissue samples were not analyzed for PCB, dioxin, or furan congeners. . Therefore, the risks from consumption of black crappie and brown bullhead fillet tissue, which were only analyzed in Round 1, likely underestimate the actual risks. . However, a range of risks was calculated for fish consumption scenarios, which included samples that were analyzed for congeners, so the lack of analysis of chemicals in certain samples should not impact the overall conclusions of this BHHRA.

Table ES-1. Ranges of Estimated Cumulative Excess Lifetime Cancer Risks and Hazard Indices for Portland Harbor Human Health Scenarios

		RME Scenarios				CT Scenarios			
		Estimated Cancer Risk		Cumulative Hazard Index		Estimated Cancer Risk		Cumulative Hazard Index	
Exposure Scenario	**Receptor**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**
Direct Exposure to Beach Sediment	Dockside Worker	5.E-07	**9.E-05**	2.E-03	7.E-02	4.E-08	**6.E-06**	5.E-04	1.E-02
	Transient	1.E-07	6.E-07	4.E-02	1.E-01	8.E-09	4.E-08	6.E-03	1.E-02
	Adult Recreational Beach User	5.E-07	**4.E-06**	8.E-03	3.E-02	2.E-08	2.E-07	2.E-03	6.E-03
	Child Recreational Beach User	**2.E-06**	**4.E-05**	8.E-02	4.E-01	2.E-07	**2.E-06**	1.E-02	5.E-02
	Combined Adult/Child Recreational Beach User	**2.E-06**	**5.E-05**	NA	NA	2.E-07	**2.E-06**	NA	NA
	Tribal Fisher	**2.E-06**	**2.E-05**	2.E-02	8.E-02	1.E-07	**2.E-06**	3.E-03	3.E-02
	Low-Frequency Fisher	4.E-07	**4.E-06**	7.E-03	3.E-02	1.E-08	1.E-07	8.E-04	3.E-02
	High-Frequency Fisher	5.E-07	**6.E-06**	1.E-02	5.E-02	2.E-08	3.E-07	2.E-03	3.E-02
	Breastfeeding Infant	7.E-09	1.E-06	1.E-02	1.E+00	5.E-10	9.E-08	2.E-03	2.E-01
Direct Exposure to Groundwater Seep	Transient	3.E-09	3.E-09	6.E-03	6.E-03	4.E-10	4.E-10	1.E-03	1.E-03
Direct Exposure to In-water Sediment	Diver in Dry Suit	3.E-08	**1.E-05**	2.E-04	2.E-01	NA	NA	NA	NA
	Diver in Wet Suit	9.E-08	**3.E-05**	7.E-04	6.E-01	3.E-09	6.E-07	6.E-05	1.E-02
	In-water Worker	7.E-08	**2.E-05**	1.E-03	1.E+00	5.E-09	4.E-07	2.E-04	6.E-02
	Tribal Fisher	1.E-06	**3.E-04**	3.E-03	**3.E+00**	6.E-08	**6.E-06**	3.E-04	9.E-02
	Low-Frequency Fisher	2.E-07	**6.E-05**	1.E-03	1.E+00	5.E-09	4.E-07	9.E-05	2.E-02
	High-Frequency Fisher	3.E-07	**8.E-05**	2.E-03	**2.E+00**	9.E-09	9.E-07	2.E-04	4.E-02
	Breastfeeding Infant	5.E-10	**3.E-04**	7.E-04	**5.E+00**	4.E-11	**3.E-06**	3.E-04	1.E-01
Direct Exposure to Surface Water	Diver in Dry Suit	1.E-08	**2.E-06**	6.E-05	2.E-03	NA	NA	NA	NA
	Diver in Wet Suit	1.E-08	**1.E-05**	8.E-05	6.E-03	8.E-10	5.E-07	1.E-05	7.E-04
	Transient	6.E-07	7.E-07	4.E-02	4.E-01	7.E-08	1.E-07	1.E-02	8.E-02
	Adult Recreational Beach User	2.E-08	2.E-08	1.E-04	1.E-04	2.E-09	2.E-09	3.E-05	3.E-05
	Child Recreational Beach User	4.E-08	5.E-08	1.E-03	1.E-03	8.E-09	9.E-09	2.E-04	2.E-04
	Combined Adult/Child Recreational Beach User	6.E-08	7.E-08	NA	NA	9.E-09	1.E-08	NA	NA
Surface Water as Hypothetical Drinking Water Source	Domestic User, Adult	**6.E-06**	**3.E-04**	3.E-02	7.E-01	1.E-06	**3.E-05**	2.E-02	3.E-01
	Domestic User, Child	**4.E-06**	**7.E-04**	1.E-01	**2.E+00**	**2.E-06**	**2.E-04**	5.E-02	8.E-01
	Domestic User, Combined Adult/Child	**9.E-06**	**9.E-04**	NA	NA	**3.E-06**	**2.E-04**	NA	NA

Table ES-1 (continued). Ranges of Estimated Cumulative Excess Lifetime Cancer Risks and Hazard Indices for Portland Harbor Human Health Scenarios

		RME Scenarios				CT Scenarios			
		Estimated Cancer Risk		Cumulative Hazard Index		Estimated Cancer Risk		Cumulative Hazard Index	
Exposure Scenario	**Receptor**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**
Tribal Fish Ingestion	Tribal Adult Consumer	**2.E-02**	**2.E-02**	**4.E+02**	**4.E+02**	**5.E-03**	**5.E-03**	**9.E+01**	**9.E+01**
Multi-Species Diet	Tribal Child Consumer	**3.E-03**	**3.E-03**	**8.E+02**	**8.E+02**	**8.E-04**	**8.E-04**	**2.E+02**	**2.E+02**
Whole Body Tissue	Combined Tribal Adult/Child Consumer	**2.E-02**	**2.E-02**	NA	NA	**5.E-03**	**5.E-03**	NA	NA
Approximate number of meals per month: 23	Breastfeeding Infant	**2.E-02**	**2.E-02**	**9.E+03**	**9.E+03**	**5.E-03**	**5.E-03**	**2.E+03**	**2.E+03**
Tribal Fish Ingestion	Tribal Adult Consumer	**1.E-02**	**1.E-02**	**3.E+02**	**3.E+02**	**2.E-03**	**2.E-03**	**5.E+01**	**5.E+01**
Multi-Species Diet	Tribal Child Consumer	**2.E-03**	**2.E-03**	**6.E+02**	**6.E+02**	**4.E-04**	**4.E-04**	**1.E+02**	**1.E+02**
Fillet Tissue	Combined Tribal Adult/Child Consumer	**1.E-02**	**1.E-02**	NA	NA	**3.E-03**	**3.E-03**	NA	NA
Approximate number of meals per month: 23	Breastfeeding Infant	**1.E-02**	**1.E-02**	**8.E+03**	**8.E+03**	**2.E-03**	**2.E-03**	**1.E+03**	**1.E+03**
Fish Ingestion	Adult Consumer	**7.E-05**	**6.E-02**	**2.E+00**	**3.E+03**	**7.E-05**	**2.E-02**	**2.E+00**	**1.E+03**
Single-Species Diet	Child Consumer	**3.E-05**	**2.E-02**	**4.E+00**	**5.E+03**	**3.E-05**	**8.E-03**	**4.E+00**	**2.E+03**
Whole Body Tissue	Combined Adult/Child Consumer	**9.E-05**	**7.E-02**	NA	NA	**8.E-05**	**2.E-02**	NA	NA
Approximate number of meals per month: 2 - 19	Breastfeeding Infant	**8.E-05**	**7.E-02**	**3.E+01**	**6.E+04**	**7.E-05**	**2.E-02**	**3.E+01**	**2.E+04**
Fish Ingestion	Adult Consumer	**7.E-06**	**4.E-02**	5.E-01	**2.E+03**	**7.E-06**	**1.E-02**	5.E-01	**7.E+02**
Single-Species Diet	Child Consumer	**3.E-06**	**1.E-02**	1.E+00	**4.E+03**	**3.E-06**	**5.E-03**	9.E-01	**1.E+03**
Fillet Tissue	Combined Adult/Child Consumer	**9.E-06**	**4.E-02**	NA	NA	**8.E-06**	**2.E-02**	NA	NA
Approximate number of meals per month: 2 - 19	Breastfeeding Infant	**6.E-06**	**2.E-02**	**7.E+00**	**5.E+04**	**6.E-06**	**2.E-02**	**7.E+00**	**2.E+03**
Fish Ingestion	Adult Consumer	**1.E-03**	**1.E-02**	**8.E+01**	**6.E+02**	**4.E-04**	**3.E-03**	**2.E+01**	**1.E+02**
Multi-Species Diet	Child Consumer	**6.E-04**	**5.E-03**	**1.E+02**	**1.E+03**	**1.E-04**	**1.E-03**	**3.E+01**	**3.E+02**
Whole Body Tissue	Combined Adult/Child Consumer	**2.E-03**	**1.E-02**	NA	NA	**4.E-04**	**4.E-03**	NA	NA
Approximate number of meals per month: 2 - 19	Breastfeeding Infant	**2.E-03**	**1.E-02**	**2.E+03**	**1.E+04**	**4.E-04**	**4.E-03**	**3.E+02**	**3.E+03**
Fish Ingestion	Adult Consumer	**1.E-03**	**9.E-03**	**6.E+01**	**5.E+02**	**2.E-04**	**1.E-03**	**9.E+00**	**7.E+01**
Multi-Species Diet	Child Consumer	**4.E-04**	**4.E-03**	**1.E+02**	**1.E+03**	**6.E-05**	**6.E-04**	**2.E+01**	**1.E+02**
Fillet Tissue	Combined Adult/Child Consumer	**1.E-03**	**1.E-02**	NA	NA	**2.E-04**	**2.E-03**	NA	NA
Approximate number of meals per month: 2 - 19	Breastfeeding Infant	**1.E-03**	**1.E-02**	**2.E+03**	**1.E+04**	**2.E-04**	**2.E-03**	**2.E+02**	**2.E+03**
Shellfish Ingestion (clam or crayfish)	Adult Consumer	9.E-07	**7.E-04**	7.E-02	**4.E+01**	9.E-07	**7.E-04**	6.E-02	**4.E+01**
Approximate number of meals per month: 0.4 - 2.5	Breastfeeding Infant	1.E-10	**7.E-04**	5.E-04	**8.E+02**	1.E-10	**7.E-04**	4.E-04	**8.E+02**

Notes:

Values presented are for exposure areas assessed in the BHHRA that lie within the Study Area.

Bolded cells exceed the EPA target cancer risk level of 1×10^{-6} or the target hazard index of 1.

Highlighted cells exceed the EPA target cancer risk level of 1×10^{-4} or the target hazard index of 1.

For tissue ingestion, the RME scenario represents the 95 percent upper confidence limit/maximum exposure point concentration. The CT scenario represents the mean exposure point concentration.

The exposure medium shown for the breastfeeding infant represents the exposure medium for the adult.

Ranges for tissue ingestion include all consumption rates.

NA = Not applicable because a CT scenario was not evaluated or because hazard indices were not calculated for the combined adult/child scenario.

Hazard indices presented are the ranges for cumulative hazard indices per exposure area and exposure scenario. Endpoint-specific hazard indices were calculated for cumulative hazard indices greater than 1.

For tissue ingestion, number of meals per month is calculated based on an 8 ounce serving for adults a 3.4 ounce serving for children.

For both cancer risks and noncancer hazards, the maximum estimates are for fish consumption and represent the highest consumption rate, the 95% UCL or maximum tissue concentrations, and localized exposure areas. . The following summarizes the assumptions associated with the highest risk estimates:

- **Fish ingestion rate.** . The highest ingestion rates used in this BHHRA for adult tribal fishers and adult fishers are 175 g/day (CRITFC 1994) and 142 g/day (EPA 2002b), respectively. . These are equivalent to 23 and 19 meals per month, respectively, based on an 8-ounce serving size, every month of the year exclusively of fish caught within the Study Area.
- **Exposure duration.** . Fish consumption is assumed to occur at that same rate every month of every year for 30 years for adult fishers and 70 years for tribal fishers. .
- **Whole body tissue.** . WOnly whole body tissue (i.e., the entire fish) is consumed. .
- **Single species.** . For non-tribal fishers, only one species (i.e., common carp) is consumed. .
- **Source of fish.** . 100 percent of the fish consumed is caught/harvested from the same location.

In addition to the uncertainty associated with the exposure assumptions listed above, there are uncertainties associated with the cooking and preparation methods for fish consumption and background contributions to the Study Area. Possible the possible effects of cooking methods, which can reduce concentrations of lipophilic chemicals in fish tissue, were not considered. . PCB concentrations have been shown to be reduced with various cooking methods though due to the variability in the measured rates of reduction there is uncertainty in assigning a rate of reduction of PCBs associated with cooking and preparation methods. . Assumptions made during this BHHRA introduce uncertainty to the actual risks that may exist within the Study Area. . The contribution of background sources is another important consideration. . On a regional scale, fish consumption results in risk estimates exceeding cumulative risks of 10^{-4} or HIs of 1 based on fish tissue data collected from the Willamette and Columbia Rivers outside of the Study Area (EVS 2000, EPA 2002c). However, concentrations are higher at the Site than in the regional tissue.

Chemicals were identified as contaminants potentially posing unacceptable risks[3] if they resulted in a cancer risk greater than the EPA point of departure of 1 x x 10^{-6} or a HQ greater than 1 under any of the exposure scenarios for any of the exposure point concentrations evaluated in the BHHRA, regardless of the uncertainties. . There were 28 chemicals identified as contaminants potentially posing unacceptable risks for the

[3] Prior deliverables and some of the tables and figures attached to this document may use the term "Chemicals posing potentially unacceptable risks," which has the same meaning as "Contaminant posing potentially unacceptable risks" and refers to "contaminants" as defined in 42 USC 9601(33).

This draft document has been provided to EPA at EPA's request to facilitate EPA's comment process on the document in order for LWG to finalize the BHHRA. The comments or changes (including redlines) on this document may not reflect LWG positions or the final resolution of the EPA comments.

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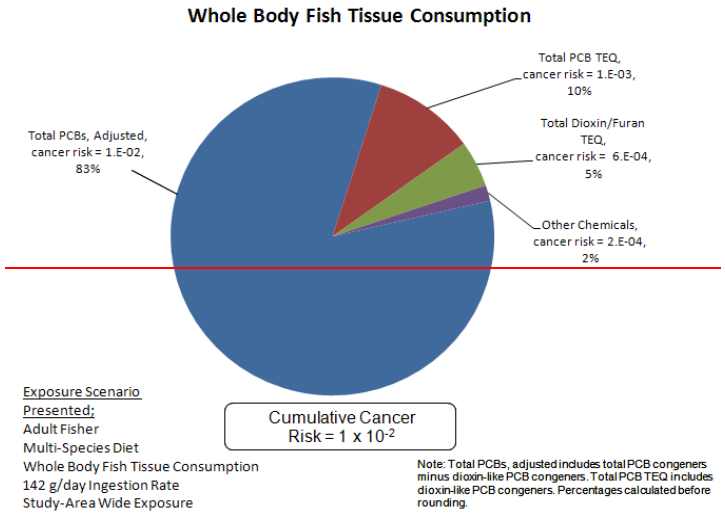
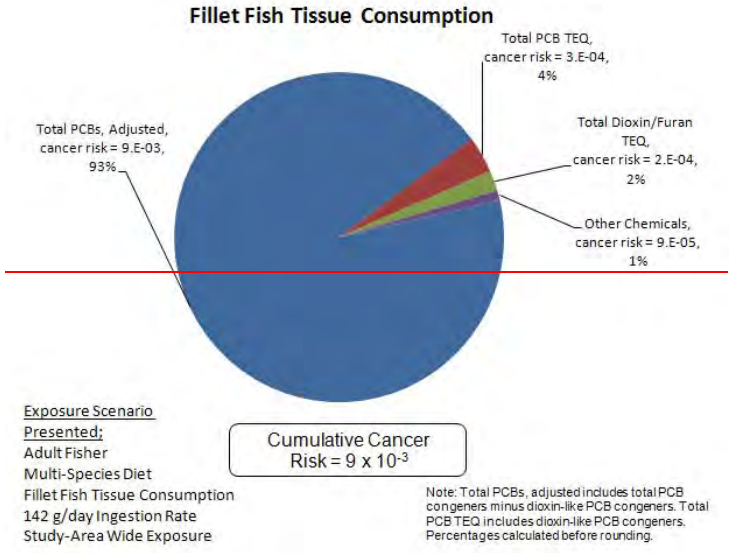
exposure scenarios listed above. . Only a subset of these contaminants were associated with cancer risks exceeding 1 x x 10^{-4} or HQs exceeding 1, and an even smaller number of contaminants contributed to most of the relative percentage of total risk. . Of the 33 contaminants identified as potentially posing unacceptable risks, four of the chemicals (alpha , beta , and gamma hexachlorocyclohexane and heptachlor) were identified on the basis of N qualified data only. . The use of an "N" qualifier indicates that the identity of the analyte is not definitive. . These four chemicals are not recommended for further evaluation of potential risks to human health. . The remaining 29 contaminants identified as potentially posing unacceptable risks to human health are evaluated further in the Human Health Risk Management Recommendations.

As shown in Figure ES-1, PCBs contribute the majority of the total cancer risk for the fish tissue consumption pathway (both whole body and fillet tissue) on a Study Area-wide exposure area basis, and are the primary contributor to risk under this exposure scenario. . Dioxins and furans are the secondary contributor to risk. PCBs contribute approximately 93 percent of the cumulative cancer risk, and dioxins/furans contribute approximately 5 percent of the cumulative cancer risk for Study Area-wide whole body fish tissue consumption. . For fillet tissue consumption, PCBs contribute approximately 97 percent of the cumulative cancer risk, and dioxins/furans contribute approximately 2 percent for Study Area-wide exposure. The remaining COPCs for Study Area-wide fish consumption account for less than 2 percent of the cumulative cancer risk. . PCBs and dioxins/furans also resulted in the highest HQs for Study Area-wide fish tissue consumption.

~~**Figure ES-1. _Relative Contribution of Individual Analytes to Cumulative Study Area-Wide Risk For The Non-Tribal Adult Fish Consumption Scenario, Whole Body and Fillet Tissue**~~



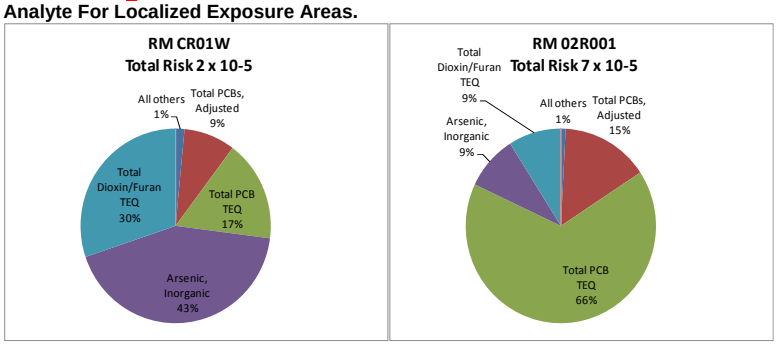


~~While tissue concentrations and risks are higher in Portland Harbor, in regional studies of fish tissue data from the Willamette and Columbia Rivers outside of the~~

Study Area (EVS 2000, EPA 2002c) both PCBs and dioxins/furans also resulted in cancer risks greater than 1 x x 10^{-4} and/or HQs greater than 1 for fish consumption using exposure assumptions similar to those in the BHHRA.

In some cases in the Portland Harbor, contaminants contributing most to cumulative risks differ between localized exposure areas. . For example, Figure ES-2 shows the relative contribution of contaminants to cumulative cancer risks from ingestion of crayfish tissue by an adult fisher at two different localized exposure areas. . In the pie chart on the left, which shows relative risks from consumption of crayfish at sampling station CR01W, arsenic is the primary contributor to cancer risk (42% percent of total risk), followed by total dioxin/furan TEQ (30% percent of total risk). The pie chart on the right shows relative risks from consumption of crayfish at sampling station RM 02R001, where ingestion of PCBs in shellfish tissue contributes to approximately 81% percent of total cancer risks (total adjusted PCBs plus total PCB TEQ), followed by an almost equal contribution from arsenic and total dioxin/furan TEQ (approximate 9% percent contribution to total risks by each contaminant)

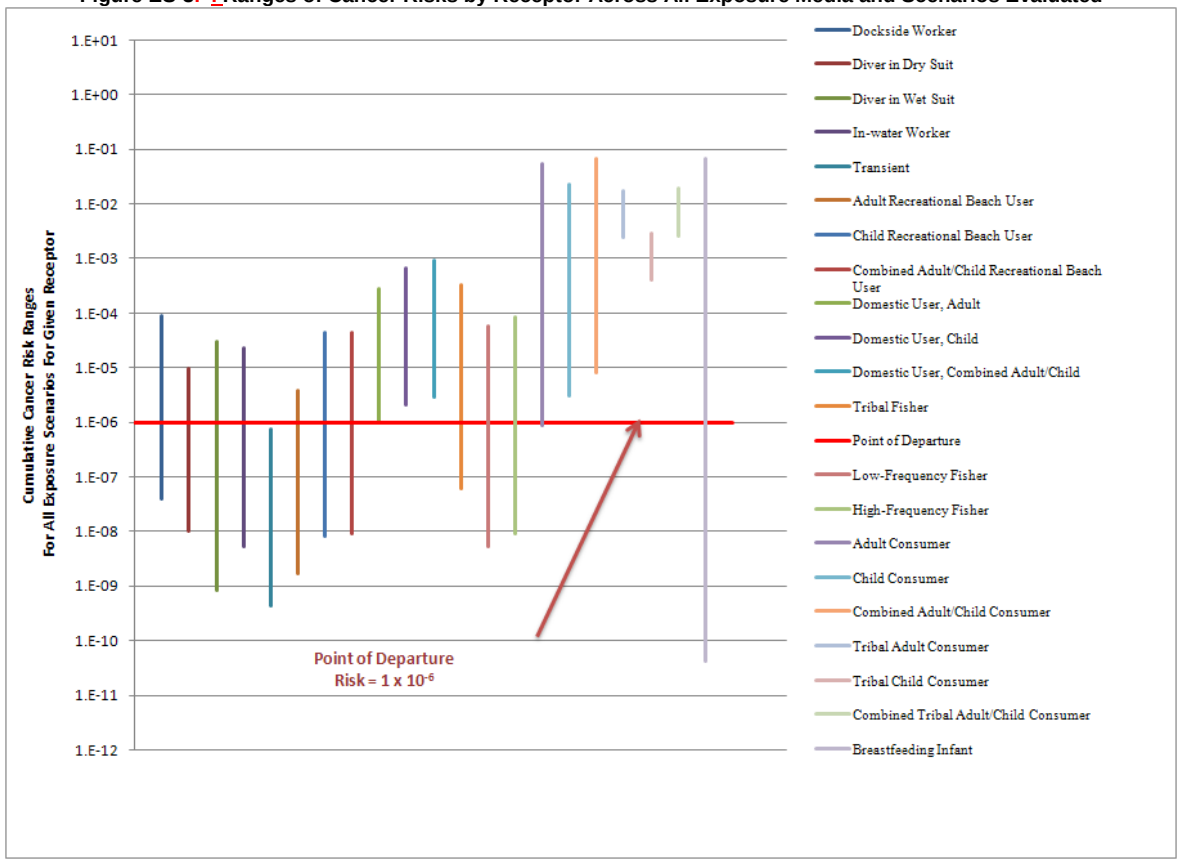
Figure ES-2. . Example of Differing Relative Contributions to Cumulative Risk by Analyte For Localized Exposure Areas.



Figures show relative risks from adult fisher consumption of crayfish tissue at the 95% percent UCL/Max Exposure Point Concentrations

A detailed breakdown of risks by exposure scenario, contaminant, and exposure area is provided in the figures and tables in Section 5 of this BHHRA. . In addition, Figure ES-3 and ES-4 provide a visual representation of the ranges of cancer risks (ES-3) and noncancer hazards (ES-4) by receptor. Fish tissue consumers have the highest estimated cancer and noncancer risks. .

Figure ES-3~~.~~ . Ranges of Cancer Risks by Receptor Across All Exposure Media and Scenarios Evaluated



~~This draft document has been provided to EPA at EPA's request to facilitate EPA's comment process on the document in order for LWG to finalize the BHHRA. The comments or changes (including redlines) on this document may not reflect LWG positions or the final resolution of the EPA comments.~~

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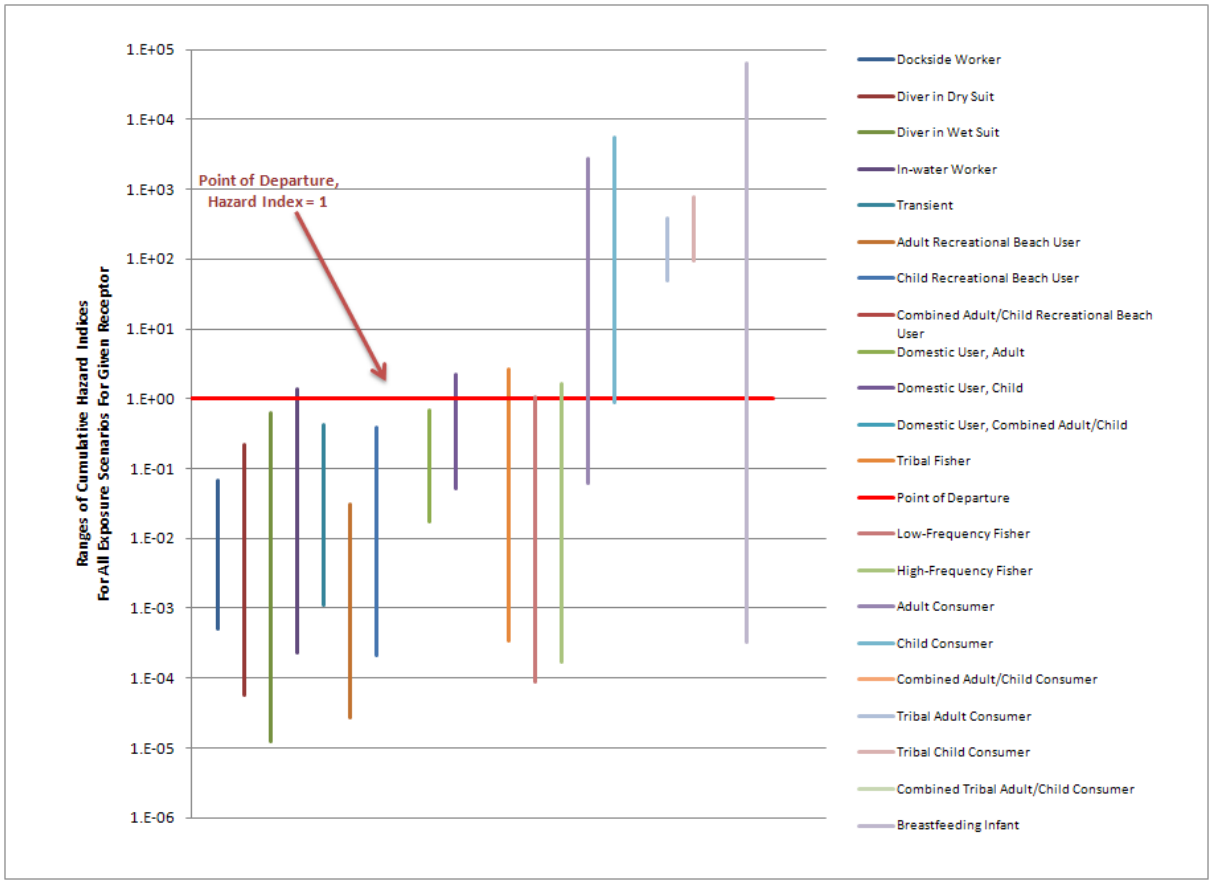
Figure ES-4. Ranges of Cumulative Noncancer Hazard Indices by Receptor Across All Exposure Media and Scenarios Evaluated



ES.6 SUMMARY OF BHHRA

The following presents the major findings of the BHHRA:

- Risks resulting from the consumption of fish or shellfish are generally orders of magnitude higher than risk resulting from direct contact with sediment, surface water, or seeps. . Risks from fish and shellfish consumption exceed the EPA point of departure for cancer risk of 1 x x 10^{-6}, as well as the target cancer risk range of 1 x x 10^{-6} to 1 x x 10^{-4} and target HI of 1. . With the exception of two ½ mile river segments for the tribal fisher scenario and one location for the hypothetical use of untreated surface water as a drinking water source by a future resident, all of the direct contact scenarios result in risks within or below the EPA target cancer risk range of 1 x x 10^{-6} to 1 x x 10^{-4}. . The direct contact scenarios also result in non-cancer hazards below the target HI of 1, with the exception of one ½-river mile segment for in-water sediment and one location for hypothetical use of untreated surface water as a drinking water source. .

- Fish consumption results in the highest risks of the scenarios evaluated in the BHHRA. . PCBs are the primary contributor to risk for fish consumption, and dioxins/furans are a secondary contributor for fish consumption for exposure occurring over the full length of the Study Area. . Other contaminants potentially posing unacceptable risks at a Study Area-wide or localized scale for at least one fish consumption exposure scenario include the following contaminants:
  - antimony
  - arsenic
  - lead
  - mercury
  - selenium
  - zinc
  - benzo(a)anthracene
  - benzo(a)pyrene
  - dibenzo(a,h)anthracene
  - total carcinogenic PAHs
  - bis(2-ethylhexy) phthalate
  - hexachlorobenzene
  - total PCBs and PCB TEQ
  - total dioxin TEQ
  - aldrin
  - dieldrin
  - heptachlor epoxide
  - total chlordane

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- total DDD
- total DDE
- total DDT
- PBDEs

- Risks from PCBs based on consumption of fish within the Study Area exceed the EPA target risk range of 1 x x 10^{-6} to 1 x x 10^{-4}, with a maximum estimated risk of 7 x x 10^{-2} (combined adult and child receptor). . The maximum cumulative hazard index from fish consumption is 5,000 (child receptor), primarily from exposure to PCBs in whole body tissue. . The maximum cumulative hazard index from consumption of fillet fish tissue is 4,000 (child receptor), also primarily from exposure to PCBs.

The body of information available regarding fish consumption rates, both nationally and regionally, indicates that the fish ingestion rates used in the BHHRA address a range of exposures that might occur for consumers of locally caught fish in Portland Harbor, including high fish consuming populations. .
Concentrations of bioaccumulative chemicals are higher at the Site than in regional tissue. . However, on a regional basis, risks from exposure to bioaccumulative chemicals in tissue exceed EPA target risk levels. . For example, the PCB concentrations detected in resident fish from the Willamette and Columbia Rivers are approximately 20 to 100 times higher than the EPA target fish tissue concentration, when adjusted for the ingestion rates used in this BHHRA and based on a target risk level of 1 x x 10^{-6}. Regional efforts are underway to reduce fish tissue concentrations. . Sources contributing to regional tissue concentrations are unknown. . The contribution of background sources of contaminants potentially posing unacceptable risks is an important consideration in risk management decisions. . For example, arsenic concentrations in beach sediment contribute approximately 50% percent of cumulative risk from exposure to this medium for the highest risk scenarios, yet arsenic concentrations detected in beach sediment within the Study Area are comparable to Oregon DEQ established background levels.

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1.0 INTRODUCTION

This Baseline Human Health Risk Assessment (BHHRA) presents ~~the Lower Willamette Group's (LWG's)~~an evaluation of risks to human health ~~for~~ at the Portland Harbor Superfund Site (Site) in Portland, Oregon. This BHHRA is intended to provide an assessment of potential exposures baseline human health risks ~~for the~~due to contaminants at the Site and to support risk management decisions ~~for the Site.~~ .

Portland Harbor encompasses the ~~authorized navigation channel in the~~ Lower Willamette River (LWR) in Portland, Oregon, from the confluence with the Columbia to about River Mile (RM~~)~~) ~~11.8~~12.~~ ~~ . ~~Portland Harbor~~It has been the focus of numerous environmental investigations completed by the LWG and various other governmental and private entities.~~ ~~. Major LWG data collection efforts occurred during ~~three~~ four sampling rounds in the Remedial Investigation/Feasibility Study (RI/FS) Study Area (~~RM~~ RM ~~1.9~~0.8 to ~~11.8~~12.2) to characterize the physical system of the river and to assess the nature and extent of contamination in sediment, surface water, transition zone water, sto~~rm RM~~rm-water, and biota.~~ ~~. ~~This BHHRA incorporates the results of these environmental investigations and builds from the initial Human Health Risk Assessment (HHRA) performed as part of the Portland Harbor RI/FS Comprehensive Round 2 Site Characterization Summary and Data Gaps Analysis Report (Round 2 Report) (Integral et. al. 2007).~~

The LWG has worked with the United States Environmental Protection Agency (EPA) to develop the methods and assumptions used in this BHHRA.~~ ~~. ~~At the direction of EPA~~Consistent with EPA guidance (1989), this BHHRA incorporates assumptions to provide a health protective assessment of risks associated with contaminants present at the Site~~, which is consistent with EPA guidance on risk assessment (1989). For many of the exposure scenarios evaluated in this BHHRA, upper bound literature values are used to quantify exposure due to the lack of site specific exposure information. In some cases, the maximum detected concentrations are used to quantify long term exposures, which may not be representative of ongoing exposures in the Study Area. Therefore, the results of the BHHRA have a margin of conservatism built into the risk conclusions consistent with EPA guidance (1989).~~ The risk assessment for Portland H~~h~~arbor is a baseline risk assessment in that it evaluates human health risks and hazards associated with contamination in the absence of remedial actions or institutional controls.

This BHHRA is being conducted as part of the Remedial Investigation Report (RI Report) to evaluate potential adverse health effects caused by hazardous substance releases at the Site, consistent with the requirements of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).~~ ~~. The BHHRA will be used to support the development of contaminant thresholds to be used as preliminary remediation goals (PRGs) for sediment.~~ ~~. ~~The BHHRA PRGs~~

~~are provided along with PRGs developed under the baseline ecological risk assessment (BERA) for the Site. ,~~The PRGs will provide preliminary estimates of the long-terms goals to be achieved by any cleanup actions in Portland Harbor~~.~~ . During the feasibility study (FS) process, the PRGs will be refined based on background sediment quality, technical feasibility, and other risk management considerations~~. –~~. EPA will identify the final remediation goals (RGs) for the site in the Record of Decision, following completion of the FS.

1.1 OBJECTIVES

The general objective of ~~a HHRA~~a human health risk assessment in the CERCLA process is to ~~assess the potential~~provide an analysis of potential baseline risks to human health from ~~exposure to chemicals present in or entering into environmental media (i.e., water or sediment) or bioaccumulating in the food chain. The overall objective of this BHHRA for the Site is~~ , ~~and~~ to evaluate ~~whether exposure~~ site-related contaminants and help determine the need for remedial actions, provide a basis for determining contaminant concentrations that can remain onsite and still be protective of public health, and provide a basis for comparing the effectiveness of various remedial alternatives.~~to – site-related contaminants in sediment, surface water, groundwater seeps, or biota may result in unacceptable risks to human health.~~ To achieve the overall objectives, the general process of BHHRA ~~following are specific objectives of this~~is ~~BHHRA~~:

- Identify contaminants of potential concern (COPCs)[4] ~~for human health~~
- Identify potentially exposed populations and ~~exposure~~ pathways of exposure to ~~populations~~ COPCs ~~who may contact COPCs~~
- Characterize potentially exposed populations and estimate the extent of their exposure to COPCs
- Quantitatively characterize the noncarcinogenic and carcinogenic risks to the populations resulting from potential exposure to COPCs and identify contaminants potentially posing unacceptable risks
- Characterize uncertainties associated with this risk assessment
- Identify the contaminants and pathways that contribute the majority of the risk.

1.2 APPROACH

This BHHRA generally follows the approach that was documented in the Programmatic Work Plan (Integral et al. 2004) and subsequent interim deliverables~~. –~~.

[4] Prior deliverables and some of the tables and figures attached to this document may use the te~~rm~~ RM "Chemicals of potential concern," which has the same meaning as "Contaminants of potential concern" and refers to "contaminants" as defined in 42 USC 9601(33).

It also reflects numerous discussions and agreements on appropriate risk assessment techniques for the Site among interested parties, including the EPA, Oregon Department of Environmental Quality (DEQ), Oregon Department of Human Services (ODHS), and Native American Tribes.

Most of the eExposure scenarios, including potential exposure pathways and potentially exposed populations, and exposure assumptions were originally identified in the Programmatic Work Plan. Most of the assumptions used to estimate the extent of exposure for these scenarios were also identified in the Programmatic Work Plan. Additional assumptions for estimating the extent of exposure were provided in the Exposure Point Concentration Calculation Approach and Summary of Exposure Factors Technical Memorandum (Kennedy/Jenks Consultants 2006) and the Human Health Toxicity Values Interim Deliverable (Kennedy/Jenks Consultants 2004a). Exposure scenarios that were not included in the Programmatic Work Plan were evaluated in this BHHRA based on direction from EPA. Specific agreements with and direction from EPAdocuments related to the approach for this BHHRA are documented presented in Attachment F1.

The approach of this BHHRA is based on EPA (1989, 1991b, 2001a, 2004, 2005a) and EPA Region 10 (2000a) guidance and direction from EPA, . The approach and is also consistent with DEQ guidance for HHRAs (DEQ 2000a, 2010).

1.3 SITE BACKGROUND

The LWR extends from the Willamette's convergence with the Columbia River at river mile (RM)) 0 upstream to the Willamette Falls at RM RM 26. Portland Harbor generally refers to a heavily industrialized reach of the LWR between RM RM RM 0 and RM RM RM 11.812, the extent of the navigation channel. Additional information on the environmental setting of Portland Harbor, including historical and current land use, regional geology and hydrogeology, surface water hydrology, the in-water physical system, habitat, and human access and use is provided in Section 3 of the RI Report. The approximate 1011-mile portion of Portland Harbor from RM RM 1.90.8 to 11.812.2 is referred to as the Study Area (Map 1-1). Because the Site boundaries have not yet been defined[5], this BHHRA focused on the Study Area.

Portland Harbor and the Willamette River have served as a major industrial water corridor for more than a century. Industrial use of the Study Area and adjacent areas has been extensive. The majority of the Study Area is currently zoned for industrial land use and is designated as an "Industrial Sanctuary" (City of Portland 2006a). Much of the shoreline in the Study Area includes steeply sloped banks covered with riprap or constructed bulkheads, with human-made structures such as piers and wharves over the water in various locations. A comprehensive update of Portland's

[5] The Site boundaries will be defined by EPA in the Record of Decision for the Site.

Willamette Greenway Plan and related land use policies and zoning (The River Plan) is underway, addressing all of the Willamette riverfront in Portland (City of Portland 2006b). The Willamette Greenway Plan addresses the quality of the natural and human environment along the Willamette River and generally includes all land adjacent to the river, public lands near the river, and land necessary for conservation of significant riparian habitat. (The Willamette Greenway Plan, adopted by the City Council November 5, 1987, Ordinance 160237). The Greenway Plan is intended to "protect, conserve, enhance, and maintain the natural, scenic, historical, economic, and recreational qualities of lands along Portland's rivers." (Portland City Code Chapter 33.440). The Plan supports industrial uses within Portland Harbor while at the same time looks to increase public access to the river. As a result, recreational use within the Study Area may increase at certain locations in the future.

There are numerous potential human uses of Portland Harbor. Worker activities occur at the industrial and commercial facilities in the Study Area. However, due to the sparse beach areas and high docks associated with most of the facilities, worker exposure to the in-water portion of the Study Area may be limited in shoreline areas. Commercial diving activities also occur in the LWR.

In addition, the LWR provides many natural areas and recreational opportunities, both within the river itself and along the riverbanks. Within the Study Area, Cathedral Park, located ~~under th~~adjacent to the~~e~~ St. Johns Bridge, includes a sandy beach area and a public boat ramp and is used for water skiing, occasional swimming, and waterfront recreation. Recreational beach use also may occur within Willamette Cove, ~~which is a riverfront natural area, in~~ Swan Island Lagoon, and on the southern end of Sauvie Island~~, which is within the Study Area~~. Swan Island Lagoon includes a public boat ramp. Additional LWR recreational beach areas exist on the northern end of Sauvie Island and in Kelley Point Park, both of which are outside of the Study Area.

Fishing is conducted throughout the LWR basin and within the Study Area, both by boaters and from locations along the banks. The LWR also provides a ceremonial and subsistence fishery for Pacific lamprey (particularly at Willamette Falls) and spring Chinook salmon for Native American Tribes. Many areas in the LWR are also important currently for cultural and spiritual uses by local Native Americans.

Transients have been observed along the LWR, including some locations within the Study Area. The observation of tents and makeshift dwellings during RI sampling events confirms that transients were living along some riverbank areas. Transients are expected to continue to utilize this area in the future.

The RI/FS being completed for the Site is designed to be an iterative process that addresses the relationships among the factors that may affect chemical distribution, risk estimates, and remedy selection. ~~Three~~ Four rounds of field investigations have

been completed as part of the RI/FS~~.—~~. A preliminary sampling effort was conducted in 2001 and 2002 prior to the RI/FS work plan. Round 1 was conducted in 2002 and focused primarily on chemical concentrations in fish and shellfish tissue and in beach sediment~~.—~~. Round 2 was conducted in 2004 and 2005 and focused on chemical concentrations in sediment cores, in-water surface sediment, surface water, transition zone water, and additional shellfish tissue and beach sediment~~.—~~. Round 3 was conducted in 2006 and 2007 and focused on chemical concentrations in additional surface water, sediment, and fish and shellfish tissue~~.—~~. These Round 1, Round 2, and Round 3 sampling efforts, while initially focused on ~~RM~~ RM 3.5 to 9.2, which is the Administrative Order on Consent-defined initial study area (ISA), extended well beyond the ISA to ~~RM~~ RM 0 downstream and to ~~RM~~ RM ~~19~~ 28.4 upstream~~.—~~.

1.4 ORGANIZATION

In accordance with guidance from EPA (1989), which is consistent with DEQ guidance (2000a, 2010), the BHHRA incorporates the four steps of the baseline risk assessment process: data collection and evaluation, exposure assessment, toxicity assessment, ~~and~~ risk characterization, as well as a discussion of overall uncertainties. ~~(which includes an uncertainty assessment).~~

This BHHRA is organized as follows:

- Section 2, Data Evaluation – This section evaluates the available data for the Study Area and identifies the COPCs for further evaluation in the BHHRA.
- Section 3, Exposure Assessment – This section presents potentially complete routes of exposure and potentially ~~receptor~~ exposed populations for further evaluation in the BHHRA, which are summarized in the conceptual site model (CSM).
- Section 4, Toxicity Assessment – This section evaluates the potential hazard and toxicity of the COPCs selected for quantitative evaluation in this BHHRA.
- Section 5, Risk Characterization – This section presents the cancer risks and noncancer hazards and identifies the contaminants potentially posing unacceptable risks to human health.
- Section 6, Uncertainty Analysis – This section discusses the uncertainties that are inherent in performing a HHRA, and the uncertainties specific to this BHHRA.
- Section 7, Summary – This section summarizes the findings of this BHHRA and identifies chemicals and pathways that contribute the majority of the risk within the Study Area.
- Section 8, Conclusions – This section provides the conclusions for this BHHRA.

- Section 9, References – This section lists the references used in this BHHRA.

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2.0 DATA EVALUATION

This section presents the data that were used in this BHHRA and the results of the selection of COPCs in sediment, water, and tissue.. The LWG and non-LWG sampling events included in the site characterization and risk assessment (SCRA) dataset are described in detail in Section 2.0Appendix A of the RI Report.. The BHHRA dataset used in this BHHRA represents a subset of data from the sampling events that comprised the SCRA dataset as of September 2008.. Data needs for the BHHRA were identified through the data quality objective (DQO) process described in Section 7 of the Programmatic Work Plan (Integral et al.. 2004).Data collection and evaluation included the gathering and analysis of data relevant to human exposures and the identification of those contaminants that are the focus of this BHHRA. Only data that met Category 1/QA2 data quality objectives was used in the BHHRA.Data needs for the BHHRA were identified through the data quality objective (DQO) process described in Section 7 of the Programmatic Work Plan (Integral et al. 2004). A

This section presents the data that were used in this BHHRA and the results of the selection of COPCs in sediment, water, and tissue. The LWG sampling events and non-LWG sampling events included in the site characterization and risk assessment (SCRA) dataset are described in detail in Section 2.0 of the RI Report. The BHHRA dataset used in this risk analysis and described in this section is a subset of data from the sampling events that comprised the SCRA dataset as of September 2008. Additional information on the BHHRA dataset and details on the use of the data in the BHHRA are provided in Attachment F2. In addition, per EPA comments on the draft BHHRA (note: why?), a risk evaluation of potentialof exposures to polybrominated diphenyl ethers (PBDEs) in detected in in-water sediment, fish tissue, and shellfish tissue was performed conducted at the direction of EPA using a subset of data from the sampling events that comprised the SCRA dataset as of February 2011.. The data for the PBDE analysis are discussed in Attachment F3, and the PBDE risk assessment used the general data evaluation methodology discussed in this section.

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2.1 AVAILABLE DATA

The risk characterization BHHRA dataset includes only those matrices relevant for direct human health exposure pathways that were quantitatively evaluated: surface sediment [(0 to 30.5 centimeter (cm) in depth]), clam and crayfish tissue, fish tissue, surface water and groundwater seeps.. Other matrices included in the SCRA dataset (esuch as.g., subsurface sediment) were not evaluated in the BHHRA because they were not relevant to the exposure scenarios evaluatedhuman exposure was considered unlikely (see Section 3).. Although the BHHRA focused on the Study Area, additional data Data from outside the Study Area, from downstream to RM RM 1.0, including Multnomah Channel, and upstream to RM RM 12.2, were included in the risk assessmentalso used to assess risk, per an agreement with EPA.

. The BHHRA dataset is divided into samples collected within the Study Area and outside of the Study Area, and and is summarized by matrix in Tables Tables 2-1 and 2-2. The dataset is described briefly in the following subsections, and described in more detail in Section 2.0 of the RI Report.

2.1.1 Beach Sediment

The Programmatic Work Plan identified Areas aAreas where potential exposure to beach sediment could occur were identified and designated as human use areas in the Programmatic Work Plan. Human use areas were designated based only on current conditions, as identified in the Programmatic Work Plan. Because Beaches beaches are relatively dynamic environments; specific if beach conditions may change in the future, additional risk evaluation of the human use areas may be required, and the evaluation presented in the BHHRA may no longer be appropriately descriptive of potential risks.

Composite sediment samples were collected during Round 1 from each beach that had been designated as a potential human use area within the Initial Study Area (ISA). Additional human use areas within the Study Area but downstream of the ISA were sampled during Round 2 as part of the sampling of shorebird habitat. All of the Round 1 beach samples and the six Round 2 beach samples that were collected from potential human use areas located downstream of the ISA were also included in the BHHRA dataset. The designated potential human use areas and associated beach sediment samples are shown in Map 2-1, and Table 2-3 2 presents a summary of the beach composite sediment samples included in the BHHRA dataset.

2.1.2 In-Water Sediment

InThe in-water sediment BHHRA dataset includes samples collected outside of the navigation channel of the river and from less than 30.5 cm in depth. Beach sediment samples Itare excludesd beach sediment samples, as well as natural attenuation core samples, radioisotope samples, and samples collected from areas that were subsequently dredged.

The in-water sediment dataset is divided into two subsets:distinguished as data collected either within andor outside of the study area. comprised of Datasamples collected within the study area includes in water sediment samples from river mile (RM) 1 .9 to RM RM 11.812.2, including Swan Island Lagoon, as well as samples from the mouth of Multnomah Channel that were included in the study area for the Round 2 Report. . Data outside the study area includes samples collected from RM RM 1 to RM RM 1.9, from RM RM 11.8 to RM RM 12.2, and from Multnomah Channel areas outside of the sStudy aArea. . As described in Appendix A of the RI, samples collected from areas that have subsequently been capped or dredged were not included in the BHHRA dataset because these samples are no longer representative of current conditions. . Per an agreement with EPA, Tthe screening

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of contaminants of potential concern (COPCs) used only the subset of data ~~containing samples within the study area~~collected from RM 1.9 to RM 11.8 (and including Swan Island Lagoon and the mouth of Multnomah Channel), whereas the exposure assessment and risk characterization used both subsets of data containing samples from ~~within and outside the study area,~~RM- 1 to RM 12.2~~ per an agreement with EPA. –~~. A summary of in-water sediment samples ~~collected within the Study Area and~~ included in the BHHRA dataset is presented in Table 2-3~~, samples collected outside the Study Area are presented in Table 2-4~~.~~surface sediment chemistry data in the BHHRA dataset include LWG collected data (from Rounds 1, 2, and 3) and non-LWG collected data. Tables 2-3 and 2-4 present a summary of the surface sediment samples both within the Study Area and outside of the Study Area that are included in the BHHRA dataset. All non-LWG data included in the BHHRA dataset (see Section 2.0 of the RI Report) met the data quality requirements for risk evaluation (Category 1/QA2), as agreed to between LWG, EPA, and EPA's partners in the Programmatic Work Plan (Integral et al. 2004).~~

~~All in-water surface sediment data included in the BHHRA dataset were collected from the top 30.5 cm in depth, outside of the navigation channel of the river. Samples from within the Study Area were located throughout its entire length (RM 1.9 to RM 11.8), and samples outside of the Study Area extended downstream to RM 1.0, including Multnomah Channel, and upstream to RM 12.2. Surface sediment samples that were collected from areas that have been characterized in the SCRA as capped or dredged were not included in the BHHRA dataset because these samples are no longer representative of the current conditions in the Study Area. A more detailed description of the in-water sediment dataset used in this BHHRA is provided in Attachment F2; a description of samples that have been characterized as capped or dredged in the SCRA is provided in Appendix A of the RI Report.~~

2.1.3 Surface Water

~~To capture seasonal water flow conditions on the LWR, S~~surface water samples were collected by the LWG in seven separate events during Rounds 2 and 3 between 2004 and 2007, and are representative of various seasonal water flow conditions.~~Surface water data were collected by the LWG during Rounds 2 and 3, as described in Appendix A of the RI Report. All Round 2 and Round 3 surface water data between RM 1.9 and 11.8, as well as samples collected from Multnomah Channel, were included in the BHHRA dataset. The use of the surface water dataset in evaluating different human exposure scenarios is discussed in subsequent sections and in Attachment F2. Surface water sampling was performed in seven separate events between 2004 and 2007 to capture the seasonal water flow conditions on the LWR. Tables 2-5 and 2-6 present a summary of the surface water samples included in the BHHRA dataset from within and outside of the Study Area.~~

~~Amongst all seven sampling events,S 37 s~~sample~~urface water locations were sampled between RM 1.9 and RM 11.8, and were included in the BHHRA dataset.~~

Surface water samples were collected between ~~RM~~ RM 1.9 and ~~RM~~ RM 11.8 ~~in the BHHRA dataset were collected~~ from 32 single point stations and 5 transect locations (at ~~RM~~ RM 2.0, Multnomah Channel, ~~RM~~ RM 3.9, ~~RM~~ RM 6.3, and ~~RM~~ RM 11)~~.~~. One additional surface water sample was collected from ~~RM~~ RM 16, outside the boundaries of the Study Area~~.~~. Surface water samples were collected ~~with~~ using either a peristaltic pump or an XAD-2 Infiltrex™ 300 system (XAD)~~.~~. Single point samples included near-bottom and near-surface samples, as well as vertically integrated water column samples~~.~~. Transect samples included horizontally integrated near-bottom and near-surface samples, cross-sectional equal discharge increment samples ~~(i.e., samples~~ horizontally integrated across the entire width of the river ~~into a single sample for either near-surface or near-bottom horizontally integrated samples)~~, and vertically integrated samples from the east, west, and middle sections of a transect on the river~~.~~. Additional information on the surface water sampling methods is available in Section 5.3 of the RI Report. Tables 2-5 and 2-6 present a summary of the surface water samples included in the BHHRA dataset from within and outside of the Study Area, respectively.

2.1.4 Groundwater Seeps

A seep reconnaissance survey was conducted during Round 1 to document readily identifiable groundwater seeps along ~~approximately 17 miles of~~both sides of the river~~bank~~ from ~~RM~~ RM 2 to 10.5 (GSI 2003)~~.~~. Twelve potential groundwater seeps were observed at or near ~~a~~ potential human use beach areas~~.~~. Of these, only three sites were identified in the survey where it was considered likely for upland contaminants of interest (COIs)[6] to reach groundwater seeps or other surface expressions of groundwater discharging to human use beaches ~~(GSI 2003):),~~: the City of Portland sto~~rm~~ ~~RM~~rm-sewer Outfall 22B, Willbridge, and McCormick and Baxter ~~(~~at Willamette Cove~~).~~.

Of the ~~three potential groundwater seep areas~~se locations, only the Outfall 22B discharge was evaluated in ~~this~~ the BHHRA~~.~~. ~~At this location, g~~Groundwater infiltrates into the outfall pipe, which subsequently discharges to a beach~~. The beach where Outfall 22B discharges was~~ that has been identified as a potential transient use area~~, so exposure to the groundwater seep in that beach by transients is considered a potentially complete pathway.~~ . The groundwater seep ~~identified~~ at Willbridge is ~~in~~ at a beach restricted to industrial use, ~~and exposure to groundwater seeps is considered an incomplete pathway for workers.~~ ~~The~~ the groundwater seep ~~identified during the seep survey (GSI 2003)~~at ~~in~~ Willamette Cove, located downgradient of the McCormick and Baxter Superfund Site, was capped during remedial activities in 2004.

The stormwater pipeline that discharges at Outfall 22B provides a conduit for surface discharge of groundwater containing COIs that infiltrates into the pipe upland of the beach~~.~~. The sampling events at Outfall 22B are described in Appendix A of the RI

[6] Prior deliverables and some of the tables and figures attached to this document may use the te~~rm~~ RM "Chemicals of interest," which has the same meaning as "Contaminants of interest" and refers to "contaminants" as defined in 42 USC 9601(33).

Report.~~—~~. ~~Samples~~ Although samples have periodically been collected for analysis of the discharge at Outfall 22B ~~have periodically been collected for analysis,~~ both during ~~stormwater events~~ and outside of stormwater events,~~.~~ samples taken during stormwater events were not included in the BHHRA dataset because they were not considered representative of typical exposures.~~In order to represent potential exposure from the groundwater seep, samples taken during stormwater events were not included in the BHHRA dataset. The data from Outfall 22B met the data quality requirements for risk evaluation (Category 1/QA2), and the results of this sampling were included in the SCRA database.~~ Samples ~~taken~~ collected since 2002 were used in the BHHRA, and~~.~~ Table 2-5 presents a summary of the samples ~~from Outfall 22B~~ that were included in the BHHRA dataset~~.—~~. ~~The BHHRA Outfall 22B dataset is further described in Attachment F2. The sampling events for this data are described in Appendix A of the RI Report.~~

2.1.5 Fish Tissue

The target fish species to be evaluated for human consumption were identified in the Programmatic Work Plan (Integral et al.~~—~~. 2004~~).~~) and consisted of both resident and non-resident species~~.—.~~ Samples ~~Resident~~ of resident fish species ~~samples~~ were collected by the LWG during Rounds 1 and 3 ~~by the LWG.—~~. ~~In addition, adult white sturgeon (*Acipenser transmontanus*), adult spring Chinook salmon (*Oncorhynchus tshawytscha*), and adult Pacific lamprey (*Lampetra tridentate*) were~~Samples of non-resident fish species were ~~-~~collected in the summer of 2003 through a cooperative effort of the ODHS, Agency for Toxic Substances and Disease Registry (ATSDR), Oregon Department of Fish and Wildlife (ODFW), the City of Portland and EPA Region 10.~~ (This sampling effort is referred to as the "ODHS Study" in the rest of this BHHRA).~~ Table 2-7 presents a summary of the fish tissue samples included in the BHHRA dataset.

2.1.5.1 Resident Fish Tissue

Resident fish species evaluated in the BHHRA are ~~Smallmouth~~ smallmouth bass (*Micropterus dolomieui*), black crappie (*Pomoxis nigromaculatus)*, common carp (*Cyprinus carpio carpio)*, and brown bullhead (*Ameiurus nebulosus*)~~ were the resident fish species collected and analyzed to support the BHHRA.—~~. The sampling ~~design~~ protocol for each species differed ~~was~~ based on the reported home ranges of ~~the target fish~~species sampled~~.—~~. ~~, so the sampling approach differed based on species. For~~T ~~Round 1 data collection, t~~he tissue compositing scheme for the Round 1 data collection ~~for each sample~~effort was reviewed and approved by EPA in November and December 2002~~ prior to laboratory analysis.—~~. The Round 3 data collection, the tissue compositing scheme was approved by EPA in October 2007~~.—~~. Smallmouth bass and carp collected during Round 3 were analyzed separately as fillet and the remaining body-without-fillet tissue, and whole body concentrations were calculated using the individual fillet and body-without-fillet results~~.—~~. Thus, for the risk assessment, the Round 3 smallmouth bass samples were reported both as fillet and whole body results~~.—~~. ~~The For Round 3~~

~~data collection, the tissue compositing scheme for each sample was reviewed and approved by EPA in October 2007 prior to laboratory analysis.~~

~~During~~ ~~S~~Round 1, ~~s~~mallmouth bass samples were collected in Round 1 from eight locations between ~~RM~~ RM 2 and 9, and corresponding to their small home range (ODFW 2005), and ~~each corresponding to approximately one river mile. Smallmouth bass were collected and~~ composited based on each river mile ~~locations due to their small home range relative to the other fish collected during Round 1.~~ . Three whole body replicate composite samples were collected at three of the eight ~~river mile~~ locations~~. At each of the remaining five river mile locations,~~, one whole body composite sample and one fillet composite sample were collected at the 5 remaining sample locations~~.~~ . ~~All Round 1 results from within the Study Area were included in the BHHRA dataset.~~

~~During~~ Round 3~~,~~ ~~smallmouth bass~~samples were collected from 18 stations between ~~RM~~ RM 2 and 12, each corresponding to approximately one river mile, ~~and~~ either the west or east ~~portion~~ side of the river, or both~~.~~ . One composite sample was collected from each station, typically consisting of five individual fish~~.~~ . ~~for which F~~fillet ~~and the remaining~~ tissue and remainder tissue (body ~~without~~ without fillet) ~~tissue were analyzed separately, and whole body concentrations were calculated using the individual fillet and body without fillet results. Thus, for the risk assessment, the Round 3 smallmouth bass samples were reported as fillet and whole body results.~~ . ~~All Round 3 results were included in the BHHRA dataset.~~

B~~During Round 1, b~~lack crappie, common carp, and brown bullhead samples were collected during Round 1 and composited ~~for~~ from two three-mile long fishing zones, ~~RM~~ RM 3-6 and ~~RM~~ RM 6-9~~each approximately three river miles in length (RM 3-6 and RM 6-9).~~ . Three common carp and brown bullhead whole body and ~~three~~ fillet replicate composite samples were collected ~~at~~ from each ~~of the two fishing~~ zone~~s for common carp and brown bullhead.~~ . Two black crappie whole body and ~~two~~ fillet replicate composite samples were collected within each ~~of the fishing~~ zone~~s for black crappie.~~ . All ~~Round 1~~ results from within the Study Area were included in the BHHRA dataset.

During Round 3, common carp samples were collected ~~for~~ from three fishing zones, each approximately four river miles in length (~~RM~~ RM 0-4, ~~RM~~ RM 4-8, and ~~RM~~ RM 8-12)~~.~~ . Three common carp composite samples were collected from each fishing zone and analyzed separately as fillet tissue and ~~remainder~~ body-without-fillet tissue~~.~~ . All Round 3 results were included in the BHHRA dataset.

S~~For s~~mallmouth bass, black crappie, and common carp~~, all~~ fillet samples were analyzed as fillet with skin, except for the analysis of mercury, which was performed using fillet without skin~~.~~ . B~~For b~~rown bullhead~~, all~~ fillet samples were analyzed as fillet without skin.

2.1.5.2 Salmon, Lamprey, and Sturgeon

Adult white sturgeon (*Acipenser transmontanus*), adult spring Chinook salmon (*Oncorhynchus tshawytscha*), and adult Pacific lamprey (*Lampetra tridentate*)~~The tissue data collected during the~~ were collected during ODHS Study~~. . were the only non-LWG fish tissue data of acceptable data quality for risk evaluation (Category 1/QA2).~~ Although these data were not collected as part of the RI, ~~they~~ the data met Category 1/QA2 data quality requirement s and were evaluated by the LWG and used in this BHHRA~~. .~~

~~, adult white sturgeon (*Acipenser transmontanus*), adult spring Chinook salmon (*Oncorhynchus tshawytscha*), and adult Pacific lamprey (*Lampetra tridentate*)~~A

~~The a~~dult Chinook salmon samples were collected at the Clackamas fish hatchery~~. . Whole body, fillet with skin, and fillet without skin composite samples were analyzed.~~ Each composite sample ~~included~~consisted of three individual fish~~ three individual fish. .~~ Five ~~whole~~ whole-body~~ composite sample~~ (~~s,~~ including one split), three fillet with skin, and three fillet without skin composite samples were analyzed~~. .~~ The fillet without skin composite samples were only analyzed for dioxin, furan, and polychlorinated biphenyl (PCB) congeners and mercury.

A~~The a~~dult Pacific lamprey samples were collected at the Willamette Falls. ~~Only whole body composite samples were analyzed.~~ Four whole body composite samples, e~~ E~~ach ~~composite sample included~~ consisting of 30 individual fish~~. Four whole body composite samples~~ were analyzed~~. .~~

A~~The a~~dult sturgeon samples were collected between ~~RM~~ RM 3.5 and 9.2~~. . Only fillet without skin samples were analyzed. Each sample was an individual fish.~~ Six fillet samples were analyzed without skin~~,~~ (including one split), each sample consisting of a single fish~~, were analyzed~~.

2.1.6 Shellfish Tissue

~~Shellfish tissue in the BHHRA dataset included field-collected samples for Ccrayfish and clam (*Corbicula* sp.) tissue samples were collected and included in the BHHRA dataset. Crayfish samples were collected during Rounds 1 and 3 and clam samples were collected during Rounds 1, 2, and 3. Although data from laboratory bioaccumulation samples were also available from Round 2, these data were not used because field-collected tissue samples provide for a more direct evaluation of potential human exposure than laboratory bioaccumulation samples. No field-collected, non-LWG shellfish tissue data of acceptable data quality for risk evaluation (Category 1/QA2) were identified. Tables 2-7 and 2-8 present a summary of the shellfish tissue samples included in the BHHRA dataset, from both inside and outside the Study Area, respectively.~~

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C~~For c~~rayfish~~,~~ samples were collected from 24 stations during Round 1~~. The Round 1 crayfish stations were selected~~ based on habitat areas~~. Crayfish were collected,~~ and from 9 stations during Round 3~~. The Round 3 crayfish stations were~~ based on habitat areas and data needs identified by the EPA ~~and habitat areas.~~ . Commensurate with their limited home range, ~~Crayfish~~ crayfish were collected and ~~composited~~ analyzed as whole body composite samples from each individual station~~s commensurate with their limited home ranges.~~ . ~~Only whole body composite samples were collected for crayfish.~~ During Round 1, two replicate composite samples were collected at three of the 24 stations~~.~~; ~~A~~a ~~t each of the remaining stations, a~~ single composite sample was collected at the remaining stations~~.~~ . During Round 3, a single composite sample was collected at each station.

Clams~~For clams, samples~~ (*Corbicula* sp.) were collected from ~~3~~ three stations during Round 1, 33 stations during Round 2, and 10 stations during Round 3~~.~~ , ~~S~~sampling locations were based on habitat areas and biomass availability.~~.~~ ~~Clams were collected and composited from individual stations that were selected based on habitat areas and biomass availability.~~ A single composite sample was collected at each station in Rounds 1 and 2~~.~~ . In Round 3, two composite samples were collected from each of five stations, and a single composite sample was collected from each of the remaining five stations~~.~~ . ~~Depuration is a common method for cleansing shellfish that is often done prior to human consumption to eliminate the sediment present in the gastrointestinal (GI) tract of the shellfish. The~~ Round 1 and Round 2 ~~field-collected clams~~samples were ~~not depurated prior to analysis~~analyzed undepurated~~, and the data therefore may over predict human health risks from this exposure pathway for consumers that do depurate clams prior to consumption.~~ . ~~In~~ As previously noted, two samples were collected from each sampling station in Round 3~~,~~ , one sample from each station was depurated prior to analysis, the other was analyzed undepurated~~.~~ . ~~five samples were depurated prior to analysis (depurated samples were from stations where two samples were collected; one sample from each Round 3 station was not depurated). Additional discussion of the potential effects of depuration on human health risks is included in Section 6. All LWG field-collected clam samples were included in the BHHRA dataset.~~ Although data from laboratory bioaccumulation samples were also available from Round 2, these data were not used because field-collected tissue samples provide for a more direct evaluation of potential human exposure than laboratory bioaccumulation samples~~.~~ . Tables 2-7 and 2-8 present a summary of the shellfish tissue samples included in the BHHRA dataset, from both inside and outside the Study Area, respectively.

2.2 ~~USE OF DATA~~DATA EVALUATION

Prior to using the data in the BHHRA, the data ~~reduction was conducted~~were evaluated for inclusion in the BHHRA consistent with the Guidelines for Data Reporting, Data Averaging, and Treatment of Non-Detected Values for the Round 1 Database (Kennedy/Jenks Consultants et al~~.~~ . 2004), the Exposure Point

Concentration Calculation Approach and Summary of Exposure Factors (Kennedy/Jenks Consultants 2006), and Proposed Data Use Rules and Data Integration for Baseline Human Health Risk Assessment (BHHRA), submitted to EPA in a May 28, 2008 email ~~communication with EPA. .~~ . D~~ata reduction and d~~ata use rules applied to the combining of surface water data collected by different methods, the handling of non-detects, the summing of chemical groups, and the calculation of exposure point concentrations (EPCs)~~. .~~ . ~~These rules are described in detail in Attachment F2.~~

2.2.1 Excluded Data

The data used BHHRA ~~consists only of data that~~ meet Category 1/QA2 data quality objectives, as described in Section 2.2 of the RI Report~~. .~~. Data that were not of this quality were removed from the BHHRA dataset~~. .~~. General reductions of the SCRA dataset to create the BHHRA dataset included removal of rejected analytical results ("R" qualified results), and removal of analytical results of samples collected from locations that have been capped, dredged, or remediated. This included all samples flagged as capped, dredged or remediated, including data from task WLCMBI02: the McCormick & Baxter September 2002 Sampling.

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2.2.2 Field Replicates

Field replicates within the BHHRA dataset were handled per agreements with EPA~~.~~ . When calculating a mean or an upper confidence limit (UCL), and when reporting data in general, replicates were included in the dataset as discrete samples~~. .~~. Replicates with unique coordinates were included as separate samples when mapping or spatially weighing data~~. .~~. Where replicates have the same coordinates, data associated with the first sample were used and data from the second or third replicates were excluded.

2.2.3 Co-elution of PAHs

Benzo(b+k)fluoranthenes and benzo(k+j)fluoranthenes co-eluted in certain surface water and in-water sediment samples~~. .~~. For the purposes of the BHHRA, benzo(b+k)fluoranthenes results were assumed to be completely benzo(b)fluoranthene, and benzo(k+j)fluoranthenes results were assumed to be completely benzo(k)fluoranthene~~. .~~. Analytical results for these samples were not presented as co-elutions in the BHHRA, but rather, were presented as results for their assumed analyte.

2.2.4 Treatment of PCB Surface Water Data

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Polychlorinated biphenyls (PCBs) were analyzed as Aroclors in samples collected using a peristaltic pump, and as congeners in high-volume samples collected using the XAD-2 sampling method~~. .~~. ~~The~~Because detection limits for the peristaltic pump

samples were higher than ~~the~~those using high-volume samples, ~~so~~ the results for PCBs from the high-volume samples were used~~.~~. ~~In the high-volume samples, PCB~~ Aroclor concentrations in the high-volume samples were estimated from the PCB congener data by the analytical laboratory~~.~~. Therefore, Aroclor data were not used, and only PCB congener data were used to assess PCBs in the BHHRA surface water dataset.

2.2.5 ~~2.5.1~~ Combining XAD Column and Filtered Surface Water Data

The XAD water quality samples consisted of two components: chemicals retained on the column that –are representative of the dissolved concentration, and chemicals retained on the filter that are representative of the concentration of the suspended particulate fraction~~.~~. In order to create a whole water sample from the XAD results, the ~~A~~analytical results for column and filter fractions for a given chemical were combined to give a total concentration~~.~~. The following rules were used ~~to combine the two concentrations measured in the column and filter~~ to calculate a whole water concentration for ~~that~~individual samples:

- If an ~~chemical~~analyte was detected in both the filter and the column, the detected concentrations were summed~~.~~.
- If an ~~chemical~~analyte was detected in either the filter or the column but not in both portions of the sample, only the detected concentration was used.
- If an ~~chemical~~analyte was not detected in both the filter and the column, the highest detection limit reported for either the filter or the column was used~~.~~.

S~~ample IDs for~~ surface water samples collected using the high-volume XAD-2 sampling method ~~contain~~are identified with the letters "XAD."~~.~~ ~~Sample IDs for the~~The results of the combined XAD-2 column and filter data were renamed "WSXAD-Combo," and are presented as such in the BHHRA.

2.2.6 ~~2.5.2~~ Combining Horizontal and Vertical Surface Water Data

~~For some surface water exposure scenarios, the appropriate~~When evaluating surface water exposures ~~point is th~~for divers, transients, and residential/domestic water use, ~~e detected concentrations~~The ~~available~~ surface water data described in Section 2.1.3 were~~entire water column,~~ vertically integrated ~~from bottom to surface~~ prior to use in the BHHRA.~~.~~ T~~In the case of~~Where transect samples ~~were collected, the appropriate exposure point is the concentrations were~~are presented as a vertically and horizontally integrated transect~~.~~. N~~During some of the surface water sampling events, n~~on-integrated samples were collected from both near-bottom and near-surface (NB/NS) depths within the water column at ~~a given~~ single-point sampling locations~~.~~. V~~For some transect locations, v~~ertically-integrated transect samples were collected from the east, west, and middle (E/W/M) sections of the river, ~~or~~ horizontally integrated samples were collected from NB or NS water depths~~.~~. ~~For exposure points representing direct contact with surface water,~~ NB/NS and/or

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E/W/M samples from the same location and date were combined to provide an integrated value for the water column or transect.~~—~~. In these cases, ~~the~~ single-point data from NB and NS were vertically combined~~;~~, ~~the~~ vertically-integrated data from E/W/M were horizontally combined; and ~~the~~ horizontally-integrated data from NB/NS were vertically combined using the following rules:

- If an ~~chemical~~analyte was detected in each sample, the detected concentrations were averaged ~~and the average was used.~~ .
- If an analyte ~~chemical~~ was detected in at least one sample ~~and not detected in at least one sample~~, ~~the detected~~the mean concentration was calculated using ~~concentration(s) were averaged with ½~~one-half the detection limit ~~of the non-detected concentration(s), and the average was used~~for non-detect results.
- If ~~a chemical was not detected in any of the two or three samples to be combined~~all results were non-detect, ~~the full detection limit of each sample was averaged~~the mean of the detection limits was calculated~~,~~ and ~~the average was~~ used as the non-detected concentration ("U" qualified).
- ~~If a result for a given analyte was rejected or did not exist for any of the two or three samples to be combined, a combined value was not calculated.~~
- In some ~~cases~~instances, a field replicate sample was collected from the middle of the river without corresponding replicate samples from the east or west side of the river, ~~(~~indicated by "M2" in the Sample ID~~).~~ ~~—~~. The results from these samples were included in the dataset at their reported concentrations, without combining them with other results.

Sample IDs for the results of the horizontally or vertically combined integrated data were renamed to include "-Int" at the end of the ID name, and are presented as such in the BHHRA ~~as such~~.

2.2.7 Combining Fillet and Body ~~–~~Without ~~–~~Fillet Tissue Data

Smallmouth bass and carp samples collected during the LWG Round 3 sampling event were analyzed separately as fillet~~-~~ and body ~~–~~without ~~–~~fillet tissue~~.~~ ~~—~~. The results of these analyses were combined on a weighted-average basis to provide whole body results for use in the BHHRA~~.~~ ~~—~~. The steps used in combining the data were as follows:

- The whole-body tissue mass was calculated for each individual fish within each composite by summing its fillet~~-~~ and body-without-fillet tissue mass.
- The ratio of fillet to whole-body tissue mass was calculated for each individual fish within each composite~~.~~ ~~—~~. Likewise, the ratio of body-without-fillet to whole-body tissue mass was calculated for each individual fish within each composite.

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- For each composite, the average of the fillet- to whole-body tissue mass ratios was calculated, and the average of body-without-fillet to whole-body tissue mass ratios was calculated to provide an average of the percentage of fillet- and body-without-fillet tissue mass for each composite.

The average percentages were then used to calculate a weighted average ~~of the analytical results~~concentration for each composite sample ~~using~~according to the following rules:

- If the analyte was detected in both the fillet tissue and the body without fillet tissue, a weighted average was calculated using the detected values
- If the analyte was not detected in either of the tissue types, a weighted average was calculated using the full detection limits
- If the analyte was detected either the fillet or body-without-fillet sample, one-half the detection limit for the non-detect result was used to calculate the weighted average.

The combined fillet and body without fillet tissue data were considered whole body tissue results for carp and smallmouth bass and were used in the BHHRA as such.

2.2.8 ~~Summed Analytes and~~ Summation Rules for Analytes Evaluated as Summed Values

Certain ~~Some toxicity values used in the BHHRA were based on exposure to chemical~~contaminants were evaluated as the sum of similar individual ~~mixtures that are~~ congeners, isomers, and ~~or~~ closely related degradation products of ~~a~~the parent compound ~~. As a result, risks were evaluated in the BHHRA based on exposure to the chemical mixture~~ rather than as ~~to the~~ individual ~~components~~chemicals~~.~~. The chemicals evaluated as mixtures and for which analytes ~~were~~evaluated as ~~summed~~sums in the BHHRA ~~include~~are as follows:

- Total PCBs ~~(either as sum of Aroclors or sum of congeners)~~were calculated as either the sum of nine Aroclor mixtures (1016, 1221,1232, 1242, 1248, 1254, 1260, 1262, 1268) or the sum of individual PCB congeners.
- Total endosulfan was calculated as the sum of α-endosulfan, β-endosulfan, and endosulfan sulfate.
- Total chlordane was calculated as the sum of *cis*- and *trans*-chlordane, oxychlordane, and *cis*- and *trans*-nonachlor.
- Total DDD was calculated as the sum of 2,4'-DDD and 4,4'-DDD.
- Total DD~~T~~E was calculated as the sum of 2,4'-DDE and 4,4'-DDE
- Total DD~~E~~T was calculated as the sum of 2,4'-DDT and 4,4'-DDT

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- Total dioxin-like PCB congeners were calculated as the sum of PCBs 77, 81, 105, 114, 123, 126, 156, 157, 167, 169, and 189.
- Total PCBs-adjusted ~~(~~were calculated as the sum of total PCB congeners ~~without~~minus dioxin-like PCB congeners.~~)~~

~~Total dioxin-like PCB congeners (calculated to determine value for total PCBs-adjusted)~~

- Total xylenes were calculated as the sum of *m*-, *o*-, and *p*-xylene.

The individual components of each chemical mixture used in the BHHRA are presented in Table F2-2.~~.~~ ~~¿~~

If an individual analyte of a chemical mixture was detected at least once within the study area in a given medium, it was considered present in that medium~~.~~ ~~–~~. ~~For,~~ The presence of an analyte in biota samples was assessed separately for each individual species and tissue~~.~~ ~~–~~. The presence of individual analytes in sediment, and surface water were also assessed separately based on the specific exposure scenario~~.~~ ~~–~~. Individual analytes that were a part of a chemical mixture but were determined not to be present are summarized in Table F2-3 by medium and species~~.~~ ~~–~~. Additionally, a minimum number of individual analytical results in the mixture was required for the summed analytical result to be calculated ~~(regardless of whether the analyte was detected or determined to be present).~~ ~~–~~. For example, if a sample was only analyzed for a limited number of individual PCB congeners, or if a large number of individual congener results for a sample were rejected, a total PCB congener sum may not have been calculated~~.~~ ~~–~~. In addition, chemical mixtures for samples meeting the criterion for the minimum number of individual analytical results required to calculate a sum, but with a limited number of individual analytical results, were qualified with an "A."~~–~~ Mixture sums that did not have a limited number of individual analytical results were qualified with a "T," indicating a calculated total~~.~~ . Table F2-4 shows the minimum number of individual analytical results required to calculate a sum for each mixture, and the maximum number of individual analytical results that would result in an "A" qualifier, indicating a limited number of individual analytical results were available for a sample~~.~~ ~~–~~. Table F2-4 also lists the number of samples for each medium for which a summed total was calculated, and the number of samples for which a summed total was not calculated because of lack of individual analytical results for the mixture~~.~~ ~~–~~. Sample IDs of samples for which a summed analytical result was not calculated are presented in Table F2-5.

Concentrations of the individual analytes that comprise ~~the~~a mixture~~s~~ were summed for each sample according to the following rules~~, unless otherwise noted~~:

- If an ~~individual~~ analyte was detected in the sample, the detected concentration was used ~~for that chemical in~~to calculate the sum

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- If an ~~individual~~ analyte was not detected in ~~the~~a sample but was ~~determined~~assumed to be present in the sample medium ~~according to the rules in Section 3.1~~, one-half the detection limit was used ~~for that chemical in~~to calculate the sum

- ~~If an individual analyte was determined not to be present in the medium according to the rules in Section 3.1, it was not included in the sum~~

- If ~~none of the individual analytes were detected in the sample~~all results were non-detect, the highest detection limit of the analytes ~~determined~~assumed to be present in the medium ~~according to the rules in Section 3.1~~ was used as the detection limit for the ~~sum~~sample, and the sample was flagged as a non-detect.

~~For surface water, a chemical mixture could result in different summed values for the same sample. This is because these summation rules are based upon the presence of individual analytes in the receptor-specific study area-wide dataset for a given medium, and surface water is the only medium for which subsets of data are different for the different human receptors.~~

~~For some chemical mixtures, a minimum number of individual analytical results in the mixture was required for the summed analytical result to be calculated (regardless of whether the analyte was detected or determined to be present). For example, if a sample was only analyzed for a limited number of individual PCB congeners, or if a large number of individual congener results for a sample were rejected, a total PCB congener sum may not have been calculated. In addition, chemical mixtures for samples meeting the criterion for the minimum number of individual analytical results required to calculate a sum, but with a limited number of individual analytical results, were qualified with an "A." Mixture sums that did not have a limited number of individual analytical results were qualified with a "T," indicating a calculated total. Table F2-4 shows the minimum number of individual analytical results required to calculate a sum for each mixture, and the maximum number of individual analytical results that would result in an "A" qualifier, indicating a limited number of individual analytical results were available for a sample. Table F2-4 also lists the number of samples for each medium for which a summed total was calculated, and the number of samples for which a summed total was not calculated because of lack of individual analytical results for the mixture. Sample IDs of samples for which a summed analytical result was not calculated are presented in Table F2-5. This table shows 85 in-water samples for which Total PCB congeners were not calculated because of limited number of analytical results from the City of Portland outfall sediment investigation. These samples were analyzed for a limited number of congeners that did not meet the minimum number of PCB congeners required to compute a sum. In addition, TEQs were calculated for dioxin and furan congeners and dioxin-like PCB congeners, as discussed in Section 4.0 of this Attachment F2.~~

2.2.9 Total Dioxin/Furan and PCB TEQs

A toxicity equivalence procedure was used to assess the cumulative toxicity of complex mixtures of PCDD, PCDF, and PCB congeners. The procedure involves assigning individual toxicity equivalency factors (TEF's) to the PCDD, PCDF, and PCB congeners in terms of their relative toxicity to 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (2,3,7,8-TCDD). ~~. Toxic Equivalents (TEQs)~~

~~Toxic equivalency factors (TEFs) were used to evaluate risks from dioxin and furan congeners and dioxin-like PCB congeners. C~~The reported concentration~~s~~ of ~~congeners~~each congener in a sample ~~are~~is multiplied by ~~their~~its respective TEF~~s~~ to ~~estimate~~give the TEF-equivalent ~~toxicity~~concentration~~ of the congeners relative to 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (2,3,7,8-TCDD).~~ . The resulting concentrations are then summed ~~into a~~to give a TEQ~~.~~. The World Health Organization (WHO) TEFs (Van den Berg et al. 2006), shown in Table 4-3, were used to calculate the total dioxin/furan and PCB TEQs~~.~~. Dioxin/furan and PCB-TEQs were calculated according to the following rules~~The following subsections discuss how the TEQs used in the BHHRA were calculated.~~

~~4.1 Total Dioxin/Furan TEQ~~

~~Total dioxin/furan TEQ was calculated by multiplying dioxin and furan congeners by their TEFs, and summing the resulting concentrations. The World Health Organization (WHO) TEFs (Van den Berg et al. 2006), which are shown in Table 4-3 of Appendix F, were used to calculate the total dioxin/furan TEQ. Total dioxin/furan TEQs were calculated according to the following rules:~~

- ~~For those congeners that were detected, the detected concentration multiplied by the TEF was used in the sum~~
- ~~For those c~~Congeners ~~that were~~reported as not detected in a given sample~~,~~ but determined to be present in the medium ~~according to the rules in Section 3.1~~, ½one-half the detection limit multiplied by the TEF was used in the sum
- ~~Congeners that were determined not to be present in the medium according to the rules in Section 3.1 were not included in the sum~~
- If all ~~congeners~~results ~~used to create a TEQ~~in a sample were non-detect~~s~~, the maximum toxicity-weighted detection limit was used for the TEQ, and the result was flagged as non-detect (U-qualified)~~.~~. The maximum toxicity-weighted detection limit was obtained by multiplying each detection limit by its respective TEF and selecting the maximum value.
- Dioxin/furan TEQs were not calculated for those samples where a~~A~~nalytical results ~~were needed~~ for all 12 dioxin/furan congeners ~~for a TEQ to be calculated, regardless of whether it determined to be present, as indicated in Table F2-4 (i.e., a~~

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~~dioxin/furan TEQ was not calculated for a sample if at least one individual dioxin/furan congener result was rejected, or not analyzed for)~~were not available.

~~4.2 TOTAL PCB TEQ~~

~~Total PCB TEQ was calculated by multiplying coplanar PCB congeners by their TEFs and summing the resulting concentrations. The WHO TEFs, which are shown in Table 4-3 of Appendix F, were used to calculate the total PCB TEQ. The rules for calculating the total PCB TEQ are the same as those used for calculating the total dioxin/furan TEQ.~~

~~4.3 TOTAL TEQ~~

Values were not presented for total TEQ in the BHHRA~~.~~. Rather, risks from total TEQ were estimated by summing the risks from the total PCB TEQ and the total dioxin/furan TEQ.

~~For the purposes of mapping total TEQ concentrations, the values for total PCB TEQ and total dioxin/furan TEQ were summed. If a sample did not have both PCB TEQ and dioxin/furan TEQ values, a total TEQ was not calculated.~~

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2.3 CHEMICAL SCREENING CRITERIA AND SELECTION OF ~~COPC~~CONTAMINANTS OF POTENTIAL CONCERN~~s~~

~~EPA guidance (1989) recommends considering criteria to limit the number of chemicals that are included in a quantitative risk assessment while also ensuring that all contaminants that may contribute significantly to the overall risk are addressed. According to EPA guidance, the screening procedure is used to focus quantitative risk assessment efforts on contaminants that could be of concern under health-protective exposure assumptions. For purposes of the BHHRA, the only screening criterion used to select COPCs was a comparison with risk-based concentrations, a~~As ~~described in the Programmatic Work Plan (Integral et al. 2004),~~ Because of the large number of chemicals detected in environmental media, a risk-based screening approach was used to focus the risk assessment on those contaminants most likely to significantly contribute to the overall risk. COPCs were selected for quantitative evaluation in the BHHRA by comparing the SCRA analytical data to risk-based screening values~~).~~. The specific risk-based concentrations used to select COPCs are described below for the ~~respective~~ each media~~BHHRA media.~~. ~~If the maximum detected concentration of a contaminant in a specific media was greater than the screening level, that contaminant was selected as a COPC for beach sediment. When specified below, COPCs were selected for a medium based on a subset of data determined to represent exposure to a specific human population. Potentially exposed human populations are discussed as part of the exposure assessment in Section 3, and include but are not limited to: transients, divers, recreational beach users, and fishers.~~

2.3.1 Sediment

~~2.3.1 Sediment~~

~~Sediment data were quantitatively evaluated in the BHHRA for direct exposure scenarios. As a health-protective initial approach, the current~~ EPA's Regional Screening Levels (RSLs) for soil (EPA 2010a) were used as the ~~basis for~~ screening values for beach and in-water sediment~~s~~.~~.~~. RSLs are risk-based concentrations in soil, air and water, and have been developed for both residential and industrial exposure scenarios~~.~~. Using default exposure assumptions, RSLs represent concentrations that equate to a target cancer risk of 1×10^{-6} or a hazard quotient of 1~~.~~. As described in Region 10 guidance (2007a), RSLs based on a noncancer endpoint were divided by 10 to give a value equivalent to using a

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hazard quotient of 0.1.~~–~~. This was done to account for the additive nature of noncancer effects.~~–~~. RSLs based on ~~For noncarcinogenic chemicals, the EPA RSLs~~noncancer endpoints were divided by 10 to account for potential cumulative effects from multiple chemicals, and these modified RSLs were used as the screening values.~~–~~. ~~For chemicals that exhibit both carcinogenic and noncarcinogenic effects, the lower screening value was used for selecting COPCs.~~ Consistent with the then current EPA Region- 10 ~~guidance~~recommendations (EPA, 2008), a RSL of 7.7- mg/kg in soil for residential land use was calculated for trichloroethylene (TCE) using a cancer slope factor of 0.089 per mg/kg--day, ~~representing~~which represents the geometric mid-point of the slope factor range from EPA 2001.~~–~~. EPA finalized its risk assessment for TCE in 2011 and the revised RSL is 0.9 mg/kg. Because TCE does not contribute substantially to the cumulative risk estimates for the in-water portion of Portland Harbor, the screening process was not re-evaluated. Chemicals for which no RSL was available were screened using RSLs for~~Surrogate~~ chemicals with a similar chemical structures~~, RSLs for were used if available (e.g., pyrene was used as a surrogate for phenanthrene) for chemicals without RSLs.~~ –.

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~~Dividing EPA RSLs for noncarcinogenic chemicals by 10 is Because the potential exposure to sediments that may occur is anticipated to be less than the exposure that was assumed to occur with soil in developing the EPA RSLs, the soil RSLs represent conservative screening values for protection of human health.~~ Because uses of Portland Harbor include both recreational and industrial activities, COPCs were selected using both residential and industrial ~~EPA~~ RSLs, consistent with the EPA comments on the Round 2 Comprehensive Report ~~provided on January 15, 2008~~ (EPA- 2008b).~~ For chemicals that do not have EPA RSLs, EPA RSLs for surrogate chemicals with similar chemical structures were used if available (e.g., pyrene for was used as a surrogate for phenanthrene). As required by EPA Region 10 (see e-mail from Dana Davoli to Laura Kennedy, October 17, 2008, in Attachment F1), for trichloroethylene, the geometric mid-point of the slope factor range from EPA 2001 (0.089 per mg/kg-day) was used for evaluating cancer risks for both inhalation and oral exposures. This value was also used to calculate an acceptable soil screening level of 7.7 mg/kg.~~ Residential

~~For carcinogenic chemicals, the EPA RSLs were used as the screening values. For noncarcinogenic chemicals, the EPA RSLs were divided by 10 to account for potential cumulative effects from multiple chemicals, as required by EPA Region 10 (2007a), and these modified RSLs were used as the screening values. For chemicals that exhibit both carcinogenic and noncarcinogenic effects, the lower screening value was used for selecting COPCs.~~

~~EPA RSLs have been developed for both residential and industrial exposure scenarios for soil. Residential soil EPA RSLs are based on exposure assumptions of 350 days per year. For cancer endpoints, the residential EPA RSLs are calculated using an age-adjusted soil ingestion factor that takes into account the difference in daily soil ingestion rates, body weight, and exposure duration for children from 1 to 6 years old and others from 7 to 31 years old (total exposure over 30 years). For noncancer endpoints, the residential EPA RSLs are calculated using exposure factors for children from 1 to 6 years old and chronic toxicity criteria. Industrial soil EPA RSLs are based on exposure assumptions of 250 days per year for 25 years. Both residential and industrial EPA RSLs are based on a target cancer risk of 1 x x 10^{-6} for carcinogenic chemicals or a hazard quotient of 1 for noncarcinogenic chemicals. Dividing EPA RSLs for noncarcinogenic chemicals by 10 is equivalent to using a hazard quotient of 0.1. Because the potential exposure to sediments that may occur is anticipated to be less than the exposure that was assumed to occur with soil in developing the EPA RSLs, the soil RSLs represent conservative screening values for protection of human health. Because uses of Portland Harbor include both recreational and industrial activities, COPCs were selected using both residential and industrial EPA RSLs, consistent with the EPA comments on the Round 2 Comprehensive Report provided on January 15, 2008 (EPA 2008b).~~

~~For beach sediment, residential soil EPA~~ RSLs were used to select COPCs ~~in for~~in beach sediment ~~in~~for those areas where exposures could occur during recreational, transient, or fishing activities~~.~~ ~~Only~~ in those areas considered reasonably accessible~~, such as those with access~~ from contiguous upland areas or by boat~~.~~. In-water sediment data collected within the navigation channel were not used in the COPC screen~~.~~. ~~were evaluated as~~ In areas where occupational exposures could occur, and for in-water sediment~~,~~ COPCs were selected using industrial ~~soil EPA~~ RSLs~~.~~.

If the maximum detected concentration of a contaminant at a specific use area was greater than its respective screening level, that contaminant was selected as a COPC~~.~~. The designated potential uses for beaches in the Study Area are presented in ~~Map~~ Map 2~~–~~1~~.~~. ~~The contaminants selected as~~ COPCs ~~for~~for beach ~~beach~~ sediment and the rationale for selection are presented in Tables~~-~~ 2-9 and 2-10~~,~~. COPCs for in-water sediment are presented in Table 2-11.

~~Groundwater Seep~~

~~Chemicals concentrations detected in the groundwater seep at Outfall 22B were compared to the residential tapwater RSLs. . As with the soil RSLs, the tapwater RSLs based on a noncancer endpoint were divided by 10 to give values equivalent to a HQ of 0.1. . The location of Outfall 22B is shown on Map 2-5, and COPCs are presented in Table 2-15.~~

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~~The extent of direct contact (i.e., ingestion and dermal contact) with in-water sediment that could occur under site-specific exposure scenarios would be significantly less than with upland soil or beach sediment. Therefore, COPCs for in-water sediment were identified using only the industrial soil EPA RSLs.~~

2.3.2 Surface Water ~~and Groundwater Seeps~~

Screening values for surface water and groundwater seeps ~~Surface water and groundwater seep data were quantitatively evaluated in the BHHRA for direct exposure scenarios. A discussion of potential sources of contaminants to surface water is provided in the RI. As a health-protective initial approach,~~ EPA residential tapwater RSLs ~~for residential tapwater~~ (EPA 2010a) and MCLs (EPA 2003a) ~~-~~were generally used as ~~the~~ screening values for surface water and the groundwater seep to select COPCs for direct exposure scenarios~~.~~ . ~~For chemicals that do not have EPA RSLs, EPA RSLs for surrogate chemicals with similar chemical structures were used if available (e.g., pyrene for phenanthrene). As required by EPA Region 10 (EPA 2007a),~~ TCE was evaluated using the~~the~~ EPA Region 6 Human Health Medium-Specific Screening Level~~s for trichloroethylene~~ (EPA 2008a)~~, rather than the EPA RSLs, were used in this BHHRA.~~ . ~~For carcinogenic chemicals, the EPA RSLs were used as the screening values. For noncarcinogenic chemicals, the EPA RSL was divided by 10 to account for potential cumulative effects from multiple chemicals, and this modified EPA RSL was used as the screening value, as required by EPA Region 10.As with the soil RSLs, screening levelsthe tapwater RSLs based on a noncancer endpoint were divided by 10 to give values equivalent to a HQ of 0.1.~~

COPCs were selected separately for divers ~~and~~, transient/beach user exposures, and the potential use of surface water as a ~~drinkinghousehold~~drinking~~—~~ water source.~~.~~ COPCs for evaluating exposure ~~by~~to divers and for drinking water were selected from ~~all available surface water samples taken within the Study Area~~the combined surface water data set described in Section 2.2.6~~.—~~. ~~Near-bottom and near-surface sample results, as well as vertically integrated transect results, were combined according to the rules described in Attachment F2 prior to selecting COPCs. For transients and beach users,~~ COPCs for transient and beach use scenarios were selected from surface water samples taken from areas where direct contact ~~with transient or beach users~~ could occur.~~, including both single point sampling stations where vertically integrated samples were collected and transect samples. This included one sample from Swan Island Lagoon.~~ A summary of samples used for screening surface water for COPCs is provided in Table 2-12~~.—~~. Sample locations of surface water data evaluated and COPCs for diver exposures are shown on Map 2-3 and in Table 2-13; sample locations and COPCs for transient and recreational beach uses~~, diver exposures,~~ are shown on Map 2-4 and Table 2-14; sample locations and COPCs for ~~household~~the use of surface water as a drinking water source are shown on ~~Map 2-3, 2-4, and~~ Map 2-8~~, respectively~~ and in Table 2-16.~~ Surface water data gathered during the RI were used to identify the COPCs for quantitative evaluation in the BHHRA. At the direction of EPA, results from surface water samples collected near-bottom and near-~~

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surface within the water column were combined according to the rules described in Attachment F2. The combined near-bottom and near-surface samples, vertically integrated single point samples, and vertically integrated transect samples were used to select the COPCs. These samples are presented in Table 2-12, and shown in Map 2-8. Filter and column data collected from samples collected by XAD were combined before selection of COPCs, according to the rules described in Attachment F2Section 2.2.5. The contaminants selected as COPCs for surface water as a drinking water source, and the rationale for selection, are presented in Table 2-16.

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2.3.3 Groundwater Seep

Chemicals concentrations detected in the groundwater seep at Outfall 22B were compared to the residential tapwater RSLs. As with the soil RSLs, the tapwater RSLs based on a noncancer endpoint were divided by 10 to give values equivalent to a HQ of 0.1. The location of Outfall 22B is shown on Map 2-5, and COPCs are presented in Table 2-15.

No further data reduction was performed on the hypothetical future domestic water dataset prior to COPC selection.

For chemicals that were detected in this dataset, the detected concentrations were compared to screening values based on the RSLs for tap water and on EPA MCLs for drinking water (EPA 2003a). If the maximum detected concentration of a contaminant in surface water was greater than either of the screening values, that contaminant was selected as a COPC for surface water and was quantitatively evaluated in the BHHRA.A summary of samples used for for each surface water COPC screening surface water for COPCs is provided in Table 2-12. SIn addition, the sample locations of the surface water data evaluated for transients and recreational beach uses r exposure scenarios are shown in Map 2-3., The sample locations of the surface water data evaluated for diver exposures are shown in Map 2-4.

Fish and Shellfish Residential tapwater EPA RSLs are based on domestic use of water, including ingestion, and represent conservative screening values for direct contact scenarios where water may not be used for domestic purposes, such as surface water contact during beach recreation. EPA RSLs are based on a target cancer risk of 1 x -x 10^{-6} for carcinogenic chemicals or a hazard quotient of 1 for noncarcinogenic chemicals. Dividing EPA RSLs for noncarcinogenic chemicals by 10 is equivalent to using a hazard quotient of 0.1.

2.3.3 Tissue

EPA Region 10 has not accepted any risk-based screening criteria for screening tissue from Portland Harbor; therefore, per an agreement with EPA, risk-based concentrations were not used for screening the tissue data,. Aand all chemicals

detected in fish and shellfish in the BHHRA dataset were selected as COPCs for tissue.

2.3.4 Hypothetical Future Exposure to Untreated Surface Water for Domestic Use

Even though no current or future uses of the LWR within Portland Harbor as a domestic water source have been identified, under OAR 340-041-0340 Table 340A, domestic water supply is a designated beneficial use of the Willamette River, with adequate pretreatment. Because the Willamette River is capable of serving as a potential drinking water source, the expectation is that this resource will be protected to achieve such use with adequate pretreatment. Although surface water within the Study Area is not currently used as a domestic water source, nor are there future plans for domestic water use within the Study Area, surface water data were quantitatively evaluated in the BHHRA as a hypothetical future domestic water source at the direction of EPA (see Section 2.4.5 below). The same criteria and screening values used for data to assess direct contact with surface water and the groundwater seep were used to select COPCs for surface water as a hypothetical future domestic water source. As with the surface water and groundwater seep screening, the noncarcinogen RSLs were divided by 10 to account for potential multiplicative effects, and the modified RSLs were used as the screening values.

In addition to the EPA RSLs, EPAEPA residential tapwater RSLs (EPA 2010a) and maximum contaminant levels (MCLs) for drinking water (EPA 2003a) were used as screening criteria for the selection of COPCs for the hypothetical future use of untreated surface water for for drinking waterdomestic purposes. If the maximum detected concentration for of a contaminant in the dataset selected to represent hypothetical exposure to untreated surface water for domestic use exceeded either the EPA RSL or the EPA MCL, the contaminant was selected as a COPC for this scenario.

2.4 IDENTIFICATION OF CONTAMINANTS OF POTENTIAL CONCERN

As described in the Programmatic Work Plan (Integral et al. 2004), COPCs were selected for quantitative evaluation in the BHHRA by comparing the SCRA analytical data to risk-based screening values. The specific risk-based concentrations used to select COPCs are described below for the each media. COPCs for human health were selected according to the approach described in the Programmatic Work Plan (Integral et al. 2004) using the screening criteria described in Section 2.3 and were quantitatively evaluated in this BHHRA. The process used to select the COPCs for quantitative evaluation in this BHHRA is described in the following subsections.

2.4.1 Sediment

Humans can be exposed to both beach sediment and in-water sediment. Because the exposure scenarios for beach versus in-water sediment are different, COPCs were selected for both beach and in-water sediment exposures.

2.4.1.1 Beach Sediment

Beach sediment data were evaluated in the BHHRA for potential risks to human health through direct contact. The selection of COPCs for beach sediment evaluated sediment data from potential human use areas where direct contact with human receptors could occur (only reasonably accessible beach sediments, such as those with access from contiguous upland areas or by boat). The locations of the beach sediment data evaluated in the BHHRA are shown in Map 2-1.

For contaminants that were detected in beach sediment, the detected concentrations were compared to risk-based screening levels described in Section 2.3.1. The maximum detected concentration of each contaminant from all samples collected in recreational, transient, or fishing beach areas was compared to the screening level based on the residential soil EPA RSL. The maximum detected concentration of each contaminant from all samples collected in industrial beach areas was compared to the screening level based on the industrial soil EPA RSL. If the maximum detected concentration of a contaminant was greater than the screening level, that contaminant was selected as a COPC for beach sediment. The contaminants selected as COPCs for beach sediment and the rationale for selection are presented in Tables 2-9 and 2-10.

Contaminants selected as COPCs for beach sediment were quantitatively evaluated in this BHHRA. Contaminants with maximum detected concentrations less than the screening values were not selected as COPCs and were not evaluated further in this BHHRA for direct contact with beach sediment.

2.4.1.2 In-Water Sediment

In-water sediment data were evaluated in the BHHRA for potential risks to human health through direct contact and not basedrather than on the potential for bioaccumulation. The potential for bioaccumulation, which is evaluated separately in this BHHRA as part of the fish and shellfish tissue assessments. The selection of COPCs for in-water sediment evaluated all surface sediment data in the BHHRA dataset within the Study Area, excluding the navigation channel and beach composite samples. The sample locations of the in-water sediment data evaluated in the BHHRA are shown in on Map 2-2.

For chemicals that were detected in in-water sediment, the maximum detected concentration of each chemical from surface sediment samples was compared to the screening level based on the EPA industrial soil EPA RSL, as described in Section

2.3.1. If the maximum detected concentration of a contaminant was greater than the screening level, that chemical was selected as a COPC for in-water sediment. The contaminants selected as COPCs for in-water sediment and the rationale for selection are presented in Table 2-11.

Contaminants selected as COPCs for in-water sediment were quantitatively evaluated in this BHHRA. Chemicals with maximum detected concentrations less than the EPA RSLs were not selected as COPCs and were not evaluated further in this BHHRA for direct contact with in-water sediment.

2.4.2 Surface Water

Direct contact with surface water was evaluated in the BHHRA for potential risks to human health. The selection of COPCs for quantitative evaluation in the BHHRA in surface water was based only on potential for direct human contact and not based on the potential for bioaccumulation. The potential for bioaccumulation is evaluated separately in this BHHRA as part of the fish and shellfish tissue assessments. Surface water data gathered during the RI were used to identify the COPCs in surface water for quantitative evaluation in the BHHRA. Because the exposure scenarios for divers are different from those of transients and beach users, COPCs were selected separately for both divers and transient/beach user exposuresscenarios. For divers, COPCs were selected for divers from using all available surface water samples taken within the Study Area, as described in Section 2.1.3. Near-bottom and near-surface sample results, as well as vertically integrated transect results, were combined according to the rules described in Attachment F2 prior to selecting COPCs. For transients and beach users, COPCs were selected for transients and beach users from surface water samples taken from areas where direct contact with transient or beach users could occur, including both single point sampling stations where vertically integrated samples were collected and transect samples were collected. This included, as well as one sample from Swan Island Lagoon. Chemicals that were detected in each surface water dataset, the detected concentrations were compared to screening values based on the residential tapwater RSLs. If the maximum detected concentration of a contaminant in surface water was greater than the screening value, that contaminant was selected as a COPC for surface water and was quantitatively evaluated in the BHHRA. A summary of samples used for each surface water COPC screening is provided in Table 2-12. SIn addition, the sample locations of the surface water data evaluated for transients and recreational beach users exposure scenarios are shown in on Map 2-3. The, and sample locations of the surface water data evaluated for divers exposures are shown in on Map Map 2-4.

For chemicals that were detected in each surface water dataset, the detected concentrations were compared to screening values based on the residential tapwater RSLs. If the maximum detected concentration of a contaminant in surface water was greater than the screening value, that contaminant was selected as a COPC for surface water and was quantitatively evaluated in the BHHRA. Chemicals that were detected

only at concentrations less than the RSLs were not selected as COPCs for quantitative evaluation. The contaminants selected as COPCs for surface water and the rationale for selection are presented in Table 2-13 for divers, and Table 2-14 for transients and beach users.

2.4.3 Groundwater Seep

Direct contact with the groundwater seep at Outfall 22B, shown in Map 2-5, was evaluated in the BHHRA for potential risks to human health. The selection of COPCs for quantitative evaluation in the BHHRA was based only on potential for direct human contact with the groundwater seep, and not based on the potential for bioaccumulation.

For chemicals that were detected in the groundwater seep, the detected concentrations were compared to screening values based on the residential tapwater EPA RSLs. If the maximum detected concentration of a contaminant in the groundwater seep was greater than the screening value, that contaminant was selected as a COPC for the groundwater seep and was quantitatively evaluated in the BHHRA. Chemicals that were detected only at concentrations less than the EPA RSLs were not selected as COPCs for quantitative evaluation. The contaminants selected as COPCs for the groundwater seep and the rationale for selection are presented in Table 2-15.

2.4.42.3.4 Fish and Shellfish Tissue

No appropriate risk-based screening values for fish tissue were available. Although EPA Region 3 has published fish tissue screening levels, the consumption rate of 54 g/day used to derive those values is not considered representative of the range of consumption rates relevant to Portland Harbor. Fish and shellfish tissue were evaluated in the BHHRA for potential risks to human health through ingestion. Because EPA Region 10 has not accepted any criteria for screening tissue from Portland HarborAccordingly, all chemicals detected in fish and shellfish tissue in the BHHRA dataset were considered to be COPCs and evaluated further in the BHHRA. . Map 2-6 shows Tthe general locations of all fish fish in a for a particular composite of the smallmouth bass and common carp tissue dataare shown on -Map- 2--6evaluated for ingestion scenarios in this BHHRA. . BSamples for brown bullhead and black crappie were each composited for over RM RM 3-6 and RM RM 6-9, and are not shown on a map. . The sample locations of the shellfish tissue data (both crayfish and clam) evaluated for ingestion scenarios are shown in Map 2-7. Shellfish were also composited over areas representing their assumed home range, and the sample locations on Map Map 2--7 represent the general spatial distribution of composited samples. .

The contaminants detected in each individual species were selected as COPCs only for ingestion of that species. For the multi-species diet scenarios (discussed in Section 3), analytes detected in any of the target resident fish species (see Section

2.1.5) were selected as COPCs. Since no screening took place to determine COPCs for tissue, the tissue COPCs are presented in the exposure point concentration summary tables, discussed in Section 3.

2.4.5 Hypothetical Future Exposure to Untreated Surface Water for Domestic Use

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There is no known current or anticipated future use of surface water within the Study Area for a drinking water supply. Even though no current or future uses of the LWR within Portland Harbor as a domestic water source have been identified, under OAR 340-041-0340 Table 340A, domestic water supply is a designated beneficial use of the Willamette River, with adequate pretreatment. Because the Willamette River is capable of serving as a potential drinking water source, the expectation is that this resource will be protected to achieve such use with adequate pretreatment. Potential sSources of contaminants to surface water are discussed in the RI. Because future use of the LWR as a domestic water supply would require adequate pretreatment, the evaluation of untreated surface water as a drinking water source is designated a hypothetical scenario. The inclusion of the assessment of domestic use of untreated surface water from the Study Area was done at the direction of EPA.

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Surface water as a hypothetical future domestic water source was evaluated in the BHHRA for potential risks to human health. The selection of COPCs for quantitative evaluation in the BHHRA in surface water was based only on potential for hypothetical contact from domestic uses, and not based on the potential for bioaccumulation. The potential for bioaccumulation is evaluated separately in this BHHRA as part of the fish and shellfish tissue assessments. Surface water data gathered during the RI were used to identify the COPCs for quantitative evaluation in the BHHRA. At the direction of EPA, results from surface water samples collected near-bottom and near-surface within the water column were combined according to the rules described in Attachment F2. The combined near-bottom and near-surface samples, vertically integrated single point samples, and vertically integrated transect samples were used to select the COPCs. These samples are presented in Table 2-12, and shown in Map 2-8. Filter and column data collected from samples collected by XAD were combined before selection of COPCs, according to the rules described in Attachment F2. No further data reduction was performed on the hypothetical future domestic water dataset prior to COPC selection.

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For chemicals that were detected in this dataset, the detected concentrations were compared to screening values based on the RSLs for tap water and on EPA MCLs for drinking water (EPA 2003a). If the maximum detected concentration of a contaminant in surface water was greater than either of the screening values, that contaminant was selected as a COPC for surface water and was quantitatively evaluated in the BHHRA. Chemicals that were detected only atfor which the maximum detected concentrations concentration was less than both screening values were not selected as COPCs for quantitative evaluation. The maximum detected concentration did not exceed the MCL for any chemical (Table 2-16). Maximum concentrations exceeded other RSLs [e.g., tap water screening levels for arsenic and 2-(4-Chlorochloro-2-methylphenoxy)propanoic acid (MCPP)]. The contaminants selected as

~~COPCs for surface water as a hypothetical domestic water source, and the rationale for selection, are presented in Table 2-16.~~

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3.0 EXPOSURE ASSESSMENT

Exposure assessment is the determination of the magnitude, frequency, duration, and route of exposure (EPA, 1989).~~—~~. Populations that currently, or may in the future, come into contact with site contaminants are identified along with potential routes of exposure that define the mechanism by which the exposure may occur.~~—~~. Magnitude is determined by estimating the amount, or concentration, of the chemical at the point of contact over an exposure duration, as well as the actual intake, or dose, of the chemical. ~~The objectives of the exposure assessment are to identify potential exposure pathways for individuals who may come in contact with COPCs at the Study Area, to characterize potentially exposed populations, and to estimate the extent of exposure.~~

~~The exposure assessment in this BHHRA followed EPA guidance and incorporated the reasonable maximum exposure (RME) methods recommended by EPA. As stated in EPA guidance (EPA 1989), the RME is a conservative exposure level that is still within the range of possible exposures. The exposure assessment also used average values, which represent central tendency (CT) exposures, for some exposure scenarios.~~ According to EPA (1989), an exposure assessment includes ~~four~~ three primary tasks:

- ~~Identify potentially exposed human populations that may come in contact with the COPC. This requires knowledge of (and/or making reasonable assumptions regarding) both current and future populations.~~Characterization of the exposure setting.~~—~~. This step includes identifying the characteristics of populations that can influence their potential for exposure, including their location and activity patterns, current and future land use considerations, and the possible presence of any sensitive subpopulations.~~—~~.
- ~~Identify~~ Identification of ~~relevant~~ exposure pathways.~~—~~. Exposure pathways are identified for ~~human~~ each population~~s~~ by which ~~potentially exposed populations may contact environmental media containing COPCs~~they may be exposed to chemicals originating from the site.
- Quantification of exposure.~~—~~. The magnitude, frequency, and duration of exposure for each pathway is determined.~~—~~. This step consists of the estimating of exposure point concentrations and calculation of chemical intakes.~~—~~. ~~Estimate EPCs at the points of potential human contact for all identified COPCs.~~
- ~~Estimate daily intakes for exposure routes and potentially exposed populations. The daily intakes are derived using the EPCs and assumptions regarding such variables as exposure duration, consumption rates, skin absorption factors, and other parameters that describe human activities.~~

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~~As stated in EPA guidance (EPA 1989), actions at Superfund sites should be based on an estimate of the reasonable maximum exposure (RME) expected to occur under both current and future land use conditions. Tthe RME is a conservative~~

~~exposuredefined as the highest exposure that is reasonably expected to occur at a site. The intent is to estimated a conservative exposure level that is substantially greater than the average, yet is still within the range of possible exposures. Theis BHHRA also exposure assessment also used average values, which representevaluated central tendency (CT) exposures, which is intended to represent the average exposure experienced by the affected population,. for some exposure scenarios. The exposure assumptions and methods for each task included in the exposure assessment are discussed below.~~

3.1.1 Conceptual Site Model

The conceptual site model (CSM) describes potential contaminant sources, transport mechanisms, potentially exposed populations, exposures pathways and routes of exposure~~.~~. As discussed in Sections 4, 5, and 6 of the RI Report, contaminated media within the Study Area are sediment, water, and biota~~.~~. Current and historical industrial activities and processes within the Study Area have led to chemical releases from either point or nonpoint sources, including discharges to the river from direct releases or via outfalls and groundwater within the Study Area~~.~~. In addition, releases that occur upstream of the Study Area and atmospheric deposition from global, regional, and local emissions may also represent potential contaminant sources to the Study Area~~.~~. Chemicals in sediment and water may be accumulated by organisms living in the water column or ~~associated~~by benthic organisms in ~~with the~~ sediments~~.~~. Fish and shellfish within the Study Area feeding on these organisms can accumulate chemicals in their tissues through dietary and direct exposure to sediment and water~~.~~. Additional information on potential contaminant sources is provided in Section ~~5~~4 of the RI Report, and a more detailed CSM is presented in Section 10~~.~~. A graphical representation of the exposure CSM ~~Potentially complete exposure pathways were identified in the Programmatic Work Plan or based on subsequent requirements from EPA. In-water workers exposure to river sediment, transients exposure to shoreline seeps, divers exposure to surface water and in-water sediment, infant exposure via consumption of human milk for all receptors with bioaccumulative COPCs, and hypothetical future exposures of domestic water users to surface water were included as potentially complete pathways per requirements from EPA. Pathways that are potentially or hypothetically complete and may result in significant exposure, or for which significance is unknown, were evaluated quantitatively in this BHHRA, per direction from EPA. Pathways included at the direction of EPA include clam consumption, exposure to surface water and in-water sediment by a commercial diver, and hypothetical exposure to untreated surface water by a domestic water user.~~ is presented ~~i~~on Figure 3-1.

~~3.1~~3.2 IDENTIFICATION OF POTENTIALLY EXPOSED HUMAN POPULATIONS

Potentially exposed ~~and hypothetically exposed~~ populations were identified based on consideration of current ~~, future, and hypothetical~~and potential future uses of the Study Area ~~and EPA (1989) guidance.~~ . An analysis of potential exposure pathways ~~analysis~~ for the Study Area is detailed in the Portland Harbor RI/FS Programmatic Work Plan (Integral 2004)~~.~~ . The ~~human populations~~exposure scenarios identified below represent those populations that are anticipated to ~~be maximally exposed~~ have the greatest potential for exposure to contaminants within the Study Area for both ~~under~~ current and ~~reasonably foreseeable~~potential ~~or hypothetical~~ future conditions~~.~~ . ~~The~~ For this reason, this risk assessment ~~evaluation performed for the selected populations~~ is ~~considered~~ likely to be protective of ~~certain~~ other potentially exposed populations that are not evaluated quantitatively in this BHHRA~~.~~ . The ~~populations~~ receptors evaluated for current~~, future, and hypothetical~~ and future uses of the Study Area ~~include~~ are~~the following~~:

- Dockside workers
- In-water workers
- Transients
- Divers
- Recreational beach users
- ~~Non-tribal~~Recreational/Subsistence Fishers
- Tribal fishers
- ~~Domestic water users~~

~~-~~

- ~~These receptors above populations were identified based on human activities that are known to occur within the Study Area, as described in the Programmatic Work Plan, or were required directed by EPA for evaluation in this BHHRA. The receptors and exposure pathways evaluated at the direction of EPA are Diversdivers, clam consumption by fishers, and household uses of surface waterdomestic water user were included in this BHHRA as required by EPA., and exposure to bioaccumulativepersistent organic chemicals (PCBs, dioxin/furans, DDx, and PDBEs) via Infant consumption of human milk by infantswas included as a complete exposure pathway for all adult receptor populations that were assessed quantitatively for bioaccumulative chemicals (i.e., PCBs, dioxin/furans, and DDX), as required by EPA.~~

~~Potential Estimated risks were quantified for each of theidentified receptor population.s; however However, certain individuals may participate in activities resulting in potential exposures under more than one category (e.g., recreational~~

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~~beach users may also be fishers). Potentially overlapping exposures are discussed in Section 3.3.7 of this BHHRA.~~

~~This BHHRA focused on potential exposures occurring within and immediately upstream and downstream of the Study Area in quantifying potential risks to humans.~~

~~Except~~With the exception ~~for the hypothetical~~of the ~~future exposure to~~ use of ~~untreated surface water for as a domestic water users~~source~~, the exposure assessment assumes that future land and water use will be the same as current land use; therefore, the risks characterized are based only on current use.these receptors evaluated in the risk assessment are known to currently exist based on the current land use and activity patterns in the Study Area. .~~The above populations were identified based on human activities know to occur within the Study Area, with the exception the use of surface water as a domestic water source. However, public and private use of surface water is a beneficial use of the LWR, and as described in Section 1, this baseline risk assessment evaluates exposures assuming no institutional controls, such as obtaining a permit for use of surface water. ~~If land or water use changes in the future, exposures and risk estimates may also change.~~Each of these receptors is described in greater detail in the following sections.

3.2.1.1 Dockside Workers

Portland Harbor supports a large number of water-dependent commercial uses, and many of the facilities adjacent to the LWR rely on ship and barge traffic~~.~~. Dockside workers ~~include~~were evaluated to be representative of industrial and commercial workers at many of the facilities adjacent to the river~~.~~. ~~Swho conduct s~~pecific activities are assumed to occur only within natural river beach areas, and include ~~, such as~~ unloading ships or barges ~~from the beach itself~~, or conducting occasional maintenance activities ~~from~~at specific locations near or at the water's edge~~. The actual activities that occur within natural river beach areas are site-specific and generally occur only infrequently. . Although exposure is anticipated to be infrequent, workers conducting activities within natural river beach areas may contact beach sediment within riverfront industrial and commercial sites atwithin the Study Area.~~ Exposures for ~~a given worker would~~ dockside workers are evaluated ~~in the risk assessment individually~~ as ~~occur~~occurring only within ~~the~~ defined ~~dockside worker use~~ areas considered to be industrial sites, rather than on a Study Area or harbor-wide basis~~ adjacent to the facility of that worker. . Exposure frequency for the RME evaluation was assumed to be 200 days/year, which is somewhat less than a typical occupational frequency of 250 days/year (five days/week for 50 weeks/year). The CT evaluation assumed an exposure frequency of 50 days/year. Dockside workers could potentially be exposed to beach sediment in areas~~The specific areas evaluated ~~considered to be industrial sites as~~are shown on Map- 2-1~~, and beach sediment data from each of these areas were used to estimate the EPCs. . If the beach area extends across multiple industrial sites, the same EPC was used to evaluate exposure at each of the adjacent sites. EPCs in beach sediment for the dockside worker scenario are presented in Table 3-2.~~

3.2.1.2 In-Water Workers

~~While I~~~~this population is referred to as "in-water" workers, these workers are not actually in the water. Rather, i~~n-water workers ~~are~~were evaluated as representative of individuals ~~those workers~~ who conduct activities that typically occur in or over-water ~~activities such as maintenance dredging and/or repair of in-water structures~~, rather than on shore as assumed for dockside workers. ~~.—~~ Specific activities may include the repair of in-water structures such as docks or pilings, ~~Exposure to in-water sediment could occur anywhere within the Study Area that docks or pilings are being constructed, or where other in-water activities occur, such as~~ maintenance dredging of private slips or berths, or~~.– while performing these specific activities, although most maintenance dredging activities are mechanical and are unlikely to result in significant sediment contact. Although likely occurring less frequently than mechanical dredging activities, other activities such as~~ maintenance and cleaning of equipment ~~may also result in direct contact exposure to in-water sediments. –~~. While ~~these~~such activities would not necessarily be restricted to a given area, exposure would most likely be localized to ~~in-water sediment at~~ specific facilities, and between the shore and the navigation channel.~~or in-off-loading sediments to disposal sites may result in a greater exposure potential.~~

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3.2.1.3 Divers

Several different groups of people ~~Diving is done by~~dive ~~several groups of people~~ in the Portland Harbor area, including the public for recreation and gathering of biota for consumption, the sheriff's office for investigations and emergency activities, and commercial divers for a variety of purposes including marine construction, underwater inspections, routine operation and maintenance, and activities related to environmental work~~.—~~. The majority of divers are expected to be commercial divers who typically use either wet or dry suits, wet or dry gloves, and a full face mask or a regulator held in the mouth with the diver's teeth~~.—~~. Although dry suits provide greater protection, wetsuits are often used because of the higher cost of dry suits and water temperature~~.—~~. The Willamette River is 303d listed as a temperature impacted area, with the Lower Willamette reaching average temperatures of over 70 degrees F in the summer months~~.—~~. Based on communications with commercial diving companies in the Portland area (Hutton 2008, Johns 2008, and Burch 2008), the standard of practice for commercial divers is the use of dry suits and helmets when diving in the LWR~~.—~~. However, ~~EPA has noted that~~ the use of wet suits is apparently still common among many commercial divers (EPA 2008c)~~.—~~. Accordingly, two different diver exposure scenarios are included in this BHHRA, and are differentiated by considering the use of either a wet suit or dry suit~~.—~~. Each scenario assumes that divers are exposed to sediment and surface water through inadvertent ingestion and dermal contact~~.~~ throughout the Study Area. ~~. TIn the Study Area, the majority of divers are expected~~

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~~to be commercial divers. To evaluate diver exposures, two different exposure scenarios are included in this BHHRA, one assuming that a wet suit is worn during diving and one assuming that a dry suit is worn during diving. The diver exposure scenarios were directed by EPA in a memorandum regarding the *Proposed Commercial Diver Exposure Scenario for the Portland Harbor Risk Assessment* (EPA 2008c). Both the wet suit and dry suit diver exposure scenarios assume that the diver is exposed to sediment through inadvertent ingestion of sediment and dermal exposure to sedimentcontact. As EPA stated in its approach, the use of a dry suit is expected to limit diver exposure, so it is assumed that the wet suit diver has more dermal exposure to sediment than the dry suit diver. Based on communications with commercial diving companies in the Portland area (Hutton 2008, Johns 2008, and Burch 2008), the standard of practice for commercial divers is the use of dry suits and helmets when diving in the LWR. However, based on the directive of the EPA, the wet suit diver scenario is also included in this BHHRA.wo different diver exposure scenarios are included in this BHHRA, and are differentiated by considering the use of either a wet suit or dry suit. Both scenarios assume that the diver is exposed to surface water through inadvertent ingestion of dermal contact. The use of a dry suit is expected to limit diver exposure, so a diver using a wet suit is assumed to have greater potential for dermal exposure to surface water. The majority of divers in the Study Area are expected to be commercial divers. The diver exposure scenarios were directed by EPA in a memorandum regarding the *Proposed Commercial Diver Exposure Scenario for the Portland Harbor Risk Assessment* (EPA 2008c). Both the wet suit and dry suit diver exposure scenarios assume that the diver is exposed to sediment through inadvertent ingestion and dermal contact. As EPA stated in its approach, the use of a dry suit is expected to limit diver exposure, so it is assumed that the wet suit diver has more dermal exposure to sediment than the dry suit diver. Based on communications with commercial diving companies in the Portland area (Hutton 2008, Johns 2008, and Burch 2008), the standard of practice for commercial divers is the use of dry suits and helmets when diving in the LWR. However, based on the directive of the EPA, the wet suit diver scenario is also included in this BHHRA~~

3.2.1.4 Transients

~~During past site tours, tents and makeshift dwellings were observed as evidence that individuals were occupying some riverbank areas.~~Transient encampments are known to exist within the Study Area along the Lower Willamette River.~~, though individuals are anticipated to move within or outside the Study Area.~~ ~~While the tents and makeshift dwellings were typically observed above the actual beach areas, transients may contact beach sediment within transient use areas, which are beach areas that are not active industrial sites and are not otherwise restricted from access. Although transients are anticipated to move throughout the Study Area, some may spend a majority of their time at relatively few of the possible areas.~~ While ~~the~~ tents and

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makeshift dwellings are typically observed above actual beach areas, transients ~~may be expected~~ are likely to have direct contact with beach sediment and~~Exposure for a given transient was evaluated in this BHHRA on the basis of a single transient use area, although it is possible that transients move from one transient use area to others within or outside the Study Area. This BHHRA presented an evaluation of individual use areas not only because transients may inhabit single beach areas, but also because such an evaluation provides a range of possible risks for individuals that either move frequently or remain at a single location. Transients may have dermal contact with~~ surface water (including groundwater seeps) during swimming, bathing or other activities, such as washing of clothing or equipment~~. In theory, transients~~They, and may also use ~~river~~surface water as a drinking water source~~.~~. Although individuals are anticipated to move within or outside the Study Area~~.~~, ~~S~~some individuals may spend a majority of their time at relatively few areas~~,~~. Thus, ~~and~~ exposure was evaluated as occurring at individual beaches rather than averaged over a larger area~~.~~. ~~River water was assumed to be the sole source of drinking water for transients.~~ Specific locations where exposure by transients was evaluated in the risk assessment are shown on Map 2-1~~.~~. ~~It is not known how long individuals may remain at specific locations or within the Study Area. However, for the purpose of the risk assessment assumed exposure durations of 2 years for the RME and 1 year for CT evaluations. RUse of river water as a source of drinking water by transients was assumed to be the ir sole source of drinking water for transients.Exposure to surface water by transients would likely occur within transient use areas. Transients may have direct contact with groundwater seeps, within riverfront beach areas that have been identified as transient use areas. While contact with seep water would be unintentional, dermal contact with or incidental ingestion of seep water may occur.~~

3.2.1.5 Recreational Beach Users

A~~Both a~~dults and children participate in recreational activities ~~in beach areas~~at beaches within the Study Area, and the LWR is also used for boating, water skiing, swimming, and other activities.~~.~~ ~~ABeach~~The a~~-a~~reas currently used for recreational ~~beach~~ activities~~,~~ as well as other areas in the Study Area where sporadic beach use may occur were identified as recreational use areas~~.~~. ~~The LWR is used by both adults and children for boating, water skiing, swimming, and other water activities.~~ While certain individuals may frequent a specific area almost exclusively, others users may regularly use various areas throughout the Study Area~~.~~. Recreational ~~beach users may~~activities are likely to result in ~~contact with~~exposure to beach sediment and ~~within recreational use areas at the Study Area. Some recreational beach users may primarily use a specific recreational use area while other recreational beach users may use various recreational use areas throughout and outside the Study Area. The LWR is used by both adults and children for boating, water skiing, swimming, and other water activities that result in exposure to surface water. Of these activities, exposure to~~ surface water~~.~~. ~~Because specific information regarding the frequency of recreational activities in Portland Harbor is not available, professional judgment was used to assess exposure. An exposure frequency of 94~~

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~~days/year (5 days/week during summer, 1 day/week during spring/fall, and 1 day/month during winter) was used for the RME estimate and 38 days/year (2 days/week during summer, 2 days/month during spring/fall) was used for the CT estimate. would occur to the greatest extent while swimming in the river. Swimming would most likely occur primarily within recreational beach areas.~~

3.2.1.6 Recreational/Subsistence Fishers

A year-round recreational fishery exists within the Study Area~~.~~. Current information ~~suggests~~indicates that spring Chinook salmon, steelhead, Coho salmon, shad, crappie, bass, and white sturgeon are the fish species preferred by local recreational fishers (DEQ 2000b, Hartman 2002, and Steele 2002)~~.~~. In addition to recreational fishing, ~~the~~an investigation by the Oregonian newspaper and ~~the~~ limited surveys conducted on other portions of the Willamette River indicate that immigrants from Eastern Europe and Asia, African-Americans, and Hispanics are most likely to ~~be catching and eating~~use fish from the lower Willamette either as a supplemental or primary dietary source (ATSDR 2002)~~.~~. These ~~preliminary~~ surveys also indicate that the most commonly consumed species are carp, bullhead catfish, and smallmouth bass, ~~(ATSDR 2002). However,~~ although other species may also be consumed~~.~~. ~~C~~In conversations that were conducted as part of a project by the Linnton Community Center (Wagner 2004) ~~with transients~~ about ~~their~~ consumption of fish or shellfish from the Willamette River ~~as part of a project by the Linnton Community Center (Wagner 2004)~~, t~~.~~ ~~T~~ransients reported consuming a large variety of fish, and several ~~transients~~ said they ate whatever they could catch themselves or ~~get~~obtain from other fishers~~.~~. ~~However, the frequency and amount of consumption was not reported, and many of the transients indicated they were in the area temporarily. Site-specific information is not available for fish consumption rates for specific species, so a range of ingestion rates and various diets were evaluated in this BHHRA for both adult and child consumers~~

~~FishersIndividuals who fish from the water's edge within natural river beach areas couldmay have direct exposurebe exposed to beach sediment. In theory,, and fishing could occur atfrom any beach area withoutwhere restricted access is not restricted. Fishing. from boats or piers couldmay result in exposure to in-water sediment ondue to handling anchors, hooks, or crayfish pots. Exposure to in-water sediments was evaluated for both high- and a low-frequency of fishing in order to assess For in-water sediment exposure, both a high- and a low-frequency fishing scenario were included to evaluate thea range in frequency of fishing activitiesof potential activity patterns.~~

Direct exposures to beach sediments by individuals engaged in recreational or subsistence fishing ~~STThe specific areas evaluated for potential exposure to sediments as areas frequentedfor individuals engaged in by recreationalrecreational or subsistence fishersing and evaluated for potential exposure to sediments include aTherefore, all non-dockside worker use areas (i.e., allareas designated as transient~~

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~~and recreational use areas) were considered potential human use areas where fishers could be exposed to beach sediment. .~~

was evaluated at specific areas designated as transient and recreational use areas, exposures to in-water sediments were evaluated per half mile along each side of the river as well as on a Study Area-wide basis. Fish consumption was evaluated assuming a single-species diet comprised of each individual target resident fish species (smallmouth bass, black crappie, brown bullhead, and common carp), and based on whether only fillets or the whole fish is consumed~~.~~. Exposure was evaluated over fishing zones, based on the relative size of the home range~~s of~~ for each species, as well as averaged over the entire Study Area~~.~~. In addition to the individual species diet, a multiple species diet was also evaluated on a harbor-wide basis, assuming each of the four target species comprised equal portions of the total fish consumption. In order to account for a range of cultural consumption practices, both fillet-only and whole body fish consumption were evaluated.~~Some fishers may primarily use a specific beach area for fishing activities while other fishers may use beach areas throughout and outside the Study Area.~~

~~The extent to which individuals may primarily use a specific beach area for fishing move about throughout and outside the Study Area is unknown. For beach sediment exposure, two different fisher scenarios were included in this BHHRA to evaluate differences in the frequency of fishing activities. High-frequency fishers were assumed to fish recreationally, and at more frequent intervals than the low-frequency fisher (exposure frequency of 156 days per year for high frequency fishers compared to 104 days per year for low-frequency fishers). The extent to which fishing from beach areas actually occurs is unknown, as is the degree of sediment exposure that might occur while fishing. Fishers who fish from boats or piers could be theoretically exposed to in-water sediment on anchors, hooks, or crayfish pots. For in-water sediment exposure, two different fisher scenarios were included in this BHHRA to evaluate differences in the frequency of fishing activities: high-frequency fishers and low-frequency fishers. The extent to which fishing actually occurs under these two scenarios is unknown, as is the degree of sediment exposure that might occur while fishing. However, exposure assumptions provided by EPA were used to evaluate in-water sediment exposure by fishers~~

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3.2.1.7 Tribal Fishers

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The LWR provides a ceremonial and subsistence fishery for Native American tribes~~. . The extent to which tribal members fish within the Study Area, as well as the extent to which that fishing occurs from beach areas and the degree of sediment exposure that might occur while fishing are unknown. However, exposure assumptions provided by EPA were used to evaluate beach sediment exposure by tribal fishers.~~ Four ~~(Yakama, Umatilla, Nez Perce, and Warm Springs) of the six~~ Native American tribes (Yakama, Umatilla, Nez Perce, and Wa~~rm RM~~rm- Springs) ~~involved in the~~

Portland Harbor RI/FS participated in a fish consumption survey that was conducted on the reservations of the participating tribes and completed in 1994 ([Columbia River Inter-tribal Fish Commission (CRITFC) 1994]). . The results of the survey show that tribal members surveyed generally consume more fish than the general public.. Certain species, especially salmon and Pacific lamprey, are an important food source as well as an integral part of the tribes' cultural, economic, and spiritual heritage.. Consumption of fish by both adult and child tribal members was evaluated in this BHHRA.

3.2.1.8 Domestic Water User

Both public and private Uuse As mentioned in Section 2.4.5, lthough there is no known current use of surface water within the Study Area foras a domestic water supply. However, because domestic water use. Because it is a designated beneficial use of theof the Willamette River following adequate pretreatment,, the use of untreated river water as a domestic water source is a designated beneficial use of the LWR by the State of Oregon.. Hence, use of surface water as a source of household water was assessed as a hypotheticalpotentiall-y complete future pathway for both adult and child residents, at the direction of EPA. . EIn this scenario, exposure to untreated surface water could hypothetically occur fromvia ingestion and dermal contact throughout the Study Area. At the direction of the EPA, , as well as volatilization of chemicals from untreated surface water to indoor air through household uses was identified as a potentially complete exposure pathway for hypothetical future domestic water use..

Non-tribal Fishers

Fishers who fish from the water's edge within natural river beach areas could have direct exposure to beach sediment. In theory, fishing could occur at any beach area without restricted access. Therefore, all non-dockside worker use areas (i.e., all transient and recreational use areas) were considered potential human use areas where fishers could be exposed to beach sediment. Some fishers may primarily use a specific beach area for fishing activities while other fishers may use beach areas throughout and outside the Study Area.

For beach sediment exposure, two different fisher scenarios were included in this BHHRA to evaluate differences in the frequency of fishing activities. High-frequency fishers were assumed to fish recreationally, and at more frequent intervals than the low-frequency fisher (exposure frequency of 156 days per year for high frequency fishers compared to 104 days per year for low-frequency fishers). The extent to which fishing from beach areas actually occurs is unknown, as is the degree of sediment exposure that might occur while fishing.

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~~1.1~~3.3 IDENTIFICATION OF EXPOSURE PATHWAYS

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Exposure pathways are defined as the physical ways in which chemicals may enter the human body ~~(e.g., ingestion, inhalation, dermal absorption).~~ . A complete exposure pathway consists of the following four elements:

- A source of chemical release
- A release or transport mechanism (or media in cases involving media transfer)
- An exposure point (a point of potential human contact with the contaminated exposure medium)
- An exposure route (e.g., ingestion, dermal contact) at the exposure point.

If any of the above elements is missing, the pathway is considered incomplete and exposure does not occur.

~~As discussed in Sections 4, 5, and 6 of the RI Report, the affected media within the Study Area are sediment, water, and biota. Current and historical industrial activities and processes within, upstream and downstream of the Study Area may have led to chemical releases from either point or nonpoint sources to the Study Area. In addition to these releases, discharges to the river from outfalls and groundwater within the Study Area may be potential~~have also contributed to contamination ~~contaminant sources to the Study Area. Finally, releases that occur upstream and downstream of the Study Area and global, regional, and local emissions resulting in atmospheric deposition may be potential sources to the Study Area. These potential sources and release mechanisms are discussed in greater detail in Section 4 of the RI Report.~~

~~Chemicals in sediment and water may be accumulated by organisms in the water column or associated with the sediments. Edible fish and shellfish species feeding on these organisms and living within the Study Area may accumulate chemicals in their tissues through dietary exposures and direct exposure to sediment and water.~~ The potential exposure pathways to human populations at the Study Area include:

- Incidental ~~Ingestion~~ ingestion of and dermal contact with beach sediment
- Incidental ingestion ~~of~~ and dermal contact with in-water sediment
- Incidental ingestion ~~of~~ and dermal contact with surface water
- Incidental ingestion ~~of~~ and dermal contact with surface water from ~~groundwater~~ seeps
- ~~Ingestion~~ Consumption of fish and shellfish
- Infant consumption of human milk.

- **Dockside Workers**

Dockside workers include industrial and commercial workers at facilities adjacent to the river who conduct specific activities within natural river beach areas, such as unloading ships or barges from the beach itself or conducting occasional maintenance activities from the water's edge. The actual activities that occur within natural river beach areas are site-specific and generally occur only very infrequently. Although exposure is anticipated to be infrequent, workers conducting activities within natural river beach areas may contact beach sediment within riverfront industrial and commercial sites at the Study Area. Exposure for a given worker would occur only within the defined dockside worker use area adjacent to the facility of that worker.

- **Transients**

During past site tours, tents and makeshift dwellings were observed as evidence that individuals were occupying some riverbank areas. While the tents and makeshift dwellings were typically observed above the actual beach areas, transients may contact beach sediment within transient use areas, which are beach areas that are not active industrial sites and are not otherwise restricted from access. Although transients are anticipated to move throughout the Study Area, some may spend a majority of their time at relatively few of the possible areas. Exposure for a given transient was evaluated in this BHHRA on the basis of a single transient use area, although it is possible that transients move from one transient use area to others within or outside the Study Area. This BHHRA presented an evaluation of individual use areas not only because transients may inhabit single beach areas, but also because such an evaluation provides a range of possible risks for individuals that either move frequently or remain at a single location.

- **Recreational Beach Users**

Both adults and children participate in recreational activities in beach areas within the Study Area. Areas currently used for recreational beach activities, as well as other areas in the Study Area where sporadic beach use may occur were identified as recreational use areas. Recreational beach users may contact beach sediment within recreational use areas at the Study Area. Some recreational beach users may primarily use a specific recreational use area while other recreational beach users may use various recreational use areas throughout and outside the Study Area.

- **Tribal Fishers**

The LWR provides a ceremonial and subsistence fishery for Native American tribes. The extent to which tribal members fish within the Study Area, as well as the extent to which that fishing occurs from beach areas and the degree of sediment exposure that might occur while fishing are unknown. However, exposure assumptions provided by EPA were used to evaluate beach sediment exposure by tribal fishers.

~~**Non-tribal Fishers**~~

~~Fishers who fish from the water's edge within natural river beach areas could have direct exposure to beach sediment. In theory, fishing could occur at any beach area without restricted access. Therefore, all non-dockside worker use areas (i.e., all transient and recreational use areas) were considered potential human use areas where fishers could be exposed to beach sediment. Some fishers may primarily use a specific beach area for fishing activities while other fishers may use beach areas throughout and outside the Study Area.~~

~~For beach sediment exposure, two different fisher scenarios were included in this BHHRA to evaluate differences in the frequency of fishing activities. High-frequency fishers were assumed to fish recreationally, and at more frequent intervals than the low-frequency fisher (exposure frequency of 156 days per year for high frequency fishers compared to 104 days per year for low-frequency fishers). The extent to which fishing from beach areas actually occurs is unknown, as is the degree of sediment exposure that might occur while fishing.~~

~~Section 3.3 provides a~~A more detailed discussion of potential exposures for the Study Area under current~~, reasonably foreseeable~~ and ~~hypothetical~~ future conditions, and presents the rationale for including or eliminating pathways from quantitative evaluation~~.~~. The identified receptors, exposure routes, and exposure pathways, and the rationale for selection are also summarized in Table 3-1.

~~1.1.1 Definition and Significance of Exposure Pathways~~

Exposure pathways are designated in one of the following four ways:

Potentially Complete: There is a source or release from a source, an exposure point where contact can occur, and an exposure route by which contact can occur~~.~~. Pathways considered potentially complete are quantitatively evaluated in this BHHRA.

Potentially Complete ~~and~~ but Insignificant: There is a source or release from a source, an exposure point where contact can occur, and an exposure route by which contact can occur~~; .~~. ~~however~~However, ~~the~~ exposure via the pathway is ~~considered a~~ likely to be negligible relative ~~contributor~~ to the overall risk~~.~~. Pathways considered potentially complete ~~and~~ but insignificant were not evaluated further in this BHHRA.

Incomplete: There is no source or release from a source, no exposure point where contact can occur, or no exposure route by which contact can occur for the given receptor~~.~~. Pathways considered potentially incomplete were not evaluated further in this BHHRA.

Potentially complete pathway, but evaluated ~~under~~ for a different receptor ~~category~~: These pathways may be complete for some individuals ~~in this receptor category due to overlapping exposure scenarios (e.g., some in-water workers may~~

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~~also be fishers)~~, but are not evaluated for the identified receptor ~~category~~ because the pathways are not considered ~~relevant~~ typical for that receptor~~.~~. These pathways are evaluated ~~under~~ for different receptors ~~categories~~ where the pathways are considered potentially complete and significant~~.~~. Overlapping exposures that may occur for the different receptors ~~categories~~ are discussed further in Section 3.3.~~7 of this BHHRA.~~

~~1.1.2 Conceptual Site Model~~

~~2.0 The conceptual site model (CSM) for human exposures based on the current understanding of the Study Area and requirements from EPA is presented in Figure Figure 3 1. The CSM graphically depicts possible sources of COPCs based on current information, possible COPC-affected media, mechanisms of COPC transfer between media, and the processes through which human receptors may be exposed to chemicals. Additional information on potential sources of COPCs is provided in Section 5 of the RI Report. Potentially complete exposure pathways were identified in the Programmatic Work Plan or based on subsequent requirements from EPA. In-water workers exposure to river sediment, transients exposure to shoreline seeps, divers exposure to surface water and in-water sediment, infant exposure via consumption of human milk for all receptors with bioaccumulative COPCs, and hypothetical future exposures of domestic water users to surface water were included as potentially complete pathways per requirements from EPA. Pathways that are potentially or hypothetically complete and may result in significant exposure, or for which significance is unknown, were evaluated quantitatively in this BHHRA, per direction from EPA. Pathways included at the direction of EPA include clam consumption, exposure to surface water and in-water sediment by a commercial diver, and hypothetical exposure to untreated surface water by a domestic water user.~~

~~2.1 EXPOSURE SCENARIOS~~

The following sections provide a more detailed discussion of the exposure ~~scenarios~~ pathways that are quantitatively evaluated in this BHHRA~~.~~. ~~The following exposure scenarios were identified based on exposures that may generically occur throughout the Study Area and do not consider site-specific conditions that may limit exposure at a given location.~~

~~2.1.1~~3.3.1 Direct Exposure to Beach Sediment

Based on current and future uses within the Study Area, ~~Incidental~~ incidental ingestion ~~of~~ and dermal contact with beach sediment could occur within natural river beach areas ~~used by human populations within the Study Area. These areas were~~ identified as human use areas in the Programmatic Work Plan~~, based on current and future uses within the Study Area.~~. ~~Human use~~These areas were further classified ~~based~~ with respect to ~~on~~ the type of exposures that could occur~~, at these beaches~~ including recreational, recreational/subsistence and tribal ~~fishers~~fishing~~, tribal fishers~~, transient, or dockside worker use areas~~.~~. ~~These classifications are described in~~

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~~greater detail below. The~~ H~~h~~uman use areas in the Study Area and their associated classifications are shown in Map 2-1.~~—~~.

Direct exposure to beach sediments is considered to be a complete pathway for dockside workers, transients, recreational beach users, and both recreational/subsistence and tribal fishers~~—~~.

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~~**2.1.1.1** Exposure frequency for dockside workers was assumed to be 200 days/year for the RME evaluation, and 50 days/year the CT evaluationDockside Workers~~

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~~2.0 Dockside workers include industrial and commercial workers at facilities adjacent to the river who conduct specific activities within natural river beach areas, such as unloading ships or barges from the beach itself or conducting occasional maintenance activities from the water's edge. The actual activities that occur within natural river beach areas are site-specific and generally occur only very infrequently. Although exposure is anticipated to be infrequent, workers conducting activities within natural river beach areas may contact beach sediment within riverfront industrial and commercial sites at the Study Area. Exposure for a given worker would occur only within the defined dockside worker use area adjacent to the facility of that worker.~~

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~~**2.1.1.2** Transients~~

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~~3.0 During past site tours, tents and makeshift dwellings were observed as evidence that individuals were occupying some riverbank areas. While the tents and makeshift dwellings were typically observed above the actual beach areas, transients may contact beach sediment within transient use areas, which are beach areas that are not active industrial sites and are not otherwise restricted from access. Although transients are anticipated to move throughout the Study Area, some may spend a majority of their time at relatively few of the possible areas. Exposure for a given transient was evaluated in this BHHRA on the basis of a single transient use area, although it is possible that transients move from one transient use area to others within or outside the Study Area. This BHHRA presented an evaluation of individual use areas not only because transients may inhabit single beach areas, but also because such an evaluation provides a range of possible risks for individuals that either move frequently or remain at a single location.~~

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~~**2.1.1.3** Recreational Beach Users~~

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~~4.0 Both adults and children participate in recreational activities in beach areas within the Study Area. Areas currently used for recreational beach activities, as well as other areas in the Study Area where sporadic beach use may occur were identified as recreational use areas. Recreational beach users may contact beach sediment within recreational use areas at the Study Area. Some recreational beach users may primarily use a specific recreational use area while other recreational beach users may use various recreational use areas throughout and outside the Study Area.~~

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~~**2.1.1.4** Tribal Fishers~~

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5.0 The LWR provides a ceremonial and subsistence fishery for Native American tribes. The extent to which tribal members fish within the Study Area, as well as the extent to which that fishing occurs from beach areas and the degree of sediment exposure that might occur while fishing are unknown. However, exposure assumptions provided by EPA were used to evaluate beach sediment exposure by tribal fishers.

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2.1.1.5 Non-tribal Fishers

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6.0 Fishers who fish from the water's edge within natural river beach areas could have direct exposure to beach sediment. In theory, fishing could occur at any beach area without restricted access. Therefore, all non-dockside worker use areas (i.e., all transient and recreational use areas) were considered potential human use areas where fishers could be exposed to beach sediment. Some fishers may primarily use a specific beach area for fishing activities while other fishers may use beach areas throughout and outside the Study Area.

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7.0 For beach sediment exposure, two different fisher scenarios were included in this BHHRA to evaluate differences in the frequency of fishing activities. High-frequency fishers were assumed to fish recreationally, and at more frequent intervals than the low-frequency fisher (exposure frequency of 156 days per year for high frequency fishers compared to 104 days per year for low-frequency fishers). The extent to which fishing from beach areas actually occurs is unknown, as is the degree of sediment exposure that might occur while fishing.

2.1.1.6 Potentially Complete and Insignificant Exposure Pathways

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8.0 This BHHRA did not identify any potentially complete and insignificant exposure pathways for beach sediment exposure.

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2.1.1.7 Incomplete Exposure Pathways

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Beach sediment exposures are considered incomplete exposure pathways for both in-water workers and divers based on the defined activities of these receptor populations in this BHHRA. In-water workers are those workers who conduct over water activities and thus are not directly exposed to beach sediments. Dockside workers are the worker population for which beach sediments exposures are considered potentially complete and were evaluated in this BHHRA. Divers conduct activities in the river that do not result in beach sediment exposures. The hypothetical future domestic water use scenario evaluates use of surface water for domestic water supply and thus beach sediment exposures were considered incomplete exposure pathways for this receptor population. . The value of 200 days/year is slightly less than the EPA default exposure frequency of 225 days/year for outdoor workers, which , and . This value represents the average number of days worked forper year by male and female workers from according to the U.S. Census Bureau's *1990 Earnings by Occupation and Education Survey*. An exposure duration of 25 years was used, representing an EPA default value for the RME estimate of job tenure. This value is consistent with data from the U.S. Bureau of Labor Statistics showing that the 95th percentile job tenure offor men in the manufacturing sector is 25 years. The CT estimate assumed duration of 9 years.

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representing approximately the 50th percentile of residence time estimates from the U.S. Census Bureau data (EPA, 1997). A soilsediment ingestion rate of 200 mg/day was used for the RME evaluation, based on EPA Region 10 supplemental guidance on soil ingestion rates (EPA, 2000a), and is representative of approximately the midpoint between the recommended value of 100 mg/day for outdoor workers and 330 mg/day for construction workers. An ingestion rate of 50 mg/day was used to estimate CT exposure. Dermal exposure was assessed assuming that the face, forearms and hands are exposed, representing an exposed skin surface area of 3,300 cm^2, which is representative of the median value (50th percentile) for adults.

Exposure frequency for transients was assumed to be daily (365 days/year). It is not known how long individuals may remain at specific locations or within the Study Area. Based on professional judgment, an exposure durations of 2 years was assumed for the RME and 1 year for CT evaluations. SoilIncidental ingestion of sediment was evaluated at the same rates used for the dockside workers. Dermal exposure was assessed assuming that the face, forearms and hands, and lower legs are exposed, representing an exposed skin surface area of 5,700 cm^2, representing the median value for adults.

Specific information regarding the frequency of recreational activities in Portland Harbor is not available. Hence, professional judgment was used to assess exposure. An exposure frequency of 94 days/year (5 days/week during summer, 1 day/week during spring/fall, and 1 day/month during winter) was used for the RME estimate and 38 days/year (2 days/week during summer, 2 days/month during spring/fall) was used for the CT estimate. Exposure duration for recreational activities is based on the assumption that individuals are largely permanent residents of the Portland area. An exposure duration of 30 years, which represents approximately the 95th percentile of the length of continuous residence in a single location in the U.S. population (EPA, 1997) was used for the RME estimate. More recent studies described in 2011 edition of EPA's Exposure Factors Handbook show the 95th percentile value is closer to 33 years, data from the U.S. Census Bureau indicate that 32 years represents the best estimate of residence time at the 90th percentile. However, the value of 30 years is consistent with other Superfund risk assessments nationwide, and represents a reasonably conservative estimate of total residence time in the area. An exposure duration of 9 years was used for the CT estimate. ISoil ingestion rates of 100 mg/day for adults and 200 mg/day for children were used, approximating the 95th percentile soil ingestion rates. Central tendencyCT estimates assumed sediment ingestion rates of 100 mg/day for children and 50 mg/day for adults. Dermal exposures were evaluated assuming that the face, forearms and hands, and lower legs are exposed. Median values of 5,700 cm^2 and 2,800 cm^2 were used for adults and children, respectively.

As discussed in Section 3.2.1.6, a range of possible exposures was evaluated for people who engage in recreational or subsistence fishing activities by considering both a high-frequency and a low-frequency rate of fishing. RME estimates for hHigh-frequency fishers were assumed to fishfishing at more frequent intervals than the low-frequency fisher (exposure frequency of 156 days/ per year , approximating a rate of 3 days/week. Low-frequency fishers were assumed to fishfor high-frequency fishers compared to 104 days/ per year.

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~~approximating a rate of 2 days/week. CT estimates assumed a frequency 52 days/year and 26 days/year for high- and low-frequency fishers, respectively, and are representative of assumed fishing frequencies of 1 day/week and 2 days/month. The exposure duration for recreational and subsistence fishers is based on the assumption that they are largely permanent residents of the Portland area. An exposure duration of 30 years, which represents approximately the 95th percentile of the length of continuous residence in a single location in the U.S. population (EPA, 1997) was used for the RME estimate. More recent studies described in 2011 edition of EPA's Exposure Factors Handbook show the 95th percentile value is closer to 33 years, data from the U.S. Census Bureau indicate that 32 years represents the best estimate of residence time at the 90th percentile. However, the value of 30 years is consistent with other Superfund risk assessments nationwide, and represents a reasonably conservative estimate of total residence time in the area. An exposure duration of 9 years was used for the CT estimate, representing approximately the 50th percentile of residence time estimates from the U.S. Census Bureau data (EPA, 1997).Dermal exposure was evaluated assuming the same exposed skin surface area for adults of 5,700 cm^2 used for recreational exposure. People engaged in recreational or subsistence fishing were also assumed to be residents of the Portland area, therefore exposure durations of 30 years and 9 years were used for the RME and CT evaluation, respectively.~~

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~~Sediment ingestion rates for tribal fishers were evaluated at the same rate as for recreational/subsistence fishers. Fishing frequency was assumed to be 260 days/yr (5 days/week) for the RME estimate and 104 days/year (2 days/week) for the CT estimate. Specific information regarding population mobility on native American populations is less readily available than for the general U.S. population. However, input during the scoping of the Portland Harbor risk assessment indicated that this population should be considered less mobile for a variety of reasons. Hence, the evaluation of exposures to native Americans was based on the premise that they spend their entire lives in the area, and a typical lifetime was evaluated as being 70 years. for low-frequency fishers).~~

~~2.1.2~~3.3.2 Direct Exposure to In-Water Sediment

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~~Ingestion of and dermal~~Direct contact with in-water sediment could occur ~~through over-water~~during activities ~~(i.e., activities~~ conducted from a boat or other vessel~~)~~ that result in bringing sediment to the ~~river's~~ surface, during diving, or when fishing as a result of handling anchors, hooks, or crayfish pots~~.~~. Hence, direct exposure to in-water sediment is considered to be a complete pathway for in-water workers, divers, ~~and~~ recreational/subsistence and tribal fishers~~.~~. ~~-~~Although recreational beach users may contact in-water sediment while swimming, such exposures are not expected to be significant and were not quantitatively evaluated in the risk assessment~~.~~. ~~In-water sediment exposures were considered potentially complete and insignificant exposure pathways for recreational beach users and were not quantitatively evaluated.~~ Exposure to in-water sediment was evaluated throughout the Study Area by river mile rather than ~~as having the potential to occur only in~~ at specific areas~~,~~ as was done ~~for~~with exposure to beach sediments~~.~~.

Exposure factors used for in-water workers were developed based on in-depth interviews with several workers at Terminal 4 who conduct or oversee activities that could result in direct contact with in-water sediment. RME exposures were assessed assuming an exposure frequency of 10 days/year for a total exposure duration of 10 years, CT exposures are assumed at 4 days/year for 4 years. Incidental ingestion of sediment was evaluated assuming the same ingestion rates used for beach sediment, 200 mg/day for the RME evaluation and 50 mg/day for the CT evaluation. An exposed skin surface area of 3,300 cm^2 for adults was used to assess dermal exposure.

Two different scenarios were evaluated for direct exposure to in-water sediments by divers, based on whether the divers wear wet or dry suits. Divers wearing wet suits are assumed to be commercial divers without a full face mask, and wearing either wet gloves or no gloves. An exposure frequency of 5 days/year for the RME evaluation and 2 days/year for the CT evaluation are based on best professional judgment and discussions between EPA, LWG, and commercial divers, as well as the experience of EPA divers who work at the Portland Harbor Superfund site. EThe exposure durations of 25 years and 9 years arewere used for the RME and CT estimates, respectively. Sediment ingestion rates were assumed to be 50 percent of dockside workers, corresponding to values of 50 mg/day and 25 mg/day, respectively for the RME and CT evaluations. Dermal exposure to sediment was evaluated assuming the entire skin surface area was exposed. A value of 18,150 cm^2, representing the median for men and women was used for both the RME and CT evaluations. Divers wearing a dry suit (with a neck dam) would likely have only their head, neck, and hands exposure, and a RME value of 2,510 cm^2 was used. A CT evaluation was not done for divers wearing dry suits.

Exposure to in-water sediment for people engaged in recreational/subsistence fishing are generally the same as those used to assess exposure to beach sediments. Incidental ingestion of sediment The exposure assumptions were developed by EPA Region 10

where exposure would be possible. Unlike the beach sediment exposure scenarios that are restricted to specific beach areas, potential exposure to in-water sediment could occur anywhere that over-water activities occur. As a result, direct exposure to in-water sediment was evaluated throughout the Study Area. At the direction of the EPA, exposure to in-water sediment by divers is also evaluated in this BHHRA.

2.1.2.1 In-Water Workers

While this population is referred to as "in-water" workers, these workers are not actually in the water. Rather, in-water workers are those workers who conduct over-water activities such as maintenance dredging and repair of in-water structures. Exposure to in-water sediment could occur while performing these specific activities, although most maintenance dredging activities are mechanical and are unlikely to result in significant sediment contact. Although likely occurring less frequently than

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~~mechanical dredging activities, other activities such as maintenance and cleaning of equipment or in off-loading sediments to disposal sites may result in a greater exposure potential.~~

~~3.1.1.1 Divers~~

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~~4.0 In the Study Area, the majority of divers are expected to be commercial divers. To evaluate diver exposures, two different exposure scenarios are included in this BHHRA, one assuming that a wet suit is worn during diving and one assuming that a dry suit is worn during diving. The diver exposure scenarios were directed by EPA in a memorandum regarding the *Proposed Commercial Diver Exposure Scenario for the Portland Harbor Risk Assessment* (EPA 2008c). Both the wet suit and dry suit diver exposure scenarios assume that the diver is exposed to sediment through inadvertent ingestion of sediment and dermal exposure to sediment. As EPA stated in its approach, the use of a dry suit is expected to limit diver exposure, so it is assumed that the wet suit diver has more dermal exposure to sediment than the dry suit diver. Based on communications with commercial diving companies in the Portland area (Hutton 2008, Johns 2008, and Burch 2008), the standard of practice for commercial divers is the use of dry suits and helmets when diving in the LWR. However, based on the directive of the EPA, the wet suit diver scenario is also included in this BHHRA.~~

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~~5.1.1.1 Tribal Fishers~~

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~~9.0 The LWR provides a ceremonial and subsistence fishery for Native American tribes. The extent to which tribal members fish within the Study Area, as well as the extent to which that fishing occurs from boats or piers and the degree of sediment exposure that might occur while fishing are unknown. However, exposure assumptions provided by EPA were used to evaluate in-water sediment exposure by tribal fishers.~~

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~~5.1.1.2 Non-tribal Fishers~~

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~~11.0 Fishers who fish from boats or piers could be theoretically exposed to in-water sediment on anchors, hooks, or crayfish pots. For in-water sediment exposure, two different fisher scenarios were included in this BHHRA to evaluate differences in the frequency of fishing activities: high-frequency fishers and low-frequency fishers. The extent to which fishing actually occurs under these two scenarios is unknown, as is the degree of sediment exposure that might occur while fishing. However, exposure assumptions provided by EPA were used to evaluate in-water sediment exposure by fishers.~~

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~~5.1.1.3 Potentially Complete and Insignificant Exposure Pathways~~

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~~Recreational beach users could contact in-water sediment while swimming. However, any exposure to in-water sediment is expected to be minimal and the exposure would occur under water, so it cannot be quantitatively evaluated using EPA exposure models. In-water sediment exposures were considered potentially~~

~~complete and insignificant exposure pathways for recreational beach users and were not quantitatively evaluated in this BHHRA.~~

~~5.1.1.4 Incomplete Exposure Pathways~~

~~In-water sediment exposures were considered incomplete exposure pathways for dockside workers and transients based on the defined activities of these receptor populations in this BHHRA. Dockside workers are those workers who conduct specific activities within natural river beach areas and thus are not directly exposed to in-water sediments. In-water workers are the worker population for which in-water sediments exposures are considered potentially complete and were evaluated in this BHHRA. Transients who conduct specific activities while occupying natural river beach areas are unlikely to contact in-water sediment. The hypothetical future domestic water use scenario evaluates use of surface water for domestic water supply and thus in-water sediment exposures are considered incomplete exposure pathways for this receptor population.~~

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~~5.1.2~~3.3.3 Direct Exposure to Surface Water

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Direct exposure to contaminants in surface water could ~~potentially~~ occur during recreational~~l~~ or occupational activities that occur near ~~of~~or in the water.~~—~~. Transients may also use surface water ~~. either from groundwater seeps or the lower Willamette,~~ as a source of drinking water or for bathing.~~—~~. ~~-~~Accordingly, direct exposure via ingestion and dermal contact with surface water is considered to be a complete pathway for transients, recreational beach users, and divers.~~occur for many of the populations evaluated in this BHHRA. Two populations expected to potentially have the most frequent contact with surface water are transients and recreational beach users. At the direction of the EPA, exposure to surface water by divers and the hypothetical future use of untreated surface water as a domestic water source are also evaluated in this BHHRA.~~

~~5.1.2.1 Transients~~

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~~12.0 Transients may have dermal contact with surface water during swimming, bathing or other activities, such as washing of clothing or equipment. In theory, transients may also use river water as a drinking water source. Exposure to surface water by transients would likely occur within transient use areas.~~

~~5.1.2.2 Divers~~

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~~13.0 As described in Section 3.3.2.2, two different diver exposure scenarios are included in this BHHRA. The two exposure scenarios for divers differentiate between the use of either a wet suit or dry suit, as directed by the EPA (2008c). Both the wet suit and dry suit diver exposure scenarios assume that the diver is exposed to surface water through inadvertent ingestion of surface water and dermal exposure to surface water. TAs EPA stated in its approach, the use of a dry suit is expected to limit diver~~

exposure, so a diver using a wet suit is assumed to have more greater potential for dermal exposure to surface water.

5.1.2.3 Recreational Beach Users

14.0 The LWR is used by both adults and children for boating, water skiing, swimming, and other water activities that result in exposure to surface water. Of these activities, exposure to surface water would occur to the greatest extent while swimming in the river. Swimming would likely occur primarily within recreational beach areas.

5.1.2.4 Domestic Water User

As mentioned in Section 2.4.5, there is no known current use of surface water within the Study Area for a domestic water supply. However, because domestic water use is a designated beneficial use of the Willamette River following adequate pretreatment, the use of untreated river water as a domestic water source was assessed as a hypothetical future pathway for both adult and child residents, at the direction of EPA. In this scenario, exposure to untreated surface water could hypothetically occur from ingestion and dermal contact throughout the Study Area. At the direction of the EPA, volatilization of chemicals from untreated surface water to indoor air through household uses was identified as a potentially complete exposure pathway for hypothetical future domestic water use.

5.1.2.5 Potentially Complete and Insignificant Exposure Pathways

ESurface water exposure to contaminants in surface waters through via dermal absorption and ingestion were considered potentially complete and but insignificant exposure pathways for dockside workers, in-water workers, tribal fishers, and fishers. . It is unlikely that both dockside and in-water populations workers would have direct contact with surface water through industrial activitieson a regular basis, and the potential for significant exposure is considered low for . It is also unlikely thatrecreational/subsistence and tribal fishers and fishers would have significant direct contact with surface water through fishing activities. . Any exposures to surface water by the dockside workers, in-water workers, tribal fishers, or fishers would be minimal; therefore, surface water exposures were considered potentially complete and insignificant exposure pathways for these receptor populations.Additionally,

although contaminants may volatilizeVolatilization of chemicals from surface water to outdoor air, it is unlikely to result in a significant exposure considering the amount of mixing with ambient air that would occurand the relatively low concentrations of VOCs in surface water. . Given the low levels of chemicals in outdoor air from volatilization from surface water, surface water exposures throughHence, inhalation of volatiles to outdoor air was considered a potentially complete and but insignificant exposure pathway for all receptor populations who conduct outdoor activities. .

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~~5.1.2.6 Incomplete Exposure Pathways~~

~~This BHHRA did not identify any incomplete exposure pathways for surface water exposures.~~

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~~5.1.3~~3.3.4 Direct Exposure to Groundwater from Seeps

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Direct contact with groundwater ~~would~~ is assumed to occur only at seeps ~~only within human use areas~~ where groundwater comes to the surface ~~(i.e., seeps)~~ on ~~the~~ a beach above the water line~~.~~. Direct exposure to groundwater via seeps ~~and~~ is ~~only~~ considered a potentially complete exposure pathway for transients and recreational beach users~~.~~. As described in Section 2.1.4, a seep reconnaissance survey ~~there was~~ identified only ~~one a single groundwater seep,~~ Outfall 22B, which is ~~identified during the seep reconnaissance survey that has not been remediated and is~~ located at approximately ~~RM~~ RM 7W in an area designated ~~for the risk assessment~~ as ~~recreational or~~a potentially used by transients ~~use area.~~. ~~That seep, which is the potential groundwater discharge from Outfall 22B, occurs within a potential transient use area.~~ Therefore, exposure to surface water from the groundwater seeps at Outfall 22B ~~only transients were~~was ~~only~~ evaluated ~~for~~ only for transients~~for exposure to groundwater seeps in the~~is BHHRA.

~~5.1.3.1 Consumption of Transients~~

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~~Transients may have direct contact with groundwater seeps, within riverfront beach areas that have been identified as transient use areas. While contact with seep water would be unintentional, dermal contact with or incidental ingestion of seep water may occur.~~

~~5.1.3.2 Potentially Complete and Insignificant Exposure Pathways~~

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~~This BHHRA did not identify any potentially complete and insignificant exposure pathways for direct exposure to groundwater seeps.~~

~~5.1.3.3 Incomplete Exposure Pathways~~

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~~Direct exposure to groundwater seeps were considered incomplete exposure pathways for all receptor populations who do not conduct activities at beaches where groundwater discharges above the water line. As discussed above, only one groundwater seep was identified, which is within a transient use area. Therefore, direct exposure to groundwater seeps is considered an incomplete exposure pathway for dockside and in-water workers, recreational beach users, tribal fishers, fishers, and divers. The hypothetical future domestic water use scenario evaluates use of surface water for domestic water supply and thus groundwater seep exposures were considered incomplete exposure pathways for this receptor population.~~

~~5.1.4~~3.3.5 Fish ~~Consumption~~

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~~Certain chemicals may~~Many of the contaminants found in Portland Harbor are persistent in the environment and accumulate ~~through~~in the food-chain ~~bioaccumulate~~

~~in fish tissue, including fish. . and human populations~~Local populations ~~that~~ who consume fish caught in Portland Harbor may be exposed to COPCs ~~bioaccumulating that have~~ bioaccumulated in ~~the~~ fish ~~tissues. . Fish may be caught throughout the Study Area.~~ While the populations evaluated in this BHHRA are described as "fishers," ~~,~~ the fish consumption evaluation in this BHHRA includes people who consume fish caught within the Study Area, not just those who catch the fish~~.~~. Consumption of locally-caught fish is evaluated as a complete exposure pathway for

~~5.1.4.1 Non-tribal Fishers~~

~~A year-round recreational fishery exists within the Study Area. Current information suggests that spring Chinook salmon, steelhead, Coho salmon, shad, crappie, bass, and white sturgeon are the fish species preferred by local recreational fishers (DEQ 2000b, Hartman 2002, and Steele 2002). In addition to recreational fishing, the investigation by the Oregonian newspaper and the limited surveys conducted on other portions of the Willamette River indicate that immigrants from Eastern Europe and Asia, African-Americans, and Hispanics are most likely to be catching and eating fish from the lower Willamette (ATSDR 2002). These preliminary surveys also indicate that the most commonly consumed species are carp, bullhead catfish, and smallmouth bass (ATSDR 2002). However, other species may also be consumed. Conversations were conducted with transients about their consumption of fish or shellfish from the Willamette River as part of a project by the Linnton Community Center (Wagner 2004). Transients reported consuming a large variety of fish, and several transients said they ate whatever they could catch themselves or get from other fishers. However, the frequency and amount of consumption was not reported, and many of the transients indicated they were in the area temporarily. Site-specific information is not available for fish consumption rates for specific species, so a range of ingestion rates and various diets were evaluated in this BHHRA for both adult and child consumers.~~

~~5.1.4.2 Tribal Fishers~~

~~Four (Yakama, Umatilla, Nez Perce, and Warm Springs) of the six Native American tribes involved in the Portland Harbor RI/FS participated in a fish consumption survey that was conducted on the reservations of the participating tribes and completed in 1994 (Columbia River Inter-tribal Fish Commission (CRITFC) 1994). The results of the survey show that tribal members surveyed generally have higher fish ingestion rates than~~consume more fish ~~than~~ the general public. Fish ~~Certain~~ species, especially salmon and Pacific lamprey, are an ~~important food source as well as an integral part of the tribes' cultural, economic, and spiritual heritage. Ingestion~~ Consumption of fish by both adult and child tribal members ~~was evaluated in this BHHRA.~~

~~3.1.1.1 Potentially Complete but Evaluated Under a Different Receptor Category~~

~~Fish could be consumed by~~ dockside workers, in-water workers, recreational beach users, and divers. ~~; however, fish~~ Cconsumption of fish by these ~~receptor~~ populations is evaluated under the ~~fisher~~ recreational/subsistence receptor ~~category. .~~ Bty definition, ongoing ~~Long~~long-term~~,~~ ~~ongoing~~ fish consumption by transients would not be expected to occur~~;~~., ~~-~~and the evaluation of fish consumption for other

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receptors ~~therefore, the fisher receptor category would~~is considered to be protective of consumption of fish ~~consumption~~ by transients~~.~~.

~~5.1.4.3 Consumption of Incomplete Exposure Pathways~~

~~The hypothetical future domestic water use scenario evaluates use of surface water for domestic water supply and thus fish consumption was considered an incomplete exposure pathway for this receptor population.~~

~~5.1.5~~3.3.6 Shellfish ~~Consumption~~

Certain contaminants can bioaccumulate in s~~Like fish, s~~hellfish ~~may bioaccumulate certain chemicals in their tissue~~, and ~~.~~ Ppopulations ~~that consume shellfish~~ may be exposed to COPCs through consumption of shellfish that are ~~that accumulate in the shellfish tissue~~collected within the Study Area~~.~~. ~~In the Programmatic Work Plan, crayfish was identified as the species to use to evaluate shellfish consumption. Additionally, as required by EPA, consumption of clams is also evaluated in this BHHRA. Harvest and possession of Asian clams, which is the clam species that was found in the LWR during sampling events, is illegal in the State of Oregon because Asian clams are on the prohibited species list of the ODFW rules regarding the importation, possession, confinement, transportation and sale of nonnative wildlife (OAR 635-056-0050).~~

~~5.1.5.1 Fishers~~

~~S~~However~~,In theory, shellfish consumption could~~ may ~~occur throughout the Study Area wherever shellfish are found~~ T~~. However, it is not known to what~~the actual extent shellfish harvesting and consumption is presently ~~occurs~~occurring is not known~~.~~.

The Linnton Community Center project (Wagner 2004) reported that some transients reported eating clams and crayfish~~,~~; ~~however~~although~~,~~ many of the individuals indicated that they were in the area temporarily, move from location to location frequently, or have variable diets based on what is easily available~~.~~. The Superfund Health Investigation and Education (SHINE) program in the Oregon Department of Human Services (DHS) stated that is unknown whether or not crayfish are harvested commercially within Portland Harbor (ATSDR 2006)~~.~~. ODFW has records for crayfish collection in the Columbia and Willamette Rivers, but these records do not indicate whether the collection actually occurs within the Study Area~~.~~. Based on ODFW's data for 2005 to 2007, no commercial crayfish landings were reported for the Willamette River in Multnomah County~~.~~. DHS had previously received information from ODFW indicating that an average of 4,300 pounds of crayfish were harvested commercially from the portion of the Willamette River within Multnomah

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County each of the five years from 1997-2001.—. In addition to this historical commercial crayfish harvesting, DHS occasionally receives calls from citizens who are interested in harvesting crayfish from local waters who and are interested in fish advisory information.—. According to a member of the Oregon Bass and Panfish club, crayfish traps are placed in the Portland Harbor Superfund Site boundaries and crayfish collected for bait and possibly for consumption (ATSDR 2006).—. Even if collection does occur within the Study Area, it is not known whether those crayfish are consumed by humans or used as bait.

Because site-specific information is not available for shellfish consumption, a range of ingestion rates was evaluated in this BHHRA for adult shellfish consumers.CFor these reasons, consumption of crayfishshellfish was identified in the Programmatic Work Plan to evaluate shellfish consumption in the BHHRA. However, information obtained from other sources indicates that some harvesting of clams within the study area does occur. Thus, consumption of clams was also evaluated as a complete exposure pathway in the BHHRA.

3.1.1.2 Although Potentially Complete but Evaluated Under a Different Receptor Category

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SCconsumption of shellfish was evaluated asconsidered a potentially complete pathway for could potentially be consumed by dockside workers, in-water workers, recreational beach users, and divers,—, and recreational fishers.; Hhowever, as was done for consumption of fish, the consumption of shellfish consumption by these receptors populations is evaluated under the adult shellfish consumer receptor categoryas a separate receptorseparately from fish consumptionit was quantitatively evaluated only for subsistence fishers.—, as they were considered the most likely population to regularly harvest and consume shellfish.

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3.3.7 Infant Consumption of Human Milk

Lipid-soluble chemicals accumulate in body fat, including lipids in breast milk.—. and may be transferred to Bbreast-fed infants can then be exposed to these chemicals.—. in the lipid portion of human milk, water soluble chemicals also may partition into the aqueous phase and be excreted via human milk. IPer agreement with EPA and DEQ, infant exposure to PCBs, dioxins, DDx compounds, and PDBEs via the consumption of human milk was evaluated as a complete exposure pathway for the children of all receptors. Long-term, ongoing shellfish consumption by transients would not occur; therefore, the adult shellfish consumer receptor category would be protective of shellfish consumption by transients.

3.1.1.3 Incomplete Exposure Pathways

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The hypothetical future domestic water use scenario evaluates use of surface water for domestic water supply and thus shellfish consumption was considered an incomplete exposure pathway for this receptor population.

~~5.1.6~~3.3.8 Potentially Overlapping Exposure Scenarios

An estimate of reasonable maximum exposure should ~~address~~ not only address exposure for individual pathways, but also ~~Exposure~~ exposures ~~to receptors or populations~~ that ~~can~~ may ~~potentially~~ occur ~~under more than one scenario for an individual~~across multiple exposure routes~~.~~ . Examples of ~~these~~ overlapping scenarios include~~:~~ ~~an~~ in-water workers who ~~is also a high-frequency~~fish recreationally, and may also be ~~fisher and~~ recreational beach users.~~,~~ ~~a transient who is also a fisher, a tribal fisher who is also a recreational beach user, and others.~~ P~~The p~~otentially overlapping scenarios are indicated ~~in~~ on ~~Figure~~ Figure 3~~–~~1.~~–~~, and r~~It is likely that one or more of the exposure scenarios potentially affecting an individual will pose a much higher level of risk than the other scenario(s), such that combining the effects of the scenarios will not influence risk management decisions for the Study Area. ~~R~~risks from potentially overlapping scenarios are discussed in Section 5~~ of this the BHHRA~~.

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~~5.2~~3.4 CALCULATION OF EXPOSURE POINT CONCENTRATIONS

The exposure point concentration (EPC) is defined as the average concentration contacted at the exposure point(s) over the duration of the exposure period (EPA, 1992a). EPA recommends using the average concentration to represent "a reasonable estimate of the concentration likely to be contacted over time" (EPA 1989). Use of the average concentration also coincides with EPA toxicity criteria, which are based on lifetime average exposures~~.~~ ~~–~~. Because of the uncertainty associated with estimating the true average concentration at a site, EPA guidance (EPA 1989, 1992) notes that the 95 percent upper confidence limit (UCL) of the arithmetic mean should always be used for this variable~~.~~ ~~–~~. ~~Because it is generally not possible to know the true average, the 95 percent upper confidence limit (UCL) of the arithmetic mean (UCL) is typically used in CERCLA risk assessments to represent the average concentration.~~ The UCL is defined as a value that, when calculated repeatedly for randomly drawn subsets of data, equals or exceeds the true population mean 95 percent of the time~~.~~ ~~–~~. Use of the UCL can also help account for uncertainties that can result from limited sampling data, and more accurately accounts for the uneven spatial distribution of contaminant concentrations. ~~UCLs were calculated for each analyte using EPA's statistical program ProUCL, Version 4.1 (EPA 2011a) using concentrations directly measured in each~~EPCs were calculated for media and pathways that were evaluated quantitatively evaluated in this BHHRA. The process to ~~estimate~~ calculate EPCs for tissue and beach sediment was previously described in the Programmatic Work Plan, and ~~the~~ Round 1 tissue EPCs were previously presented in *Round 1 Tissue Exposure Point Concentrations* (Kennedy/Jenks Consultants 2004b) and *Salmon, Lamprey, and Sturgeon Tissue Exposure Point Concentrations for Oregon Department of Human Services* (Kennedy/Jenks Consultants 2004c), both of which were approved by EPA~~.~~ ~~–~~. The process for deriving EPCs for in-water sediment, surface water, and groundwater seeps was previously described in *Exposure Point Concentration Calculation Approach and Summary of*

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Exposure Factors (Kennedy/Jenks Consultants 2006), ~~which was approved~~as approved by EPA~~.~~.

EPCs ~~used~~ for RME evaluations ~~were calculated for asare~~represent either the ~~95% percent upper confidence limit on the arithmetic mean (~~95~~%~~ percent UCL~~,)~~ ~~and~~ or the maximum detected value when either there was insufficient data to calculate a UCL or the calculated UCL was greater than the maximum reported value~~.~~. ~~EPA guidance AAHowever, as~~although ~~inconsistent with EPA guidance (EPA 1992), described in DEQ guidance and agreed to by EPA and the LWG,~~ EPCs for ~~theseveral~~sediment and surface water CT~~E~~ evaluations ~~represent~~were calculated as the simple arithmetic~~-~~ mean~~mean as previously agreed to by EPA and the LWG~~. EPCs for fish/shellfish consumption scenarios are the lesser of the 95 percent UCL or the maximum detected concentration, central tendency evaluations were achieved by using mean or median consumption rates.~~—~~ ~~-~~For analytes with less than 5 detected concentrations, the maximum detected concentration for that exposure area was used as the EPC for the RME evaluation~~.~~. The uncertainties associated with estimating EPCs from small datasets ~~(i.e., less than 10 detected concentrations)~~ and with using the maximum detected concentration as the EPC are discussed in Section 6~~.~~. The 95 percent UCLs were calculated for each dataset following EPA guidance (EPA 2002a and EPA 2007b)~~.~~. ProUCL version 4.00.02 (EPA 2007b) was used to test datasets for normal, lognormal, or gamma distributions and to calculate the 95 percent UCLs~~.~~ ~~. Data were tested first for normality, then for gamma distributions, and finally for lognormal distributions, as recommended by ProUCL guidance (EPA 2007b).~~ If the data did not exhibit a discernable distribution, a non-parametric approach ~~(e.g., Chebyshev)~~ was used to generate a UCL~~.~~. The 95 percent UCLs were calculated using the method recommended by ProUCL guidance (EPA- 2007b) ~~for the data distribution, sample size, and skewness.~~ ~~-~~. ~~n, an. although EPA guidance the arithmetic mean for each exposure area. In some exposure areas, the maximum concentration was used instead of the 95% percent UCL. Therefore, the EPCs are referred to as the 95% percent UCL/max and mean throughout this BHHRA.~~

Prior to calculating EPCs, the ~~for sediment, surface water, tissue, and groundwater seeps,~~ data were ~~reduced~~evaluated~~,~~ ~~as needed,~~ to address reporting of multiple results for the same ~~constituent~~ analyte in the same sample and to reduce laboratory duplicates and field splits of samples to derive ~~one~~ a single value for use~~.~~. Data reductions performed within the SCRA database followed the rules described in *Guidelines for Data Reporting, Data Averaging, and Treatment of Non-Detected Values for the Round 1 Database Technical Memorandum* (Kennedy/Jenks Consultants et al~~.~~ . 2004)~~.~~ ~~. Additional data reductions and data use rules specific to the BHHRA were approved by EPA and are detailed in Attachment F2.~~

~~Chemicals that were~~Sample results are reported as not detected ~~at~~ when the concentration of the analyte in the sample is less than the detection limit~~.~~. The actual concentration~~s above the detection limit were designated as non-detects. Non-detects may represent concentrations that are~~may be zero~~, or may represent concentrations~~ .

or ~~greater than~~some value between zero ~~but less than~~and the detection limit~~.~~. ~~. For purposes of calculating mean EPCs, non-detected values were used in the calculations at one half their detection limit. For both mean CTE and~~N ~~and 95% percent UCL/max~~RME ~~EPCs, non-detect~~s ~~whose for which the detection limit was greater than the maximum detected concentration for~~ in ~~an exposure area were removed from the dataset prior to calculation calculating~~ of the EPCs. ~~For the purposes of~~When ~~calculating 95% percent UCL/max EPCs for the RME evaluations, t~~The following rules were applied to the dataset~~s~~ for tissue ~~(based on species and tissue type)~~, sediment, surface water, and ~~the~~ groundwater seep samples:

1. A~~If a~~ chemical was assumed to not be present if was not detected in any sample for a given medium within the Study Area, ~~it was assumed to not be present, so and~~ an EPC was not calculated for that chemical in that medium

2. A~~If a~~ chemical was presumed to be present if it was detected at least once within the Study Area in samples for a given medium~~.~~ ~~, the non-detect~~When calculating the 95 percent UCL, non-detects ~~concentrations~~ were used in the calculation ~~in the RME EPC calculations in accordance with the methods used~~ as recommended by ~~in~~ the ~~software~~ ProUCL software. ~~Version 4.00.02 (EPA 2007b).~~ ProUCL software output for the 95~~%~~ percent UCLs calculated in this BHHRA are provided in Attachment F4~~.~~. ~~For purposes of~~When calculating the simple mean ~~concentration~~, non-detected values were replaced with one half their detection limit in the calculations.

3. Non-detects for which the detection limit was greater than the maximum detected concentration in an exposure area were removed from the dataset prior to calculating EPCs.

~~2. For purposes of calculating the mean concentration for CT evaluations, non-detected values were used in the calculations at one half their detection limit.~~

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~~In risk characterization, some~~Certain toxicity values are based on exposure to chemical mixtures ~~and not~~rather than to individual chemicals~~. The risks from these chemicals, which~~ , as ~~were~~ identified in *Human Health Toxicity Values Interim Deliverable* (Kennedy/Jenks Consultants 2004a)~~. ,~~ Concentrations of the individual isomers or congeners that comprise the mixtures were summed as described in Section 2.2.8 to calculate the EPCs for the mixtures, and the risks from these chemicals were evaluated ~~for the combined exposure to the chemicals and not on an~~on the basis of the combined mixture ~~and not~~rather than ~~to~~for individual chemical ~~basis. , and c~~For chemicals that were evaluated as mixtures in the BHHRA, the concentrations of the individual isomers or congeners that comprise the mixtures were summed to calculate the EPCs for the mixtures, as described in Attachment F2. The chemicals evaluated as mixtures are described in Attachment F2 as well, and include: COPCs evaluated as mixtures are PCBs, endosulfans, chlordanes, DDTs, DDDs, DDEs, and 2,3,7,8-TCDD TEQs.

~~5.2.1~~3.4.1 Beach Sediment

~~Sediment~~ EPCs for beach sediment were calculated using data collected during Rounds 1 and 2 from locations designated as human use areas during Round 1 and 2~~, were used to estimate the~~~~calculate~~ ~~EPCs for beach sediment. There were no additional~~ b~~B~~each sediment data was not collected from human use areas ~~for~~ during Round 3~~.~~. ~~Within the Study Area, EPCs were estimated for exposure areas based on the different types of potentially exposed populations potentially exposed. Since potentially complete exposure pathways for sediment involve direct contact with beach sediments, only beach sediment data were used in estimating EPCs for direct exposure pathways.~~

One composite sample was collected from each beach area~~.~~, and ~~Therefore,~~ the results from ~~the~~ each composite sample were was ~~used for both the 95% percent UCL/max and~~as ~~the mean~~ as the EPC~~s~~ for the ~~both the~~ RME and CT evaluations~~s.that beach. The process to estimate EPCs for each receptor population is described below.~~

~~**5.2.1.1** Dockside Workers~~

~~15.0 Dockside workers~~ ~~could potentially be exposed to beach sediment in areas considered to be industrial sites as dockside worker use areas, which are shown in on Map 2-1, and b. Beach sediment data from each of these areas were used to estimate the EPCs for dockside workers.~~ ~~For dockside workers, the exposure area is considered to be the industrial site (i.e., facility within a property boundary) where the worker is employed. To estimate an EPC for each~~When evaluating exposure for dockside workers at industrial site~~s~~, the same EPC was used to represent adjacent sites ~~beach sediment data from the composite sample collected from the beach associated with that industrial site were used. If~~in instances where the beach area extends ~~extended~~ across ~~multiple~~ individual ~~industrial~~ site boundaries~~, the same EPC was used to evaluate exposure of dockside workers at each of the adjacent industrial sites. Beach sediment EPCs in beach sediment for the exposures of dockside workers worker scenario are presented in Table 3-2.~~. Otherwise, each designated beach area was evaluated as a single exposure area for transients, recreational beach users, and recreational/subsistence~~/~~ and tribal fishers~~.~~. Beach sediment exposure areas are presented on Map 2-1, EPCs for dockside workers are presented in Table 3-2, EPCs for transient, recreational, and fishing uses are presented in Table 3-3.

~~5.2.1.2 Transients~~

~~Transients could potentially be exposed to beach sediment in areas where such use is known or suspected to occur. transient use areas, which are While some individuals may move throughout the Study Area, others may spend a majority of their time at a single location. Accordingly, EPCs for transients were estimated for each individual beach area as shown in on Map 2-1, and . Transients may move throughout the Study Area, while some may spend a majority of their time at only one of the identified areas. Therefore, EPCs for transients were estimated for each beach area within the~~

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transient use areas to represent a range of possibilities for transients residing in the Study Area. Beach sediment EPCs for exposures by transients are presented in Table 3-3.

5.2.1.3 Recreational Beach Users

Recreational beach users could potentially be exposed to beach sediment in areas designated as having the potential for recreational use. These area may be accessed by the public either directly from the shore, or via boat. e areas For recreational beach users, the exposure areas were evaluated as a single beach, although individuals may be exposed to multiple beach areas within the Study Area during the exposure time period. , which are shown in Map 2-1. Beach sediment data from these areas were used to estimate the the EPCs for each individual beach area as shownEPCs for recreational beach users. For recreational beach users, the exposure area is considered to be one river beach area, which represents a conservative assumption for the BHHRA because the beach user could be exposed to multiple recreational beach areas within and outside of the Study Area during the exposure time period. EPCs were estimated for individual beaches within the recreational beach use areas. Beach sediment EPCs for exposures by recreational beach users are presented on Map 2-1, the specific EPCs are presented in Table 3-3.

5.2.1.4 Fishers

Fishing from shore could occur from beaches with unrestricted access, which are were considered to be the same locations as potential transient and/or recreational use areas. Although recreational and subsistence fishers may fish from multiple beach areas within the Study Area, exposures for fishers were evaluated at individual beaches in order to provide a range of risk estimates for individual beaches throughout the Study Area. Because fishing was assumed to occur at the same beach areas as evaluated for the recreational and transient use areas, the same EPCs calculated for transients and recreational beach users were used Beach sediment data from these areas were used to estimate the EPCs for non-tribal and tribal fishers, as shown on Map 2-1. Fishers are likely to fish from multiple beach areas within and outside of the Study Area during the exposure time period. The exposure area for fishers was considered to be one individual beach in order to provide a range of risk estimates for individual beaches within the Study Area. EPCs were estimated for individual beaches within the recreational and transient use areas and are the same as the EPCs for transients and recreational beach users. Beach sediment EPCs for beach sediment exposures by to fishers are presented in Table 3-3.

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5.2.23.4.2 In-Water Sediment

In-water sediment data of appropriate data quality collected within the Study Area were used to estimate EPCs for in-water sediment. Direct contact with in-water sediment would only is most likely to occur with in the near-shore areas outside of the navigation channel.. surface sedimentT, so thus, only surface sediment data collected (less than 30.5 cm in depth and) collected outside of the navigation channel

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were used ~~in~~ to ~~estimating the EPCs for~~ exposure to in-water sediment ~~exposures.~~ ~~.~~ ~~Exposure to in-water sediment was assumed to be a complete pathway~~

~~If a contaminant was detected at least once in surface sediment within the Study Area, an EPC was calculated for that contaminant, and any non-detect concentrations were included in the EPC calculations in accordance with the ProUCL Version 4.00.02 guidance (EPA 2007b). In-water sediment EPCs were estimated for in-water workers, fishers, and divers, and the calculated and EPCs are presented in Table 3-4.~~

~~**5.2.2.1** In-Water Workers~~

~~Exposure~~ For in-water workers, ~~to sediment~~ exposure ~~by in-water workers could occur anywhere within the Study Area that docks or pilings are being constructed or where other in-water activities are occurring (, such as maintenance dredging of private slips or berths). While these activities would not necessarily be restricted to a given area, exposure would most likely be localized to in-water sediment adjacent to facilities where these activities occur at specific facilities. Most of these activities would be, and between the shore and the navigation channel. As a result Accordingly, near-shore sediment samples, s in near-shore (i.e., excluding the central navigation channel) I in water sediment EPCs are calculated in one-~~half- ~~river~~ mile segments along both sides of the river ~~were used to develop EPCs for in-water sediment EPCs. . In addition to calculating EPCs for exposure within the Study Area, EPCs they were also calculated for the downstream reach of the river~~ from ~~RM~~ RM 1.0 to RM ~~1.9, the downtown reach of the river from RM~~ RM ~~11.8~~ 12.2, and for samples within Multnomah Channel~~, per an agreement with EPA.~~ ~~.~~

~~In accordance with EPA guidance (1989), the 95% percent UCL was used for the 95% percent UCL/max EPC for in-water workers for exposure areas with at least 5 detected concentrations for a given analyte. For analytes with less than 5 detected concentrations, the maximum detected concentration for that exposure area was used as the 95% percent UCL/max EPC. Uncertainties associated with estimating EPCs for small datasets (i.e., less than 10 detected concentrations) and in using the maximum detected concentration as the EPC are discussed in Section 6. The arithmetic mean of detected concentrations was used for the mean EPC. The 95% percent UCLs were calculated for each dataset following EPA guidance (EPA 2002a and EPA 2007b). ProUCL version 4.00.02 (EPA 2007b) was used to test datasets for normal, lognormal, or gamma distributions and to calculate the 95% percent UCLs. Data were tested first for normality, then for gamma distributions, and finally for lognormal distributions, as recommended by ProUCL guidance (EPA 2007b). If the data did not exhibit a discernable distribution, a non-parametric approach (e.g., Chebyshev) was used to generate a UCL. The 95% percent UCLs were calculated using the method recommended by ProUCL guidance (EPA 2007b) for the data distribution, sample size, and skewness.~~ In-water sediment EPCs for exposures by in-water workers, divers, and recreational/subsistence/tribal fishers are presented in

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Table 3-4.

5.2.2.2 Fishers

Fishers include adult non-tribal and tribal fishers. The fisher scenario is based on long-term exposure. Although rFor repeated exposures with in-water sediment over an entire lifetime, direct contact with in-water sediment wouldmay occur over a very wide area. Even though exposure would occur over a wide area, in-water sediment EPCs for the fishers were derived on a half-mile segments on each side of the river, as was done for the in-water workers, as requested by EPA in its comments, dated February 24, 2005 on the draft *Exposure Point Concentration Calculation Approach and Summary of Exposure Factors*. Deriving exposure areas based on a half-mile segment on each side of the river provides a range of possibilities for risk management and for risk communication to fishers making fishing location choices. In addition to calculating EPCs for exposure within the Study Area, EPCs were also calculated for the downstream reach of the river from RM 1.0 – 1.9, the downtown reach of the river from RM 11.8 – 12.2, and for samples within Multnomah Channel, per an agreement with EPA. Both the mean and 95% percent UCL/max EPCs were calculated as described for the in-water worker EPCs. In-water sediment EPCs for exposures to fishers are presented in Table Table 3-4.

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5.2.2.3 Divers

Commercial divers could conductmay be involved in diving activities anywhere within the Study Area, although exposure to in-water sediment would most likely be to in-water sediment adjacent to facilities where commercial diving is required for purposes such as marine construction, underwater inspections, and routine operations and maintenance. It is assumed that all other diving done by a diver is done outside of the Study Area. Accordingly, iTherefore, in-water sediment EPCs for the diver scenario were derived for half-mile segments on each side of the river, as was done for the in-water workers, and as directed by EPA in the its memorandum dated September 15, 2008 (EPA 2008c). In addition to calculating EPCs for exposure within the Study Area, EPCs were also calculated for the downstream reach of the river from RM 1.0 – 1.9, the downtown reach of the river from RM 11.8 – 12.2, and for samples within Multnomah Channel, per an agreement with EPA. Both the 95% percent UCL/max and mean EPCs were calculated as described for the in-water worker EPCs. In-water sediment EPCs for exposures to divers are presented in Table Table 3-4.

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5.2.33.4.3 Surface Water

Exposure concentrations in sSurface water were calculated using data cof appropriate data quality collected within the Study Area-, as well as the transect data collected from the mouth of Multnomah Channelwere used to estimate EPCs. . Both integrated and non-integrated water column surface water samples were collected within the

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~~Study Area and~~ were ~~used~~included in the data set, the s~~in estimating the surface water EPCs. SThe s~~pecific samples used ~~to estimate EPCs for each receptor~~ were dependent upon the anticipated exposures by the different receptors~~ of that receptor to surface water within the Study Area.~~ . ~~Surface water EPCs were estimated for transient, recreational beach user, diver, and hypothetical future domestic water user exposure scenarios, and aA summary of surface waterthe samples used to calculate EPCs for each receptor is provided in Table 3-5. Surface water EPCs were estimated for transient, recreational beach user, diver, and hypothetical future domestic water user exposure scenarios.~~

~~5.2.3.1 SBecause surface water eTransients~~

~~E~~Exposures by transients ~~tTransient exposures to surface water could~~may occur throughout the year~~ at transient use areas within the Study Area. As a result,For this reason, data~~ EPCs were calculated using data from all seven ~~of the completed~~ seasonal sampling events~~ were used.~~. The data from~~–~~ each of the five transect locations were combined as described in Section- 2.2.6. and EPCs were calculated for those five locations, at Willamette Cove using the discrete ~~in estimating the surface water EPCs for transients. Data from the four transect stations within the Study Area were used to estimate surface water EPCs for~~ evaluating exposures at ~~to~~ transients ~~use areas throughout the Study Area. Results s~~of near-bottom and near-surface ~~horizontally integrated transect samples from the same sample location and sampling event were combined prior to calculation of EPCs, as were vertically integrated transect samples from the east, middle, and west portions of the river. Rules for combining transect samples are described in Attachment F2. S~~urface water ~~samples~~ samples, and on a ~~Harbor~~Study Area-wide basis using the combined transect data from within the Study Area, excluding the transect location W027, which was collected at the mouth of Multnomah Channel~~were also collected at Willamette Cove, which is a quiescent transient use area that may not be adequately characterized by the transect samples. Year-round data from this surface water sample location were used to estimate surface water EPCs for exposures in Willamette Cove.~~ . Surface water EPCs for exposures by transients are presented in ~~Table~~ Table 3~~–~~6.

~~Given that transients can~~ may live along many parts of the river, ~~EPCs were calculated for each transect, as well as for the combination of all four transects. In addition to calculating EPCs for exposures within the Study Area, EPCs were calculated for one transect station outside of the Study Area, at Multnomah Channel. For the 95%~~ percent ~~UCL/max EPC, the 95%~~ percent ~~UCL was used for the EPC for exposure areas with at least 5 detected concentrations for a given analyte. For analytes with less than 5 detected concentrations in a given exposure area, the maximum detected concentration was used as the EPC. Uncertainties associated with estimating EPCs for small datasets (i.e., less than 10 detected concentrations) and in using the maximum detected concentration as the EPC are discussed in Section 6. The 95%~~ percent ~~UCLs were calculated as described for in-water sediment. The arithmetic mean of the detected concentrations for each exposure area was used for the mean EPC.~~

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5.2.3.2 Recreational Beach Users

Recreational beach user Eexposures to SEBecause exposure to ssurface water by recreational beach users at recreational use areas within the Study Area could is largely expectedwas assumed to occur primarily during summer months at recreational use areas within the Study Area. The only summer sampling event for recreational use areas occurred in July 2005. As a result, Accordingly,. Therefore, , only data from the low-water sampling event conducted in July 2005 that sampling event were used in for estimating calculating the surface water EPCs for recreational beach users. . The uncertainty associated with using data from only the low-water summer sampling event is discussed further in Section 6. DThese data were collected from recreational beaches in July 2005 included three transect locations and three single-point locations (Cathedral Park, Willamette Cove, and Swan Island Lagoon). . Data from the three transect stations (W005, W011, W023) were used to estimate surface watercalculate EPCs for representing exposures at non- quiescent recreational beach use areas throughout the Study Area, and data from the three single-point surface water samples sample locations were used to estimate calculate EPCs for to represent exposure at quiescent recreation beach areas. . Because only one sample was collected from each quiescent area during low-water periods, the results for the single sample were used as both the 95% percent UCL/max EPC and the mean EPCs for each area. Only three transect samples were collected in July 2005 during the low-water period, so the maximum concentrations were used as the 95% percent UCL/max EPCs and the arithmetic mean of detected concentrations were used as the mean EPCs. Surface water EPCs for exposures by recreational beach users are presented in Table Table 3- 7.

5.2.3.3 Divers

Diver Eexposures to surface water by divers could waswere assumed to occur throughout the year at all areas within the Study Area and waswere not considered seasonally dependent. . Therefore, for divers, all of the surface water data collected in the Study Area, including both transect data and data collected from single-point stations, were used to estimate EPCs. In addition to calculating EPCs for exposure within the Study Area, EPCs were also calculated for one transect station outside of the Study Area, at Multnomah Channel. Transect data were used to estimate EPCs for diver exposures as described for transient exposures (Section 3.4.3.1). Surface water data available as single-point samples from Round 2 in several areas of the Study Area, and as near-bottom and near-surface samples from Round 3 sampling, were also used to estimate EPCs. For the Round 3 surface water samples collected as single-point samples, the near-bottom and near-surface samples were combined for use in estimating EPCs, as described in Attachment F2. As with diver exposure to in-water sediment, diver exposure to surface water is expected to be in localized areas adjacent to facilities where commercial diving is required for purposes such as marine construction, underwater inspections, and routine operation and maintenance. Therefore, samples from single-point stations were used to calculate EPCs for near-shore half-river mile segments along both sides of the river, consistent with the

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approach for in-water sediment EPCs and per direction from EPA.EPCs were calculated in one-half mile intervals along each side of the river, and at each transect location.–. Surface water EPCs in surface water for exposures by divers are presented in Table Table 3–8.

5.2.3.4 Domestic Water User

UThe hypothetical use of untreated surface water as a domestic water source could was assumed to have the potential to occur within at any location through the Study Area throughout the yearon a year-round basis.–. As a resultAccordingly, data from all seven of the completed seasonal sampling events were used in estimating the surface water EPCs for the domestic water user. –. EPCs were determined calculated for all individual transect stations and for single point stations with vertically integrated samplesdata. This dataset included samples from the four transect stations within the Study Area and single point vertically integrated samples from Cathedral Park, Willamette Cove, and Swan Island Lagoon. In addition, EPA required that data from.–. In addition, data from locations where co-located near-bottom and near-surface surface water stations where both samples were collected be were averaged and used in the domestic water dataset. Study Area-wide EPCs included all vertically integrated samples.–. Transect data were used to estimate EPCs for hypothetical domestic water use as described for transient exposures (Section 3.4.3.1). For At single point stations, fewer than five samples were taken from each station, so the maximum detected concentration was used as the 95% percent UCL/max EPCfor the RME evaluation and the mean of detected concentrations was used as the mean Efor CTPC. Surface water EPCs were estimated for transient, recreational beach user, diver, and hypothetical future domestic water user Surface water EPCs in surface water for– the hypothetical use of untreated surface water as a domestic water source are presented in Table Table 3–9.

5.2.43.4.4 Groundwater Seeps

As discussed Section 2.1.4, Outfall 22B, which is located on the west side of the river at RM RM 7, was the only seep identified Direct contact with groundwater would occur only within human use areas where groundwater comes to the surface (i.e., seeps) on the beach above the water line. Each Thus, each groundwater seep where direct contact could occur represents an exposure area for this pathwayfor groundwater. The only groundwater seep where direct contact could occur within the Study Area.–. Data from two sampling events is within the potential transient use area located on the west side of the river at RM 7 (Map 2-5) at . Outfall 22B,, which is a potential conduit of groundwater discharge and results in the water present on that beach, was sampled. twice between 2002 and 2007 at times that did not involve stormwater influence. If a chemical was detected in only one of the two samples, that the result for that contaminant was used as both the 95% percent UCL/max and mean EPCsas the EPC for both RME and CT evaluations for that contaminant. If a contaminant was detected in both samples, the maximum concentration was used as

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~~the 95% percent UCL/max EPC for the RME evaluation, and the arithmetic mean of the detected concentrations was used as the mean EPC. For the CT evaluation, Groundwater seepThese~~ were used to calculate the ~~EPCs~~ EPC, and the results are presented in ~~Table~~ Table 3~~-~~10.

~~5.2.5~~3.4.5 Fish and Shellfish Tissue

EPCs ~~Fish~~ for fish and shellfish tissue ~~EPCs~~ were ~~derived~~ calculated ~~from~~ using ~~tissue sampling results~~data collected in ~~of~~ the ~~the LWG~~ Round~~-~~ 1, ~~Round~~ Round 2, and ~~Round~~ Round 3 investigations, and the ODHS study~~.~~. ~~Fish tissue EPCs are presented in Tables 3-11 through 3-21, and shellfish tissue EPCs are presented in Tables 3-22 though 3-25. The~~ EPCs derived from Round 1 data were originally presented in *Round 1 Tissue Exposure Point Concentrations* (Kennedy/Jenks ~~Consultants~~ Consultants 2004b)~~, which was approved by EPA.~~. EPCs derived using the results of the ODHS study were originally presented in *Salmon, Lamprey, and Sturgeon Tissue Exposure Point Concentrations for Oregon Department of Human Services* (Kennedy/Jenks Consultants 2004c).~~These EPCs were derived for fish species and crayfish that were evaluated for human consumption. Since Round 1, new additional data have been collected for clam, crayfish, smallmouth bass, and common carp. No new additional data have been collected since Round 1 for use in the calculation of brown bullhead and black crappie EPCs. The EPCs derived for adult salmon, adult lamprey, and adult sturgeon using the results of the ODHS study were originally presented in *Salmon, Lamprey, and Sturgeon Tissue Exposure Point Concentrations for Oregon Department of Human Services* (Kennedy/Jenks Consultants 2004c). These EPCs were derived calculated for salmon whole body, fillet with skin, and fillet fillet without without skin composite samples, lamprey whole body composite samples, and sturgeon fillet fillet without without skin samples.~~

~~Crayfish and clams were collected and composited at each sampling location. EPCs for crayfish were calculated for crayfish at individual locations, as well as for the entire Study Area per the Programmatic Work Plan. EPCs for clams were calculated for clams for approximately one river mile on each side of the river, as well as for the entire Study Area, as required by EPA in its comments on the Round 2 Report. EPCs were also calculated for crayfish and clams collected between RM 1.0 and 1.9 and between RM 11.8 and 12.2, per an agreement with EPA. EPCs for clams were calculated for both depurated and undepurated samples.~~

Smallmouth bass were collected and composited over a per river mile~~.~~. EPCs~~—~~ whole body and fillet~~—~~were calculated for smallmouth bass at each ~~per~~ river mile as well as for the entire Study Area consistent with their small home range~~, as specified in per the Programmatic Work Plan.~~. ~~EPCs were calculated for both whole body and fillet samples.~~

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Common carp, black crappie, and brown bullhead were collected and composited within river segments designated as fishing zones, which are largely based ~~based in part~~ on the home range of the fish as determined in a study of anadromous fish in the LWR by the Oregon Department of Fish and Wildlife (ODFW 2005). ~~–~~. ~~For~~ Fishing zones in ~~Round~~ Round 1 ~~consisted of two data collection, there were two fishingthree-mile long fishing zones zones that extended over~~were designated three-mile segments~~:~~ at ~~RM~~ ~~RM~~ RM 3~~–~~6 and ~~RM~~ ~~RM~~ RM 6~~–~~9~~.~~ ~~For~~ Round~~-~~ 3~~,~~ ~~which data collection, which~~ included additional samples of common carp ~~(only, collection~~ but not black crappie or brown bullhead~~)~~, ~~there were and was divided in to~~from three separate four mile long fishing zones that extended over four-mile segments ~~:~~at ~~RM~~ ~~RM~~ RM 0~~–~~4, ~~RM~~ ~~RM~~ RM 4~~–~~8, and ~~RM~~ ~~RM~~ RM 8~~–~~12~~.~~ EPCs ~~-~~for common carp, black crappie, and brown bullhead were calculated as whole body and fillet for each fishing zone ~~in~~ from which they were sampled, ~~–~~, as well as for the ~~entire sampling area to representthe entire~~ Study Area ~~wide exposure. . EPCs were calculated for both whole body and fillet samples.~~

Adult salmon ~~and lamprey~~ were collected at the Clackamas fish hatchery, ~~and Willamette Falls, respectively,~~ adult lamprey were collected at Willamette Falls, and sturgeon were collected ~~at various locations~~ throughout the Study Area~~.~~ ~~–~~. Salmon were analyzed as whole body, fillet with skin, and fillet without skin composite samples~~.~~ ~~–~~. Lamprey were analyzed only as whole body composite samples, sturgeon were analyzed only as fillet without skin composite samples~~.~~ ~~–~~. EPCs were calculated for each species accordingly as average concentrations representative of the entire Study Area.

Crayfish and clams were collected and composited at each sampling location~~.~~ ~~–~~. EPCs for crayfish were calculated for each individual location as well as for the entire Study Area~~.~~ ~~–~~. EPCs for clams were calculated for both depurated and undepurated samples per river mile on each side of the river, as well as for the entire Study Area~~.~~ ~~–~~. EPCs were also calculated for crayfish and clams collected between RM- 1.0 and 1.9 and between RM- 11.8 and 12.2, per an agreement with EPA.

EPCs for fish tissue are presented in Tables- 3--11 through 3--21, and EPCs for shellfish tissue are presented in Tables- 3--22 through 3--25. ~~EPCs representative of the entire Study Area were calculated for adult salmon, adult lamprey, and sturgeon using available data to be representative of theas follows: entire Study Area. adult salmon, EPCs were calculated for both whole body and fillet; adult lamprey, whole body; and sturgeon, fillet onlysamples for adult salmon. Only whole body data were available for adult lamprey and only fillet data were available for sturgeon, so the EPCs for adult lamprey were calculated for whole body samples and the EPCs for sturgeon were calculated for fillet samples.~~

~~In calculating the EPCs for fish and shellfish, if only one sample was collected within a given exposure area, that result was used as both the 95% percent~~

~~UCL/max and mean~~ RME and CTE ~~EPC for that contaminant. If more than one sample was collected, either the 95%~~ percent ~~UCLs or the maximum detected concentrations were was used as the 95%~~ percent ~~UCL/max~~RME ~~EPCs, depending on the number of reported concentrations~~detections~~. If detected concentrations for at least five samples were available, the 95%~~ percent ~~UCLs were calculated as described for in-water sediment. If less than five detected concentrations were available, the maximum detected concentration was used as the 95%~~ percent ~~UCL/ max EPC. EPCs for Study Area-wide exposure were calculated from the Study Area-wide data set. Uncertainties associated with estimating EPCs for small datasets (i.e., less than 10 detected concentrations) and in using the maximum detected concentration as the EPC are discussed in Section 6. The arithmetic mean of detected concentrations was used as the mean EPC, assuming that all non-detects were one-half the detection limit.~~

~~EPCs for multi-species fish~~ diet ~~tissue consumption scenarios were calculated using a weighted average of site-wide EPCs for each COPC, based on the percent of each species consumed in the diet.~~

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~~5.3~~3.5 ~~PROCESS TO CALCULATE~~ESTIMATION OF CHEMICAL INTAKES

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The amount of each chemical incorporated into the body is defined as the dose and is expressed in units of milligrams per kilogram per day (mg/kg-day)~~.~~. The dose is calculated differently when evaluating carcinogenic effects than when evaluating noncarcinogenic effects~~.~~. Each is described below:

~~Noncarcinogens~~Non-cancer effects:~~–~~ The dose is averaged over the estimated exposure period~~.~~. ~~This is done to be consistent with the assumption that adverse effects are not expected occur after exposure has ceased.~~ Thus, the ADD is used to represent the potential for adverse health effects over the period of exposure.

~~Carcinogens~~Carcinogenic effects:~~–~~ The dose is based on the estimated exposure duration, extrapolated over an estimated 70-year lifetime~~.~~. This is consistent with the cancer slope factors, which are based on lifetime exposures, and on the assumptions that the risk of carcinogenic effects is cumulative and continues even after exposure has ceased.

For non-occupational scenarios where exposures to children ~~are also expected to be present~~are considered likely, both adult and child receptors were evaluated. ~~because C~~children often exhibit behavior such as outdoor play activities and greater hand-to-mouth contact~~,~~ that can result in greater exposure than for a typical adult. In addition, children also have a lower overall body weight relative to the predicted intake. Because cancer risks ~~is~~are averaged over a lifetime, ~~it~~they ~~is~~are directly proportional to the exposure duration as well as the dose and the potency of the chemical. Accordingly, cancer risks were also assessed for a combined exposure from

childhood through adult years, to account for the increased relative exposure and susceptibility associated with childhood exposures.

Superfund exposure assessments should be conducted such that the intake variables for an exposure pathway should result in an estimate of the reasonable maximum exposure (RME) expected to occur under both current and future land use conditions (EPA, 1989)~~.~~. The RME is defined as the highest exposure that is reasonably expected to occur at a site~~.~~. The intent is to estimate an exposure that is substantially greater than the average, yet is still within the range of possible exposures~~.~~. In general, this is accomplished by using a combination of 90th or 95th percentile values for contact rate, exposure frequency and duration, and 50th percentile values for other variables~~.~~. This BHHRA also evaluated central tendency (CT) exposures, which is intended to represent an average exposure by the affected population~~.~~.~~.~~ ~~EPA (1989) defines exposure as "the contact with a chemical or physical agent" and defines the magnitude of exposure as "the amount of an agent available at human exchange boundaries (i.e., the lungs, gut, and skin) during a specified time period." Exposure assessments are designed to determine the degree of contact a person has with a chemical. Thus, estimating human exposure to a chemical requires information regarding the concentration of the chemical in the environmental media (sediment, water, tissue) with which a person will come into contact and the extent of contact the person will have with the media.~~

~~Chemical specific intake or dose was quantified in this BHHRA by estimating the chronic daily intake (CDI) for noncarcinogens, or the lifetime average daily intake (LADI) for carcinogens. CDI and LADI, expressed in terms of the mass of substance taken into the body per unit body weight per unit time (mg/kg/day), were calculated using equations based on exposure parameters that represent the duration of exposure, frequency of exposure, and other factors that affect overall chemical dose. Consistent with EPA guidance (1989), exposure assessments were based on the RME expected to occur under both current and potential future land use conditions, as well as hypothetical future conditions. Exposure assessments using CT values, which are more representative of average exposures, were also conducted.~~ Rationale and/or references for each of the RME and CT values for exposure pathways that were quantitatively assessed for each exposure scenario for different populations are presented in exposure factor Tables 3-26 through 3-30 and discussed in the following sections.

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3.5.1 Incidental Ingestion of ~~Soil and~~ Sediment

The following equation was used to calculate the intake (expressed as milligrams per kilogram per day [mg/kg-day]) associated with the incidental ingestion of contaminants in soil or sediment:

$$CDI / LADI = \frac{C_s \times IRS \times 10^{-6}\, kg/mg \times EF \times ED}{BW \times AT}$$

Age-weighted exposures for the combined child and adult receptors were calculated using the following equations:

$$CDI / LADI = \frac{C_s \times IFS_{adj} \times EF \times 10^{-6}\, kg/mg}{AT}$$

where:

$$IFS_{adj} = \frac{ED_c \times IRS_c}{BW_c} + \frac{ED_a \times IRS_a}{BW_a}$$

where:

C_s = chemical concentration in soil or sediment (mg/kg)
IFS_{adj} = age-adjusted soil/sediment ingestion factor [(mg-year)/(kg-day)]
IRS_a = adult soil/sediment ingestion rate (mg/day)
IRS_c = child soil/sediment ingestion rate (mg/day)
EF = exposure frequency (days/year)
ED_a = adult exposure duration (years)
ED_c = child exposure duration (years)
BW_a = adult body weight (kg)
BW_c = child body weight (kg)
AT = averaging time (days)

The exposure assumptions for estimating chemical intake from the ingestion of chemicals in ~~soil and~~ sediment are provided in Tables 3-26 and 3-27.

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3.5.2 Dermal Contact with ~~Soil or~~ Sediment

The following equation was used to calculate ~~the intake~~exposure resulting from dermal contact with contaminants in soil or sediment:

$$CDI / LADI = \frac{C_S \times ABS \times SA \times AF \times EF \times ED \times 10^{-6}\, kg/mg}{BW \times AT}$$

Combined child and adult a~~The following a~~ge-weighted ~~equation~~exposures resulting from ~~was used to calculate the intake from~~ dermal contact with contaminants in sediment for the recreational beach user exposure scenarios:

$$CDI / LADI = \frac{C_S \times SFS_{adj} \times ABS \times EF \times 10^{-6}\, kg/mg}{AT}$$

where:

$$SFS_{adj} = \frac{ED_c \times AF_c \times SA_c}{BW_c} + \frac{ED_a \times AF_a \times SA_a}{BW_a}$$

where:

C_s = chemical concentration in soil or sediment (mg/kg)
SFS_{adj} = age-adjusted dermal contact factor [(mg-year)/(kg-day)]
ABS = absorption efficiency
SA_a = adult exposed skin surface area (square centimeters [cm^2])
SA_c = child exposed skin surface area (cm^2)
AF_a = adult soil-to-skin adherence factor (mg/cm^2)
AF_c = child soil-to-skin adherence factor (mg/cm^2)
EF = exposure frequency (days/year)
ED_a = adult exposure duration (years)
ED_c = child exposure duration (years)
BW_a = adult body weight (kg)
BW_c = child body weight (kg)
AT = averaging time (days)

The exposure assumptions for estimating exposure from dermal contact with soil or sediment are provided in Tables 3-26 and 3-27. ~~Dermal absorption factor values were obtained from EPA 2004.~~

Dermal absorption of chemicals from soil or sediment adhered to the skin is dependent on a variety of factors, including the condition of the skin, the nature of adhered soil/sediment, and the chemical concentration. Dermal absorption factors, representing the fraction of a chemical absorbed from soil or sediment adhered to the skin, are presented in Table 3-31. Only those compounds or classes of compounds for which dermal absorption factors are presented were evaluated quantitatively via dermal contact, although assuming less than complete absorption may not fully describe risks associated with dermally active compound such as carcinogenic PAHs. The uncertainties associated with the exposure and risk estimates via dermal exposures with soil and sediments are presented in Section 6.

3.5.2.1 Ingestion of Surface Water

~~The following age-weighted equation was used to calculate intake associated with the ingestion of groundwater or surface water~~Exposure resulting from ingestion of surface water was evaluated using the following equation:

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$$CDI / LADI = \frac{C_w \times IR_w \times EF \times ED \times 10^{-6}\, kg/mg}{BW \times AT}$$

Combined child and adult age-weighted exposures due to ingestion of surface water were calculated as follows:

$$CDI / LADI = \frac{C_w \times IFW_{adj} \times EF}{AT}$$

where:

$$IFW_{adj} = \frac{ED_c \times IRW_c}{BW_c} + \frac{ED_a \times IRW_a}{BW_a}$$

where:

C_W = chemical concentration in water (mg/L)
IFW_{adj} = age-adjusted water ingestion factor [(L-year)/(kg-day)]
IRW_a = adult groundwater ingestion rate (L/day)
IRW_c = child groundwater ingestion rate (L/day)
EF = exposure frequency (days/year)
ED_a = adult exposure duration (years)
ED_c = child exposure duration (years)
BW_a = adult body weight (kg)
BW_c = child body weight (kg)
AT = averaging time (days)

The exposure assumptions for estimating chemical intake from the ingestion of groundwater or surface water are provided in Tables 3-28 and 3-30.

3.5.3 Dermal Contact with Surface Water

~~The~~ Dermal absorption of contaminants due to direct contact with surface water was evaluated using the following equation~~ was used to calculate the dose associated with dermal contact with surface water~~:

$$CDI / LADI = \frac{DA_{event} \times EV \times EF \times ED \times EF \times SA}{AT \times BW}$$

The combined child and adult a~~The following a~~ge-weighted ~~equation~~exposure was ~~used to calculate the intake associated with dermal contact with surface water or surface water~~calculated as follows:

$$CDI / LADI = \frac{C_w \times SFW_{adj} \times K_p \times EF \times ET \times CF}{AT}$$

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where:

$$SFW_{adj} = \frac{ED_c \times SA_c}{BW_c} + \frac{ED_a \times SA_a}{BW_a}$$

Where:

C_{Ww} = chemical concentration in water (mg/L)
DA_{event} = dermally absorbed dose (mg/cm^2-event)
SFW_{adj} = age-adjusted water dermal contact factor [(cm^2-year)/kg]
K_p = dermal permeability coefficient (cm/hour)
EF = exposure frequency (days/year)
ET = exposure time (hour)
CF = Conversion Factor (0.001 L/cubic centimeter)
ED_a = adult exposure duration (years)
ED_c = child exposure duration (years)
SA_a = adult exposed skin surface area (cm^2)
SA_c = child exposed skin surface area (cm^2)
BW_a = adult body weight (kg)
BW_c = child body weight (kg)
AT = averaging time (days)

~~One of the parameters in the intake equations for dermal contact with surface water or groundwater seeps is the~~The absorbed dose per event (DA_{event})~~.~~ ~~This parameter was derived~~ for assessing direct contact with water ~~per~~ was calculated ~~EPA guidance (2004)~~ using the chemical-specific factors~~, which are~~ presented in Tables 3-32 ~~for scenarios involving direct contact with surface water or groundwater seeps and in Table~~and 3-33 ~~for the hypothetical domestic water use scenario.~~ . These ~~chemical-specific factors used in the calculation of DA$_{event}$~~values were obtained from Appendix B ~~(Screening Tables and Reference Values for the Water Pathway)~~ of EPA's Supplemental Guidance for Dermal Risk Assessment (2004)~~.~~ . The uncertainties associated with calculating DA_{event} for chemicals with factors outside of the predictive domain are discussed in Section 6.

3.5.4 Consumption of Fish/Shellfish

~~To evaluate the potential for risk to human consumers of fish (i.e., recreational anglers), site-specific fish tissue data were used.~~ The following equation was used to estimate ~~chemical intake~~exposure associated with the consumption of fish and shellfish:

$$CDI / LADI = \frac{C_t \times IR \times 10^{-3} kg/g \times EF \times ED}{BW \times AT}$$

Combined child and adult exposure was evaluated using the following equation:

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$$CDI / LADI = \frac{C_t \times IR_{t-adj} \times 10^{-3}\, kg/g \times EF}{AT}$$

where:

$$IR_{t-adj} = \frac{ED_c \times IR_c}{BW_c} + \frac{ED_a \times IR_a}{BW_a}$$

where:

C_t = Contaminant concentration in fish tissue (mg/kg, wet-weight basis)
IR_{fc} = Fish ~~ingestion~~consumption ~~-~~rate - child (g/day, wet-weight basis)
IR_a = Fish consumption rate - adult (g/day, wet-weight basis)

EF = Exposure frequency (days/year)
ED_c = Exposure duration – child (years)
ED_a = Exposure duration – adult (years)
BW_c = Body weight – child (kg)
BW_a = Body weight – adult (kg)
AT = Averaging time (days)

The exposure assumptions used to estimate exposure from fish consumption are presented in Table 3-29.

3.5.5 Calculation of Intake due to Infant Consumption of Human Milk

Exposure to breastfeeding infants due to consumption of human milk was evaluated using a methodology developed by ODEQ, OHA, and EPA Region 10, ~~and~~ adapted from EPA's Methodology for Assessing Health Risks Associated with Multiple Pathways of Exposure to Combustor Emissions (EPA 1998a) and the Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities (EPA 2005a), and is described in detail in Appendix D of the DEQ Human Health Risk Assessment Guidance (DEQ 2010)~~.~~. The evaluation for this pathway focuses on PCBs, dioxins/furans, DDx, and PDBEs because of the propensity of these chemicals to bioaccumulate~~.~~. Because the concentration of lipophilic chemicals in human milk is most directly correlated with the ~~long-term~~ steady-state body burden~~-~~, which itself is directly related to the long-te~~rm RM~~rm~~-~~ intake of the chemical, the daily maternal absorbed intake is calculated from the average daily dose to the mother (as calculated in the preceding sections) using the following equation:

$$DAI_{maternal} = ADD_{maternal} \times AE$$

where:

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$DAI_{maternal}$ = daily absorbed intake of the mother (mg/kg-day)
$ADD_{maternal}$ = age-adjusted soil/sediment ingestion factor (mg/kg-day)
AE = absorption efficiency of the chemical

The steady-state chemical concentration in milk fat is then calculated as:

$$C_{milkfat} = \frac{DAI_{maternal} \times h \times f_f}{ln(2) \times f_{fm}}$$

where:

$C_{milkfat}$ = chemical concentration in milk fat (mg/kg-lipid)
$DAI_{maternal}$ = daily absorbed intake of the mother (mg/kg-day)
h = half-life of chemical (days)
f_f = fraction of absorbed chemical stored in fat
f_{fm} = fraction of mother's weight that is fat

Intake for infants via breastfeeding is then calculated as:

$$Intake = \frac{C_{milkfat} \times f_{mbm} \times CR_{milk} \times ED_{inf}}{BW_{inf} \times AT}$$

where:

f_{mbm} = fraction of fat in breast milk
CR_{milk} = ~~consunmption~~consumption rate of breast milk (kg/day)
ED_{inf} = exposure duration of breastfeeding infant (days)
BW_{inf} = average infant body weight (kg)
AT = averaging time (days)

3.5.6 Ca~~Ca~~lculation of Intake for Mutagenic COPCs

~~**Calculation of Intake for Mutagenic COPCs**~~

Early~~—~~in-life susceptibility to carcinogens has long been recognized by the scientific community as a public health concern.~~—~~. In its revised Cancer Assessment Guidelines, EPA concluded that existing risk assessment approaches did not adequately address the possibility that exposures to a chemical in early life may can result in higher lifetime cancer risks than a comparable duration adult exposure (EPA 2005b).~~—~~. In order to address this increased risk, the agency recommends use of a potency adjustment to account for early-in-life exposures.~~—~~. When no chemical-specific data are available to assess directly cancer susceptibility from early-life exposure, the following default Age Dependent Adjustment Factors (ADAFs) are recommended to

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be used when evaluating a carcinogen known to cause cancer through a mutagenic mode of action.

- 10-fold adjustment for exposures during the first 2 years of life;
- 3-fold adjustment for exposures from ages 2 to <16 years of age; and
- No adjustment for exposures after turning 16 years of age.

Of the COPCs evaluated in this HHRA, EPA considers that there is sufficient weight-of-evidence to conclude the carcinogenic PAHs cause cancer through a mutagenic mode of action. ~~For this HHRA, consideration of early life stage exposure was limited to residential exposures and recreational beach users.~~

3.5.7 Incidental Ingestion of Sediment

~~**Incidental Ingestion of Sediment**~~

The following equation was used to calculate the intake in mg/kg-day for mutagenic COPCs associated with incidental ingestion of soil or sediment:

$$CDI / LADI = \frac{C_s \times \left(\frac{(ED_{0\text{-}2} \times IRS_c) \times 10}{BW_c} + \frac{(ED_{2\text{-}6} \times IRS_c) \times 3}{BW_c} + \frac{(ED_{6\text{-}16} \times IRS_a) \times 3}{BW_a} + \frac{(ED_{16\text{-}30} \times IRS_a) \times 1}{BW_a} \right) \times EF}{AT}$$

where:

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C_s = chemical concentration in soil or sediment (mg/kg)
IRS_a = adult soil/sediment ingestion rate (mg/day)
IRS_c = child soil/sediment ingestion rate (mg/day)
EF = exposure frequency (days/year)
$ED_{0\text{-}2}$ = exposure duration ages 0-2 (years)
$ED_{2\text{-}6}$ = exposure duration ages 2-6 (years)
$ED_{6\text{-}16}$ = exposure duration ages 6-16 (years)
$ED_{16\text{-}30}$ = exposure duration ages 16-30 (years)
BW_a = adult body weight (kg)
BW_c = child body weight (kg)
AT = averaging time (days)

3.5.8 Dermal Contact with Sediment

~~**Dermal Contact with Sediment**~~

The following equation was used to calculate the intake from dermal contact with contaminants in soil or sediment:

$$CDI / LADI = \frac{C_S \times \left(\frac{ED_{0\text{-}2} \times AF_c \times SA_c \times 10}{BW_c} + \frac{ED_{2\text{-}6} \times AF_c \times SA_c \times 3}{BW_c} + \frac{ED_{6\text{-}16} \times AF_a \times SA_a \times 3}{BW_a} + \frac{(ED_{16\text{-}30} \times AF_a \times SA_a \times 1}{BW_a} \right) \times ABS \times EF \times 10^{-6}\ kg/mg}{AT}$$

where:

C_s = chemical concentration in soil or sediment (mg/kg)
ABS = absorption efficiency
SA_a = adult exposed skin surface area (square centimeters [cm^2])
SA_c = child exposed skin surface area (cm^2)
AF_a = adult soil-to-skin adherence factor (mg/cm^2)
AF_c = child soil-to-skin adherence factor (mg/cm^2)
EF= = exposure frequency (days/year)
$ED_{0\text{-}2}$ = exposure duration ages 0-2 (years)
$ED_{2\text{-}6}$ = exposure duration ages 2-6 (years)
$ED_{6\text{-}16}$ = exposure duration ages 6-16 (years)
$ED_{16\text{-}30}$ = exposure duration ages 16-30 (years)
BW_a = adult body weight (kg)
BW_c = child body weight (kg)
AT = averaging time (days)

3.5.9 Ingestion of Surface Water

~~**Ingestion of Surface Water**~~

The following equation was used to calculate intake of chemicals associated with ingestion of surface water:

$$CDI / LADI = \frac{C_w \times \left(\frac{(ED_{0\text{-}2} \times IRW_c) \times 10}{BW_c} + \frac{(ED_{2\text{-}6} \times IRW_c) \times 3}{BW_c} + \frac{(ED_{6\text{-}16} \times IRW_a) \times 3}{BW_a} + \frac{(ED_{16\text{-}30} \times IRW_a) \times 1}{BW_a} \right) \times EF}{AT}$$

where:

C_{Ww} = chemical concentration in water (mg/L)
IFW_{adj} = age-adjusted water ingestion factor [(L-year)/(kg-day)]
IRW_a = adult groundwater ingestion rate (L/day)
IRW_c = child groundwater ingestion rate (L/day)
EF = exposure frequency (days/year)

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$ED_{0\text{-}2}$ = exposure duration ages 0-2 (years)
$ED_{2\text{-}6}$ = exposure duration ages 2-6 (years)
$ED_{6\text{-}16}$ = exposure duration ages 6-16 (years)
$ED_{16\text{-}30}$ = exposure duration ages 16-30 (years)
BW_a = adult body weight (kg)
BW_c = child body weight (kg)
AT = averaging time (days)

~~Intakes were quantified using standard exposure equations (EPA 1989). These equations take the general form:~~

$$\text{CDI or LADI} = \frac{EPC \times IR \times EF \times ED}{BW \times AT}$$

~~Where:~~

- ~~CDI = Chronic daily intake~~
- ~~LADI = Lifetime average daily intake~~
- ~~EPC = Exposure point concentration~~
- ~~IR = Intake rate~~
- ~~EF = Exposure frequency~~
- ~~ED = Exposure duration~~
- ~~BW = Body weight~~
- ~~AT = Averaging time.~~

The ~~detailed intake equations, as well as the specific~~ exposure parameters ~~and associated units, are dependent on the exposure scenario evaluated; please see~~are presented in Tables 3-26 to 3-30 ~~for additional details.~~ . ~~For exposure areas outside of the Study Area, the same intake equations and exposure parameters were used as used for exposure areas within the Study Area.~~

~~5.3.1~~3.5.10 Population-Specific Exposure Assumptions

Assumptions about each receptor population evaluated in this BHHRA were used to select exposure parameters used to calculate the pathway-specific chemical intakes~~.~~ . S~~Currently, s~~ite-specific values are not available for all populations and pathways~~.~~ . Therefore, default values representative of the general U.S. population (EPA 1991b) ~~, were used where site-specific values are not available. Where default values are not available, exposure~~or values ~~were selected using~~representing best professional judgment based on ~~knowledge of~~known human uses of the Study Area~~, or requirements from EPA~~ were used~~, were used.~~ . The majority of the

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Eexposure parameters that were used in this BHHRA to calculate the CDIs and LADIs for most receptors were previously included described in the *Exposure Point Concentration Calculation Approach and Summary of Exposure Factors* (Kennedy/Jenks Consultants 2006), which was approved by EPA.–. For divers, the Eexposure parameters for divers were provided by EPA in a directive dated September 15, 2008. For To evaluate hypothetical future domestic water use, EPA default exposure parameters for residential drinking water were used as required by EPA in its comments on the Round Round 2 Report.–. The exposure parameters are discussed below and presented in Tables Tables 3–-26 to 3–-30.–. These values represent potential exposures for application at appropriate areas and/or areas agreed upon with EPA and its partners within the Study Area.–. Except where specifically noted, the exposure assumptions used in the BHHRA were applied uniformly to all ofused throughout the Study Area.; and may or may not be applicable at specific locations within the Study Area depending on factors not specifically addressed in the BHHRA (e.g., accessibility, habitat). AThe actual exposures for specific individuals at a given specific locations may be less than that assumed for the population and Study Area as a whole due to location-specific conditions. . Specific instances where harbor-wide values may not always be applicable are discussed in the following sections.

5.3.1.13.5.10.1 Dockside Workers

For the dockside worker, exposure to beach sediment is the only exposure pathway determined to be potentially complete and evaluated in this BHHRA. Industrial land use was assumed only for portions of the Study Area that are zoned for industrial use and with river-front areas that include natural river beach or bank areas. Activities at Portland Harbor industrial sites do not occur frequently in these areas, which are the only areas where direct exposure to beach sediment might occur. It is unlikely that workers are in direct contact with beach sediment through typical industrial activities on a daily basis. Exposure frequency for dockside workers was assumed to be 200 days/year for the RME evaluation, and 50 days/year the CT evaluation.–. The value of 200 days/year is slightly less than the EPA default exposure frequency of 225 days/year for outdoor workers, and represents the average number of days worked per year according to the U.S. Census Bureau's *1990 Earnings by Occupation and Education Survey*.–. An exposure duration of 25 years was used, representing an EPA default value for the RME estimate of job tenure.–. This value is consistent with data from the U.S. Bureau of Labor Statistics showing that the 95th percentile job tenure for men in the manufacturing sector is 25 years.–. The CT estimate assumed duration of 9 years, representing approximately the 50th percentile of residence time estimates from the U.S. Census Bureau data (EPA, 1997).–.

A sediment ingestion rate of 200 mg/day was used for the RME evaluation, based on EPA Region 10 supplemental guidance on soil ingestion rates (EPA, 2000a), and is representative of approximately the midpoint between the recommended values of 100- mg/day for outdoor workers and 330- mg/day for construction workers.–. An ingestion rate of 50 mg/day was used to estimate CT exposure.–.

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Dermal exposure was assessed assuming that the face, forearms and hands are exposed, representing an exposed skin surface area of 3,300 cm^2, which is representative of the median value (50^{th} percentile) for adults~~.~~. A body weight of 70 kg, representing the 50^{th} percentile of mean body weights of men and women combined (EPA, 1997a) was used for all adult receptors~~.~~. RME and CT exposure values for dockside workers are presented in Table 3-26. ~~summarizes RME and CT exposure values for the dockside worker and the reference or rationale for each value~~

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~~Because it is unlikely that significant beach sediment exposure would occur for a dockside worker on a daily basis, exposure assumptions for the dockside worker were developed using EPA default exposure values for an industrial worker for most parameters except for exposure frequency. For exposure frequency, it was assumed that a worker would contact sediment one day per week while working at the industrial site, rather than the EPA default value or 5 days per week. Therefore, the default exposure frequency of 250 days per year, which represents 5 days per week for 50 weeks, was changed to 50 days per year (i.e., 1 day per week for 50 weeks) for RME. Table 3-26 summarizes RME and CT exposure values for the dockside worker and the reference or rationale for each value.~~

~~5.3.1.2~~3.5.10.2 In-Water Worker~~s~~

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~~For the in-water worker, E~~exposure to in-water surface sediment ~~by in-water workers is the only exposure pathway determined to be potentially complete and evaluated as potentially complete in this BHHRA. In-water workers could contact in-water sediment while performing specific activities; such as replacement of fender piles or maintenance dredging. Exposure factors for in-water workers for in-water sediment were developed for Terminal 4 based on in-depth interviews with several workers at Terminal 4 who either conduct or oversee activities that could result in contact with in-water sediment. .~~According to the Army Corps of Engineers (Siipola 2004), the Port of Portland conducts the most frequent dredging within the Study Area, ~~so~~ thus the exposure factors for workers at Terminal 4 are considered protective of in-water workers for potential in-water sediment exposures throughout the Study Area ~~for potential in-water sediment exposures. ~~. Exposure factors for in-water workers were developed based on in-depth interviews with several workers at Terminal 4 who either conduct or oversee activities that could result in contact with in-water sediment. For the RME ~~scenario~~evaluation, ~~in-water workers are assumed to contact~~ in-water sediment exposures were assumed to occur for 10 ~~years during~~ of 25 years of employment at a given facility, with an exposure frequency of 10 days of sediment contact per year~~.~~. For the CT ~~scenario~~evaluation, ~~in-water workers are assumed to~~ contact with in-water sediment is assumed ~~for~~ for 4 ~~years during~~of 9 years ~~of~~ employment at a given facility, with an exposure frequency of 10 days of sediment contact per year~~.~~. ~~I~~The ~~in-water worker exposure factor i~~ntake rates for in-water sediment are the same as those used for the dockside worker ~~for beach sediment~~, which ~~in turn~~ are the ~~same as~~ default ~~exposure factors~~ingestion rate ~~for~~ of soil for an

industrial worker.—. RME and CT exposure values for the in-water worker are presented in Table 3-–27 summarizes RME and CT exposure values for the in-water worker and the reference or rationale for each value.

5.3.1.3 Transients

Transients may be exposed to beach sediment, surface water, and groundwater at seeps while utilizing river beaches. Such exposures are Transient land use is assumed to occur only for portionsat locations of within the Study Area with riverfront access which and that are not also active industrial sites. Transients may be exposed to beach sediment, surface water, and groundwater seeps while utilizing river beaches within transient use areas. As EPA does not have recommended default exposure parameters for transient scenarios, so the exposure frequency and duration for transients are based on best professional judgment. BHowever, by definition, transient exposures are assumed to occur over a short duration of time. Little information is available regarding how long individuals may remain at specific locations or within the Study Area itself. Based on professional judgment, an exposure duration of 2 years was assumed for the RME and 1 year for CT evaluations, exposure frequency was assumed to be daily (365 days/year). Incidental ingestion of sediment was evaluated at the same rates used for the dockside workers (200 mg/day). Dermal exposure was assessed assuming that the face, forearms and hands, and lower legs are exposed, representing an exposed skin surface area of 5,700 cm^2, which represents the median value for adults. A At However, at the request of EPA, it was assumed that transients might would remain at a single beach for up to two years for the RME scenarioevaluation. For intake rates for transients, EPA required that , and a the soil ingestion rate of 200 mg/day and soil adherence factor of 0.3 mg/cm^2 used bewas used for evaluating direct contact exposures tofor beach sediment be increased above those EPA default values recommended for residential soil exposures, based on the expectation that transients living on a beach sediment would have greater contact with beach sediment than a residential adult might have with soil and dust , and that residential tap water ingestion rates be used for surface water.. A higher soil ingestion rate (200 mg/day instead of 100 mg/day) and soil adherence factor (0.3 mg/cm^2 instead of 0.07 mg/cm^2) were used as it is expected that transients living on a beach would have more contact with beach sediment than a residential adult might have with residential soil and dust. a greater moisture content than dry soil. Transients may also have limited access to washing facilities and could therefore more frequently transfer sediments from hand to mouth while eating, smoking, etc. An ingestion rate of 2 L/day was used for consumption of surface water, which represents the default value for domestic water use. Tables 3-26 and 3-28 summarize RME and CT exposure values for the transient scenario for beach sediment and surface water, (surface water and groundwater seeps respectively), and the reference or and rationale for each value.

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3.5.10.3 Divers

. The water ingestion rates for both diver exposure scenarios were the same as those used for the recreational beach swimmers. Tables 3-27 and 3-28 summarize exposure assumptions for the wet suit and dry suit divers for in-water sediment and surface water, respectively, and the reference or rationale for each value.

Two different scenarios were evaluated, based on whether the divers wear wet or dry suits.—. Divers wearing wet suits are assumed to be working as commercial divers without a full face mask, and wearing either wet gloves or no gloves.—. An exposure frequency of 5 days/year for the RME evaluation and 2 days/year for the CT evaluation are based on best professional judgment and discussions between EPA, LWG, and commercial divers, as well as the experience of EPA divers who work at the Portland Harbor Superfund site.—. Exposure durations of 25 years and 9 years were used for the RME and CT estimates, respectively, based on the labor statistics for job tenure described in Section 3.5.109.1.

Sediment ingestion rates were assumed to be 50 percent of the ingestion rate for dockside workers, corresponding to values of 50 mg/day and 25 mg/day, respectively for the RME and CT evaluations.—. Rates for incidental The water ingestion of surface water rates for both diver exposure scenarios were the same as those used for the recreational beach swimmers.r.

Dermal exposure to sediment was evaluated assuming the entire skin surface area was exposed.—. Event duration for exposure to sediment and surface water for both diver scenarios was 4 hours per diver for the RME and 2 hours per diver for the CT exposure A value of 18,150 cm^2, representing the median skin surface area for men and women was used for both the RME and CT evaluations.—. Divers wearing a dry suit (with a neck dam) would likely have only their head, neck, and hands exposure, and a RME value of 2,510 cm^2 was used.—. SThe sediment dermal adherence factors for both diver exposure scenarios were the same as those for the in-water fishersof 0.3 mg/cm^2-event and 0.07- mg/cm^2- event was used for the was used for the RME estimate and CT estimate, respectively.—. A CT evaluation was not done for divers wearing dry suits.

Incidental ingestion of surface water for both diver scenarios was assumed to be 50 mL/hour for both the RME and CT evaluations (EPA 1989), based on the recommended value from EPA's Superfund Exposure Assessment Manual. –. More recent data regarding estimates of the amount of water ingested by commercial divers.— Iindicates that Oon average, occupational divers ingested 6 mL/dive in freshwater and 10 mL/dive in marine water, with the maximum estimated ingestion ranging between 25 and 100/mL/dive (EPA 2011).—. eExposure via ingestion and dermal contact was assumed to occur for 4 hours/event for the RME estimate and 2 hours/event for the CT estimate.—.

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Tables 3-27 and 3-28 summarize exposure assumptions for the wet suit and dry suit divers for in-water sediment and surface water, respectively., and the reference or rationale for each value.

3.5.10.4 Transients

Little information is available regarding how long individuals may remain at specific locations or within the Study Area itself.. Based on professional judgment, an exposure duration of 2 years was assumed for the RME and 1 year for CT evaluations, exposure frequency was assumed to be daily (365 days/year).. Incidental ingestion of sediment was evaluated at the same rates used for the dockside workers (200 mg/day).. Dermal exposure was assessed assuming that the face, forearms and hands, and lower legs are exposed, representing an exposed skin surface area of 5,700 cm^2, which represents the median value for adults.. A soil adherence factor of 0.3 mg/cm^2 was used based on the expectation that beach sediment would have a greater moisture content than dry soil.. An ingestion rate of 2 L/day was used for consumption of surface water, which represents the default value for domestic water use.. Tables 3-26 and 3-28 summarize RME and CT exposure values for the transient scenario for beach sediment and surface water, and the reference and rationale for each value.

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5.3.1.43.5.10.5 Recreational Beach User

Recreational use of beaches can result in direct contact with beach sediment within river beach areas and with surface water while swimming or during other water-related activities. Recreational beach use is assumed to occur only for portions of the Study Area where recreational exposures are reasonably likely to occur. Recreational beach users may have direct contact with beach sediment within river beach areas and with surface water while swimming or during other water activities. In the absence of EPA does not have recommendeddefault exposure parameters for recreational beach use scenarios, so potential the exposures frequency and duration for recreational beach users are based on best professional judgment as follows. Beach use was: beach use was assumed to be occur more most frequently (5 days per week) in the summer, with less frequent use in the spring/fall (1 day per week), and with only even lessintermittent use in the winter (1 day per month). Incidental ingestion of beach sediment was assumed to occur at the same rate as for soil in a residential setting (100 mg/day for adults, 200 mg/day for children), a soil skin adherence of 3.3 mg/cm^2-day was used for children to account for the greater moisture content of beach sediment versus typical soil in a residential yard. The temperature of river waterWater temperatures in the Lower Willamette River would typically limit swimming activities during much of the year. Therefore, exposure to surface water was only evaluated forto the summer months, thus s. Swhen swimming might was assuming to

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~~occur~~ at a rate of (~~2~~6 ~~days per week~~year). ~~For beach sediment intake, the recommended default values for residential soil were generally used but the adherence factor for children was more than 10 times greater than the value for residential soil. For surface water intake, the recommended default values for swimming scenarios were used. Incidental ingestion of river water while swimming was assumed to occur at a rate of 50 mL/hour while swimming. The recreational beach user includes both adults and children. Tables 3-26 and 3-28 summarize RME and CT exposure values for beach sediment and surface water, respectively, for adult and child recreational beach users. A reference or rationale is included for each value.~~In the absence of specific information regarding the frequency of recreational activities in Portland Harbor, potential exposures are based on best professional judgment, assuming that beach use is most frequent in the summer, with less frequent use in the spring/fall, and only intermittent use in the winter~~.~~. An exposure frequency of 94 days/year (5 days/week during summer, 1 day/week during spring/fall, and 1 day/month during winter) was used for the RME estimate and 38 days/year (2 days/week during summer, 2 days/month during spring/fall) was used for the CT estimate~~.~~. Exposure duration for recreational activities is based on the assumption that individuals are largely permanent residents of the Portland area~~.~~. Accordingly, an exposure duration of 30 years, which represents approximately the 95th percentile of the length of continuous residence in a single location in the U.S. population (EPA~~,~~ 1997) was used for the RME estimate~~.~~. More recent studies described in the 2011 edition of EPA's Exposure Factors Handbook show the 95th percentile value is closer to 33 years, data from the U.S. Census Bureau indicate that 32 years represents the best estimate of residence time at the 90th percentile~~.~~. However, the value of 30 years is consistent with other Superfund risk assessments nationwide, and represents a reasonably conservative estimate of total residence time in the area~~.~~. An exposure duration of 9 years was used for the CT estimate~~.~~.

Sediment ~~I~~ingestion rates of 100 mg/day for adults and 200 mg/day for children were used, approximating the 95th percentile soil ingestion rates~~.~~. CT estimates assumed sediment ingestion rates of 100 mg/day for children and 50 mg/day for adults~~.~~. Dermal exposures were evaluated assuming that the face, forearms and hands, and lower legs are exposed~~.~~. Median values of 5,700 cm^2 and 2,800 cm^2 were used for adults and children, respectively~~.~~. A soil-skin adherence of 3.3 mg/cm^2-day was used for children to account for the greater moisture content of beach sediment~~.~~.

Water temperatures in the Lower Willamette River would typically limit swimming to the summer months, thus swimming was assum~~ing~~ed to occur at a rate of 26 days per year~~.~~. As discussed in Section 3.5.10.~~5~~3, ~~I~~incidental ingestion of river water ~~while swimming~~ was assumed to occur at a rate of 50 mL/hour while swimming~~.~~. Based on current recommendations, 50 mL/hr represents mean value, assuming 21mL/hr for adults and 49 mL/hr for children, upper-percentile recommended values are 71 mL/hr for adults and 121 mL/hr for children(EPA 2011)~~.~~. Tables 3-26 and 3-28 summarize RME and CT exposure values for beach sediment and surface water, respectively, for adult and child recreational beach users~~.~~.

3.5.10.6 Recreational/Subsistence Fishers

~~A year-round recreational fishery exists within the Study Area. Current information indicates that spring Chinook salmon, steelhead, Coho salmon, shad, crappie, bass, and white sturgeon are the fish species preferred by local recreational fishers (DEQ 2000b, Hartman 2002, and Steele 2002). In addition to recreational fishing, an investigation by the Oregonian newspaper and limited surveys conducted on other portions of the Willamette River indicate that immigrants from Eastern Europe and Asia, African-Americans, and Hispanics are most likely to be catching and eating fish from the lower Willamette either as a supplemental or primary dietary source (ATSDR 2002). These surveys also indicate that the most commonly consumed species are carp, bullhead catfish, and smallmouth bass, although other species may also be consumed. In conversations that were conducted as part of a project by the Linnton Community Center (Wagner 2004) about consumption of fish or shellfish from the Willamette River, transients reported consuming a large variety of fish, and several said they ate whatever they could catch themselves or obtain from other fishers.~~

~~Individuals who fish from the water's edge within natural river beach areas may be exposed to beach sediment, and fishing could occur from any beach area where access is not restricted. Fishing from boats or piers may result in exposure to in-water sediment due to handling anchors, hooks, or crayfish pots. As discussed in Section 3.2.1.6,~~ Because there is limited information regarding the frequency of fishing activities within the Study Area, a range of possible exposures was evaluated for people who engage in recreational or subsistence fishing activities by considering both a high-~~frequency~~ and a low-frequency rate of fishing~~.~~. RME estimates for high-frequency (subsistence) fishers assumed a fishing frequency of 156 days/year, approximating ~~-~~a rate of 3 days/week~~.~~. Low-frequency (recreational) fishers were assumed to fish 104 days/year, approximating a rate of 2 days/week~~.~~. CT estimates assumed a frequency of 52 days/year and 26 days/year for high- and low-frequency fishers, respectively, and are representative of assumed fishing frequencies of 1 day/week and 2 days/month~~.~~. People engaged in recreational or subsistence fishing were also assumed to be residents of the greater Portland area, therefore exposure durations of 30 years and 9 years, ~~s~~were used for the RME and CT evaluations, respectively, based on the population statistics for residency discussed in Section 3.5.~~10~~9.5~~.~~.

~~Exposure to in-water sediments was evaluated for both high- and a low-frequency of fishing in order to assess a range of potential activity patterns. Although the true extent of direct contact with in-water sediment is not known~~I~~,~~ incidental ingestion of beach sediment was evaluated assuming 100 mg/day for the RME estimate and 50 mg/day for the CT estimate, representative of soil ingestion rates in a typical residential setting~~.~~. ~~r~~Rates of 50 mg/day for the RME estimate and 25 mg/day for the CT estimate were used for incidental ingestion of in-water sediment, representing 50 percent of the rates ~~of~~used ~~for incidental soil ingestion ratein a typical residential setting~~for beach sediment~~.~~. An exposed surface area of 5,700 cm^2, representing the

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face, hands, forearms and lower legs was used to assess dermal exposure to beach sediments, exposures to in-water ~~Direct contact of~~ sediment ~~with the~~was assumed to be limited to the hands and forearms, corresponding to a surface area of 1,980 cm^2~~.~~. ~~was assumed to be the most likely route of dermal exposure, and dermals~~Sediment~~oil~~ adherence ~~if~~to skin ~~is~~was evaluated using a weighted adherence factor based on exposure to the hands, forearms, and lower legs (EPA 2004).~~ in-water sediment was assumed to be similar to that for beach sediments corresponding to .~~ A factor of 25 percent was used to ~~represent the percent of~~account for the time spent fishing in a single area within the Study Area~~.~~. E~~The~~ exposure assumptions for beach and in-water sediment contact for recreational/subsistence fishers are presented in Tables 3-27~~6~~ and 3-27

~~Current~~Information currently available ~~information~~ indicates that spring Chinook salmon, steelhead, Coho salmon, shad, crappie, bass, and white sturgeon are the fish species preferred by local recreational fishers (DEQ 2000b, Hartman 2002, and Steele 2002)~~.~~. In addition to recreational fishing, an investigation by the Oregonian newspaper and limited surveys conducted on other portions of the Willamette River indicate that immigrants from Eastern Europe and Asia, African-Americans, and Hispanics are most likely to be catching and eating fish from the lower Willamette either as a supplemental or primary dietary source (ATSDR 2002)~~.~~. These surveys also indicate that the most commonly consumed species are carp, bullhead, catfish, and smallmouth bass, although other species may also be consumed~~.~~. In conversations that were conducted as part of a project by the Linnton Community Center (Wagner 2004) about consumption of fish or shellfish from the Willamette River, transients reported consuming a large variety of fish, and several said they ate whatever they could catch themselves or obtain from other fishers~~.~~.

No studies were located that document specific consumption rates of recreational o~~r~~ subsistence anglers in Portland Harbor prior to its listing as a Superfund site.~~, and any survey conducted since the site has was listed as a Superfund site in 2000 and~~ Surveys conducted subsequent to the listing would not be representative of historical, baseline consumption patterns due to ~~subsequent~~subsequent fish advisories and efforts to limit consumption of fish caught from the harbor~~ would not be representative of historical, baseline consumption patterns~~. Therefore, f~~Specific information is not available regarding consumption rates for locally caught fish within the Study Area. F~~ish c~~In order to assess a range of exposures, c~~onsumption rates from published studies were used to describe the range of reasonably expected exposures relevant to the different populations known to occur in the Portland Harbor area. ~~Specific areas evaluated for potential exposure to sediments for individuals engaged in recreational or subsistence fishing include all areas designated as transient and recreational use areas.~~

~~Non-tribal fish consumption was evaluated for both adults and children while sediment exposure was evaluated for adults only, with the assumption that fishing is done primarily by adults but both adults and children may consume the fish that are~~

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caught.As discussed in Section 3.2.1.6, a range of possible exposures was evaluated for people who engage in recreational or subsistence fishing activities by considering both a high-frequency and a low-frequency rate of fishing. RME estimates for high-frequency fishers assumed fishing 156 days/year, approximating a rate of 3 days/week. Low-frequency fishers were assumed to fish 104 days/year, approximating a rate of 2 days/week. CT estimates assumed a frequency 52 days/year and 26 days/year for high- and low-frequency fishers, respectively, and are representative of assumed fishing frequencies of 1 day/week and 2 days/month. Dermal exposure was evaluated assuming the same exposed skin surface area for adults of 5,700 cm^2 used for recreational exposure. People engaged in recreational or subsistence fishing were also assumed to be residents of the Portland area, therefore exposure durations of 30 years and 9 years were used for the RME and CT evaluation, respectively. At the request of EPA, the exposure frequencies and durations for beach sediment for each fisher scenario were assumed to represent the fishing activity at the Study Area regardless of whether that fishing occurs from a beach or a boat. A factor of 25 percent was used to represent the percent of time spent fishing in a single area within the Study Area.

Based on the exposure scenarios for in-water sediment (i.e., contact with sediment on anchors, hooks, or crayfish pots), the extent of contact with in-water sediment is expected to be less than what would occur with residential soil. Ingestion rates for soil are based on exposure to soil during yard work and to indoor dust (EPA 1997a). These ingestion rates are not applicable to the in-water sediment exposure scenarios; however, incidental ingestion rates are not available for sediment. It is assumed that the incidental ingestion rate for in-water sediment is 50 percent of the ingestion rate for residential incidental soil scenarios. For dermal contact, hands and forearms are the only body parts that could be exposed to in-water sediment on a regular basis (i.e., on a year-round basis). It is assumed that the entire surface area of both hands and forearms would be exposed to in-water sediment. The adherence and absorption factors are assumed to be the same as those for beach sediment. Exposure assumptions for in-water sediment contact for fishers are presented in Table 3-27

T The fish consumption scenario included three different fish fish ingestionconcsumption rates were evaluated in the human health risk assessment: 17.5 grams per day (approximately 2 eight ounce meals per month), 73 g/ day (10 eight ounce meals per month), and 142 g/day per day (19 eight ounce meals per month).. The term RMrm- "recreational fishers" is intended to encompass a broader spectrumrange of the population, including those who may infrequently catch and consume fish, as well as while focusing on those who may do sofish on a more-or-less regular basis, and "subsistence fishers" to represent populations with high fish consumption rates, recognizing that fish are not an exclusive source of protein in their diet. Accordingly, 17.5 g/day is considered representative of a CT value for recreational fishers, and 73 g/day was selected as the RME value representing the higher-end consumption practices of recreational fishers. The consumption rate of 142 g/day represents a RME value for high fish consuming, or subsistence, fishers.

No CT value was selected because the evaluations based on 17.5 g/day and 73 g/day inform RMrm- the risks associated with lower consumption rates. Consumption rates for children aged 6 years and younger were calculated by assuming that their rate of fish consumption is approximately 42 percent of an adult, based on the ratio of child-to-adult consumption rates presented in the CRITFC Fish Consumption Survey (CRITFC 1994). The corresponding rates that were used for children are 7 g/day, 31 g/day, and 60 g/day.

The rates of 17.5- g/day and 142 g/day represent the 90th and 99th percentiles, respectively, of per capita consumption of uncooked freshwater/estuarine finfish and shellfish ofby individuals (consumers and non-consumers) 18 or older, as reported in the Continuing Survey of Food Intakes by Individuals (CSFII) and described in EPA's Estimated Per Capita Fish Consumption in the United States -(EPA 2002b).—. While the values are presented in terms of "uncooked weight," it should not be construed to imply that the fish are consumed raw, as the consumption rates represent adjusted values to account for the amount of fish needed to prepare specific meals. No adjustments were made to contaminant concentrations in raw fish tissue because of the uncertainties associated with accounting for specific preparation and cooking practices.

The CSFII surveys recorded food consumption for two non-consecutive days.—. For the purpose of the report, "cConsumers only" were defined as individuals who ate fish at least once during the 2—-day reporting period, individuals who reported not consuming any fish during the reporting period were designated as "non-consumers.". For comparison, the 90th and 99th percentile consumption rates for consumers-only are 200 g/day and 506 g/day, respectively (EPA 2002b).—. Because of theTherefore, the limitedshort time period of dietary intake collection over which the survey is conducted, the results characterize the empirical distribution of average daily per capita consumption does not produce usualrather than describe true long-term RMrm-intake estimates. Usual intakes are defined as "the long run average of daily intakes of a dietary component by an individual. Although 17.5 g/day represents a 90th percentile value, it is considered an average consumption rate for sport fishers (EPA 2000d).—. Similarly, 142 g/day is considered to be representative of average consumption estimates for subsistence fishers when compared to upper percentile values for consumers only. However, the use of values representative of both non-consumers and consumers is appropriate as it accounts for the fact that some portion of the total diet of fish consumed may come from sources other than Portland Harbor. " Use of the combined "consumer" and "non-consumer" per capita consumption rates reduces bias introduced by using only the values for those individuals that actually consumed fish during the survey period. Rather, the estimates presented in this report characterize the empirical distribution of daily average per capita consumption For comparison, the 90th and 99th percentile ingestion ratesconsumption rates for consumers only are uncooked freshwater and estuarine finfish and shellfish for consumers only are 200 g/day and 506 g/day, respectively (EPA 2002b).

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The consumption rate of 73 g/day is from a creel study conducted in the Columbia Slough~~.~~, and represents the 95 percent upper confidence limit on the mean, where 75 percent of the mass of the total fish is consumed ~~The value of 73 g/day represents the 95 percent upper confidence limit on the mean consumption rate from a creel study conducted in the Columbia Slough (Adolfson 1996)).~~, ~~as well as single species and multiple species diets of resident fish species.~~ . ~~The term "recreational fishers" is intended to encompass a broader spectrum of the population, including those who may infrequently catch and consume fish, as well as to those who may do so on a more or less regular basis.~~ . ~~Accordingly, the 17.5 g/day consumption rate is considered arepresentative of a CT value for fish consumption for recreational fishers, and the 73 g/day rate was selected as the RME value representing the higher end consumption practices of recreational fishers.~~ . ~~The consumption rate of 142 g/day represents a RME value for high fish consuming, or subsistence, fishers.~~ . ~~NO o CT value was evaluatedselected because the evaluations based on 17.5 g/day and 73 g/day inform the risks associated with lower consumption rates.~~ . ~~Study Area-specific fish consumption information is not available for the fish consumption scenarios. Therefore, to evaluate the potential range in consumption patterns that may exist, three ingestion rates were used to calculate intakes for adults and three were used for children. EPA specified the ingestion rates used in this BHHRA. For adults, the fish ingestion rates were 17.5 grams per day (g/day), 73 g/day, and 142 g/day. These rates correspond to approximately 2 meals per month, 10 meals per month, and 19 meals per month, based on an 8-ounce serving size, every month of the year, consisting exclusively of fish caught within the Study Area. It should be noted that the current fish consumption advisory, based on PCBs, for the LWR recommends that children and expectant mothers do not eat resident fish from the Portland Harbor, and that healthy adults eat no more than one 8-ounce meal per month of resident fish from the Portland Harbor (ODHS 2007). However, it is unclear to what extent this advisory is followed by people who consume fish from the Study Area.~~

~~Consumption rates for children aged 6 years and younger were calculated by assuming that their rate of fish consumption is approximately 42 percent of an adult, based on the ratio of child-to-adult consumption rates Two of these rates, 17.5 g/day and 142 g/day, represent the 90th and 99th percentile ingestion rates for diets including uncooked freshwater and estuarine finfish and shellfish by individuals (consumers and non-consumers) of age 18 and over in the United States (EPA 2002b). The 90th and 99th percentile ingestion rates for uncooked freshwater and estuarine finfish and shellfish for consumers only are 200 g/day and 506 g/day, respectively (EPA 2002b). Because these rates are from a national dietary study, they may not be representative of site-specific consumption patterns. Relative to the ingestion rate of 142 g/day, an adult consuming fish and shellfish tissue at a rate of 200 g/day would need approximately 70 percent of their total fish and shellfish diet to be fish caught within the Study Area, and an adult consuming fish and shellfish tissue at a rate of 506 g/day would need approximately 28 percent of their total fish and shellfish diet to be fish caught within the Study Area. If a different proportion of fish were caught within the Study Area versus outside of the Study Area, exposure to~~

~~chemicals within the Study Area would change accordingly. Additional uUncertainties associated with these ingestion rates are discussed in Section 6. The other ingestion rate used in this BHHRA, 73 g/day, is from a creel study conducted in the Columbia Slough and is the 95 percent upper confidence limit on the average for ingestion of fish where 75 percent of the mass of the total fish is consumed (Adolfson 1996). While this study may be more representative of consumption patterns for the Study Area, the study was limited in scope and the reported ingestion rates were estimated based on numerous assumptions. These ingestion rates were used for both the mean and 95 percent UCL/max risk calculations.~~

~~Limited information is available about fish consumption by children. The child scenario evaluated in this BHHRA is for 0 to 6-year olds. Th e national dietary study does not include consumption information for this age range. However, this age range was evaluated inpresented in the CRITFC Fish Consumption Survey (CRITFC 1994). .). In that survey, the ratio of the child 95th percentile ingestion to the adult 95th percentile ingestion rate, which is the comparison specified by EPA, was 0.42. This ratio was applied to the three adult ingestion rates to estimate the child ingestion rates. The corresponding rates that were used for children wereare 7 g/day, 31 g/day, and 60 g/day. . Exposure assumptions for recreational/subsistence fish consumption are presented in Table 3-29., and the uncertainties associated with these consumption rates are discussed in Section 6.~~

~~For the fish consumption scenarios, risks were evaluated separately for consumption of each individual target resident fish species (smallmouth bass, black crappie, brown bullhead, and common carp) assuming only one species was consumed in each scenario. For these individual species scenarios the ingestion rates for the entire diet (regardless of species) were used with concentration data on each individual resident species (for both whole body and fillet tissue). EPCs were calculated for fishing zones (common carp, black crappie and brown bullhead) and mile reach (smallmouth bass) as well as for the entire Study Area, as described in Section 3.4.5. In addition to the individual species diet, a multiple species diet was also evaluated by using the fish ingestion rates for the scenarios with the concentration data of all resident species (for whole body and fillet tissue) for the Study Area (i.e., a multiple species diet assuming that each of the 4 fish target species represents 1/4 of a person's diet). The following scenarios were evaluated for each of the above ingestion rates using both the 95 percent UCL/max and mean EPCs described in Section 3.4.5 for both whole body and fillet samples (because these scenarios were not classified as CT or RME):~~

	~~River Mile~~	**~~Fishing Zone~~**	**~~Entire Study Area~~**
~~Smallmouth bass~~	~~X~~		~~X~~

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~~Black crappie~~		~~X~~	~~X~~
~~Common carp~~		~~X~~	~~X~~
~~Brown bullhead~~		~~X~~	~~X~~
~~Multiple species~~			~~X~~

~~The uncertainties associated with the fish consumption scenarios are discussed in Section 6 of this BHHRA.~~

~~Because site-specific information is not available for shellfish consumption, a range of ingestion rates was evaluated in this BHHRA for adult shellfish consumers.Site-specific shellfish consumption information is not available.~~ Consumption of shellfish was evaluated ~~For shellfish,~~considering only ~~adult~~ consumption by adults~~was evaluated.~~ , and assuming that consumption of shellfish is primarily a component of a subsistence diet. Site-specific information regarding consumption of shellfish is not available, thus a range of consumption rates were evaluated. ~~. It should be noted that there is currently a fish consumption advisory for wood-treating chemicals in a portion of the Study Area recommending that crayfish not be eaten (ODHS 2007).~~ ~~Ingestion~~Consumption rates of 3.3 g/day and 18 g/day were selected as representative of CT and RME estimates ~~, were used to calculate intakes from shellfish consumption. These values representing~~These values represent the 50th ~~percentile (3.3 g/day)~~ and 95~~,~~th percentile ~~(18 g/day) ingestion~~consumption rates ~~for~~of shellfish ~~consumption~~ from freshwater and estuarine systems for individuals of age 18 and older in the United States (EPA 2002b). ~~These ingestion rates were used with 95 percent UCL/max and mean EPCs for crayfish and clams described in Section 3.4.5 (because these scenarios were not classified as CT or RME). Exposure assumptions for shellfish consumption are presented in Table 3-29. The uncertainties associated with the shellfish consumption scenario are discussed in Section 6 of this BHHRA.~~

Exposure assumptions for recreational/subsistence fish consumption are presented in Table 3-29, and the uncertainties associated with these consumption rates are discussed in Section 6~~.~~.

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3.5.10.7 Tribal Fishers

~~The LWR provides a ceremonial and subsistence fishery for Native American tribes. . Four of the six Native American tribes (Yakama, Umatilla, Nez Perce, and Warm Springs) involved in the Portland Harbor RI/FS participated in a fish consumption survey that was conducted on the reservations of the participating tribes and completed in 1994 [Columbia River Inter-tribal Fish Commission (CRITFC) 1994)]. . The results of the survey show that tribal members surveyed generally consume more fish than the general public. . Certain species, especially salmon and Pacific lamprey, are an important food source as well as an integral part of the tribes' cultural, economic, and spiritual heritage. .~~

Specific information regarding population mobility on ~~n~~Native American populations is less readily available than for the general U.S. population. The evaluation of exposures to ~~n~~Native Americans was based on the premise that they spend their entire lives in the area (EPA 2005c), and a typical lifetime was evaluated as 70 years. Fishing frequency was assumed to be 260 days/yr (5 days/week) for the RME estimate and 104 days/year (2 days/week) for the CT estimate~~.~~. ~~Specific information regarding population mobility on native American populations is less readily available than for the general U.S. population. . However, input during the scoping of the Portland Harbor risk assessment indicated that this population should be considered less mobile for a variety of reasons. . Hence, the evaluation of exposures to native Americans was based on the premise that they spend their entire lives in the area, and a typical lifetime was evaluated as 70 years.~~

~~ISediment ingestion rates of beach sediment for tribal fishers were evaluated at the same rate as for recreational/subsistence fishers.~~Incidental ingestion of beach sediment was evaluated assuming 100 mg/day for the RME estimate and 50 mg/day for the CT estimate~~.~~. Rates of 50 mg/day for the RME estimate and 25 mg/day for the CT estimate were used for incidental ingestion of in-water sediment, representing 50 percent of the rates used for incidental soil ingestion in a typical residential setting~~.~~. An exposed surface area of 5,700 cm^2, representing the face, hands, forearms and lower legs was used to assess dermal exposure to beach sediments, exposures to in-water sediment was assumed to be limited to the hands and forearms, corresponding to a surface area of 1,980 cm^2~~.~~. Sediment adherence to skin was evaluated using a weighted adherence factor based on exposure to the hands, forearms, and lower legs (EPA 2004)~~.~~. A factor of 25 percent was used to account for the time spent fishing in a single area within the Study Area. ~~Fishing frequency was assumed to be 260 days/yr (5 days/week) for the RME estimate and 104 days/year (2 days/week) for the CT estimate. Specific information regarding population mobility on native American populations is less readily available than for the general U.S. population. However, input during the scoping of the Portland Harbor risk assessment indicated that this population should be considered less mobile for a variety of reasons. Hence, the evaluation of exposures to native Americans was based on the premise that they spend their entire lives in the area, and a typical lifetime was evaluated as 70 years.~~

~~Tribal fishers were assumed to fish from the same beach area five days per week for the entire year (260 days/year) for an entire lifetime (70 years) for the RME. Although it is not known how much sediment contact actually occurs during fishing activities, default intake values for residential soil were used.~~ Exposure assumptions for beach~~–~~ and in-water sediment contact for tribal fishers are presented in Tables~~-~~ 3~~--~~26 and 3-27.

Fish consumption by tribal members was evaluated assuming a~~A~~ multi-species diet that includes both resident ~~fish as well as~~and anadromous fish (salmon~~ids~~, lamprey, and sturgeon)~~ was evaluated for tribal fish consumption. –~~. An overall rate of 175 g/day (approximately 23 eight oz meals per month), representing the ~~While site-specific fish consumption information is not available for the tribal fish consumption scenario, a fish consumption survey was conducted on the reservations of four of the participating Tribes (CRITFC 1994). The~~ 95th percentile of ~~fish ingestion~~consumption rates for consumers and non-consumers ~~only from~~in the CRITFC ~~Fish Consumption~~ Survey~~, which is 175 g/day,~~ was used ~~to calculate intakes~~ for adult tribal fish consumers~~.–~~. A consumption rate of 73 g/day, representing ~~On October 23, 2008, the Oregon Environmental Quality Commission approved a fish consumption rate of 175 g/day, referenced from the CRITFC (1994) survey, as the basis for ODEQ to revise state water quality standards. To date, the water quality standards have not yet been revised using the fish consumption rate of 175 g/day. This rate corresponds to approximately 23 meals per month every month of the year of fish caught exclusively within the Study Area. The CRITFC survey reported that none of the respondents fished the Willamette River for resident fish and approximately 4 percent fished the Willamette River for anadromous fish. T~~the 95th percentile ~~fish ingestion~~of consumption ~~rate of 73 g/day~~ for children from the CRITFC ~~Fish Consumption~~ Survey was used for child tribal fish consumers~~.–~~. ~~Exposure assumptions for tribal fish consumption are presented in Table 3-29.~~

~~A multi-species diet was evaluated using the fish consumption data from the CRITFC Fish Consumption Survey (CRITFC 1994) with concentration data from the target resident species as well as from sturgeon, salmon and lamprey caught as a part of the ODHS sampling effort.~~ The CRITFC survey reported that none of the respondents fished the Willamette River for resident fish, and approximately 4~~-~~ percent fished ~~the Willamette River~~ for anadromous fish. ~~The~~ Overall fish consumption information from the CRITFC survey was used to determine the ingestion rate for each fish species, as shown below:

Species	Grams per day[(a)]	Percent of diet
Salmon	67	38.4

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Species	Grams per day[(a)]	Percent of diet
Lamprey	12.3	7.0
Sturgeon	8.6	4.9
Smelt	12.5	7.2
Whitefish	23.2	13.3
Trout	25.1	14.3
Walleye	9.9	5.7
Northern Pikeminnow	3.7	2.1
Sucker	7.3	4.2
Shad	5.2	3.0
Total ~~Ingestion~~Consumption Rate	175	100

(a) ~~Grams per day~~Rates are based on the weighted mean data in Table 18 of ~~the~~ CRITFC ~~Fish Consumption survey~~1994.

~~For adult tribal consumers, the ingestion~~As shown, consumption rates ~~for~~of anadromous species ~~(salmonids (67 g/day), lamprey (12.3 g/day), and sturgeon (8.6 g/day) were used in conjunction with the respective EPCs for each species to calculate intakes~~account for approximately 50 percent of total intake~~.~~. Thus, consumption of salmon, lamprey and sturgeon were equally apportioned at a combined consumption rate of 88 g/day, and the remaining portion of the diet was evaluated assuming equal portions of the four resident fish (smallmouth bass, brown bullhead, common carp, and black crappie) for which tissue data were available~~.~~. ~~For the remaining species, each of the 95 percent UCL/max and mean EPCs calculated for the entire Study Area for smallmouth bass, black crappie, common carp, and brown bullhead were used with an ingestion rate of 21.7 g/day (i.e., the ingestion rate for the sum of the species that are not anadromous salmonid, sturgeon or lamprey, 86.9 g/day, divided by 4). The combined intakes from anadromous salmonids and lamprey, from sturgeon, and from the remaining fish species in the above table were used to estimate risks from fish consumption. The intakes~~Consumption rates for children ~~tribal fish consumers~~ were calculated using the same dietary percentages as the adult tribal fish consumers~~, but with a total ingestion~~ and a total intake~~rate~~ of 73 g/day~~.~~. Exposure assumptions for tribal fish consumption are presented in Table 3-29~~.~~.

Adult salmon, adult lamprey, and sturgeon have life histories such that significant ~~exposure to~~ contaminant~~s~~ loading can occur outside of the Study Area, making it problematic to associate tissue concentrations with site contamination~~.~~.

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However, including consumption of anadromous fish in conjunction with resident fish provides useful information regarding risks to tribal members who may fish the Lower Willamette River. ~~a.~~

~~Exposure assumptions for tribal fish consumption are presented in Table 3-29.The uncertainties in estimating the proportion of contaminants in sturgeon, salmon and lamprey and associated risks that result from contaminants at the Study Area are discussed in Section 6.~~

~~**Domestic Water User**~~

~~Although there is no known current use of surface water within the Study Area as a domestic water supply. Because it is a designated beneficial use of the Willamette River, the use of river water as a domestic water source was assessed as a potential complete pathway. Exposure to surface water could hypothetically occur from ingestion and dermal contact throughout the Study Area. At the direction of the EPA, volatilization of chemicals from untreated surface water to indoor air through household uses was identified as a potentially complete exposure pathway for hypothetical future domestic water use.~~

~~1.0~~

~~**5.3.1.5 Non-Tribal Fishers**~~

~~Exposure assessments for the non~~Non ~~tribal fisher scenarios evaluated potential~~may ~~be exposed~~ ure to COPCs through direct contact with beach and in-water sediment~~,~~ ~~and through consumption of fish and shellfish. Direct contact with beach sediment only occurs in river beach areas where fishing activities occur. Non-tribal fishers could theoretically contact in-water sediment on anchors, hooks, or crayfish pots while fishing from boats or piers at the Study Area. For fish and shellfish consumption, it is assumed that exposure could occur throughout the Study Area and is continuous year-round as fishers may catch fish at the Study Area and then freeze them for later use.~~

~~This BHHRA evaluated both a non-tribal fisher exposure scenario and a tribal fisher exposure scenario, which is discussed in Section 3.5.1.6. The non-tribal fisher scenario included two different fishing frequencies for sediment exposures, three different ingestion rates for fish consumption exposures, and two different ingestion rates for shellfish consumption exposures. Non-tribal fish consumption was evaluated for both adults and children while sediment exposure was evaluated for adults only, with the assumption that fishing is done primarily by adults but both adults and children may consume the fish that are caught.~~

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~~5.3.1.5.1 Beach Sediment Exposure~~

~~Beach sediment exposure would only occur for fishers during bank fishing at natural river beach areas within the Study Area. EPA specified the exposure frequencies and durations for the fishers used in this BHHRA. High-frequency fishers were assumed to fish from the same beach area three days per week for the entire year (156 days/year) for 30 years for the RME. Low-frequency fishers were assumed to fish from the same beach area for two days per week for the entire year (104 days/year)for 30 years for the RME. Exposure assumptions for beach sediment contact for fishers are presented in Table 3-26.~~

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~~5.3.1.5.2 In-Water Sediment Exposure~~

~~At the request of EPA, the exposure frequencies and durations for beach sediment for each fisher scenario were assumed to represent the fishing activity at the Study Area regardless of whether that fishing occurs from a beach or a boat. A factor of 25 percent was used to represent the percent of time spent fishing in a single area within the Study Area.~~

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~~Based on the exposure scenarios for in-water sediment (i.e., contact with sediment on anchors, hooks, or crayfish pots), the extent of contact with in-water sediment is expected to be less than what would occur with residential soil. Ingestion rates for soil are based on exposure to soil during yard work and to indoor dust (EPA 1997a). These ingestion rates are not applicable to the in-water sediment exposure scenarios; however, incidental ingestion rates are not available for sediment. It is assumed that the incidental ingestion rate for in-water sediment is 50% percent of the ingestion rate for residential incidental soil scenarios. For dermal contact, hands and forearms are the only body parts that could be exposed to in-water sediment on a regular basis (i.e., on a year-round basis). It is assumed that the entire surface area of both hands and forearms would be exposed to in-water sediment. The adherence and absorption factors are assumed to be the same as those for beach sediment. Exposure assumptions for in-water sediment contact for fishers are presented in Table 3-27.~~

~~5.3.1.5.3 Fish Consumption~~

~~The fish consumption scenario included three different fish ingestion rates, as well as single species and multiple species diets of resident fish species. Study Area-specific fish consumption information is not available for the fish consumption scenarios. Therefore, to evaluate the potential range in consumption patterns that may exist, three ingestion rates were used to calculate intakes for adults and three were used for children. EPA specified the ingestion rates used in this BHHRA. For adults, the fish ingestion rates were 17.5 grams per day (g/day), 73 g/day, and 142 g/day. These rates correspond to approximately 2 meals per month, 10 meals per month, and 19 meals per month, based on an 8-ounce serving size, every month of the year, consisting exclusively of fish caught within the Study Area. It should be noted that the current fish consumption advisory, based on PCBs, for the LWR recommends that children and expectant mothers do not eat resident fish from the Portland Harbor, and that healthy adults eat no more than one 8-ounce meal per month of resident fish from the~~

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Portland Harbor (ODHS 2007). However, it is unclear to what extent this advisory is followed by people who consume fish from the Study Area.

Two of these rates, 17.5 g/day and 142 g/day, represent the 90th and 99th percentile ingestion rates for diets including uncooked freshwater and estuarine finfish and shellfish by individuals (consumers and non-consumers) of age 18 and over in the United States (EPA 2002b). The 90th and 99th percentile ingestion rates for uncooked freshwater and estuarine finfish and shellfish for consumers only are 200 g/day and 506 g/day, respectively (EPA 2002b). Because these rates are from a national dietary study, they may not be representative of site-specific consumption patterns. Relative to the ingestion rate of 142 g/day, an adult consuming fish and shellfish tissue at a rate of 200 g/day would need approximately 70 percent of their total fish and shellfish diet to be fish caught within the Study Area, and an adult consuming fish and shellfish tissue at a rate of 506 g/day would need approximately 28 percent of their total fish and shellfish diet to be fish caught within the Study Area. If a different proportion of fish were caught within the Study Area versus outside of the Study Area, exposure to chemicals within the Study Area would change accordingly. Additional uncertainties associated with these ingestion rates are discussed in Section 6. The other ingestion rate used in this BHHRA, 73 g/day, is from a creel study conducted in the Columbia Slough and is the 95 percent upper confidence limit on the average for ingestion of fish where 75 percent of the mass of the total fish is consumed (Adolfson 1996). While this study may be more representative of consumption patterns for the Study Area, the study was limited in scope and the reported ingestion rates were estimated based on numerous assumptions. These ingestion rates were used for both the mean and 95% percent UCL/max risk calculations.

Limited information is available about fish consumption by children. The child scenario evaluated in this BHHRA is for 0 to 6 year olds. The national dietary study does not include consumption information for this age range. However, this age range was evaluated in the CRITFC Fish Consumption Survey (CRITFC 1994). In that survey, the ratio of the child 95th percentile ingestion to the adult 95th percentile ingestion rate, which is the comparison specified by EPA, was 0.42. This ratio was applied to the three adult ingestion rates to estimate the child ingestion rates. The corresponding rates that were used for children were 7 g/day, 31 g/day, and 60 g/day. Exposure assumptions for fish consumption are presented in Table 3-29.

For the fish consumption scenarios, risks were evaluated separately for consumption of each individual target resident fish species (smallmouth bass, black crappie, brown bullhead, and common carp) assuming only one species was consumed in each scenario. For these individual species scenarios the ingestion rates for the entire diet (regardless of species) were used with concentration data on each individual resident species (for both whole body and fillet tissue). EPCs were calculated for fishing zones (common carp, black crappie and brown bullhead) and mile reach (smallmouth bass) as well as for the entire Study Area, as described in Section 3.4.5. In addition to

the individual species diet, a multiple species diet was also evaluated by using the fish ingestion rates for the scenarios with the concentration data of all resident species (for whole body and fillet tissue) for the Study Area (i.e., a multiple species diet assuming that each of the 4 fish target species represents 1/4 of a person's diet). The following scenarios were evaluated for each of the above ingestion rates using both the 95% percent UCL/max and mean EPCs described in Section 3.4.5 for both whole body and fillet samples (because these scenarios were not classified as CT or RME):

	River Mile	Fishing Zone	Entire Study Area
Smallmouth bass	X		X
Black crappie		X	X
Common carp		X	X
Brown bullhead		X	X
Multiple species			X

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The uncertainties associated with the fish consumption scenarios are discussed in Section 6 of this BHHRA.

5.3.1.5.4 Shellfish Consumption

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Site-specific shellfish consumption information is not available. For shellfish, only adult consumption was evaluated. It should be noted that there is currently a fish consumption advisory for wood-treating chemicals in a portion of the Study Area recommending that crayfish not be eaten (ODHS 2007). Ingestion rates of 3.3 g/day and 18 g/day were used to calculate intakes from shellfish consumption. These values represent the 50th percentile (3.3 g/day) and 95th percentile (18 g/day) ingestion rates for shellfish consumption from freshwater and estuarine systems for individuals of age 18 and older in the United States (EPA 2002b). These ingestion rates were used with 95% percent UCL/max and mean EPCs for crayfish and clams described in Section 3.4.5 (because these scenarios were not classified as CT or RME). Exposure assumptions for shellfish consumption are presented in Table 3-29. The uncertainties associated with the shellfish consumption scenario are discussed in Section 6 of this BHHRA.

5.3.1.6 Tribal Fishers

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For thousands of years, the Willamette River has been an important ceremonial and subsistence fishery (i.e., salmon, lamprey, and sturgeon) for Native American tribes of the region. Native Americans continue to rely on the Willamette River. For example, tribal members conduct a ceremonial spring Chinook harvest and continue to harvest lamprey at Willamette Falls annually.

~~5.3.1.6.1 Beach Sediment Exposure~~

~~Beach sediment exposure would only occur for tribal fishers during bank fishing at natural river beach areas within the Study Area. EPA provided the exposure frequencies and durations for the tribal fishers used in this BHHRA. Tribal fishers were assumed to fish from the same beach area five days per week for the entire year (260 days/year) for an entire lifetime (70 years) for the RME. Although it is not known how much sediment contact actually occurs during fishing activities, default intake values for residential soil were used. Exposure assumptions for beach sediment contact for tribal fishers are presented in Table 3-26.~~

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~~5.3.1.6.2 In-Water Sediment Exposure~~

~~At the request of EPA, the exposure frequencies and durations for beach sediment were assumed to represent the fishing frequency at the Study Area regardless of whether that fishing occurs from a beach or a boat. Therefore, a factor of 25 percent was used to represent the percent of time exposed to in-water sediment while fishing in a single area within the Study Area.~~

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~~Contact with sediment on anchors or hooks represents the most likely exposure route for contact with in-water sediments for tribal fishers. Ingestion rates for soil are based on exposure to soil during yard work and to indoor dust (EPA 1997a). These ingestion rates are not applicable to the in-water sediment exposure scenarios; however, incidental ingestion rates are not available for sediment. It is assumed that the incidental ingestion rate for in-water sediment is 50% percent of the ingestion rate for residential soil scenarios. For dermal contact, hands and forearms are the only body parts that could be exposed to in-water sediment on a regular basis. It is assumed that the entire surface area of both hands and forearms would be exposed to in-water sediment. The adherence and absorption factors are assumed to be the same as those for beach sediment. Exposure assumptions for in-water sediment contact for tribal fishers are presented in Table 3-27.~~

~~5.3.1.6.3 Tribal Fish Consumption~~

~~A multi-species diet that includes resident fish as well as salmonids, lamprey, and sturgeon was evaluated for tribal fish consumption. While site-specific fish consumption information is not available for the tribal fish consumption scenario, a fish consumption survey was conducted on the reservations of four of the participating Tribes (CRITFC 1994). The 95th percentile fish ingestion rate for consumers only from the CRITFC Fish Consumption Survey, which is 175 g/day, was used to calculate intakes for adult tribal fish consumers. On October 23, 2008, the Oregon Environmental Quality Commission approved a fish consumption rate of 175 g/day, referenced from the CRITFC (1994) survey, as the basis for ODEQ to revise state water quality standards. To date, the water quality standards have not yet been revised using the fish consumption rate of 175 g/day. This rate corresponds to approximately 23 meals per month every month of the year of fish caught exclusively within the Study Area. The CRITFC survey reported that none of the respondents fished the Willamette River for resident fish and approximately 4 percent fished the~~

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~~Willamette River for anadromous fish. The 95th percentile fish ingestion rate of 73 g/day for children from the CRITFC Fish Consumption Survey was used for child tribal fish consumers. Exposure assumptions for tribal fish consumption are presented in Table 3-29.~~

~~A multi-species diet was evaluated using the fish consumption data from the CRITFC Fish Consumption Survey (CRITFC 1994) with concentration data from the target resident species as well as from sturgeon, salmon and lamprey caught as a part of the ODHS sampling effort. The fish consumption information from the CRITFC survey was used to determine the ingestion rate for each fish species, as shown below:~~

~~Species~~	~~Grams per day[(a)]~~	~~Percent of diet~~
~~Salmon~~	~~67~~	~~38.4~~
~~Lamprey~~	~~12.3~~	~~7.0~~
~~Sturgeon~~	~~8.6~~	~~4.9~~
~~Smelt~~	~~12.5~~	~~7.2~~
~~Whitefish~~	~~23.2~~	~~13.3~~
~~Trout~~	~~25.1~~	~~14.3~~
~~Walleye~~	~~9.9~~	~~5.7~~
~~Northern Pikeminnow~~	~~3.7~~	~~2.1~~
~~Sucker~~	~~7.3~~	~~4.2~~
~~Shad~~	~~5.2~~	~~3.0~~
~~Total Ingestion Rate~~	~~175~~	~~100~~

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3.5.10.8 Domestic/Household Water User

~~(a) Grams per day are based on the weighted mean data in Table 18 of the CRITFC Fish Consumption survey.~~

~~For adult tribal consumers, the ingestion rates for anadromous salmonids (67 g/day), lamprey (12.3 g/day), and sturgeon (8.6 g/day) were used in conjunction with the respective 95% percent UCL/max and mean EPCs for those each species to calculate intakes. For the remaining species, each of the 95% percent UCL/max and mean EPCs calculated for the entire Study Area for smallmouth bass, black crappie, common carp, and brown bullhead were used with an ingestion rate of 21.7 g/day (i.e., the ingestion rate for the sum of the species that are not anadromous salmonid, sturgeon or lamprey, 86.9 g/day, divided by 4). The combined intakes from anadromous salmonids and lamprey, from sturgeon, and from the remaining fish species in the above table were used to estimate risks from fish consumption. The intakes for child tribal fish consumers were calculated using the same dietary~~

percentages as the adult tribal fish consumers, but with a total ingestion rate of 73 g/day.

Adult salmon, adult lamprey, and sturgeon have life histories such that significant exposure to contaminants can occur outside of the Study Area. The uncertainties in estimating the proportion of contaminants in sturgeon, salmon and lamprey and associated risks that result from contaminants at the Study Area are discussed in Section 6.

5.3.1.7 Divers

1.0 Divers could contact in-water sediment and surface water while performing specific commercial diving activities such as marine construction, underwater inspections, and routine operation and maintenance. As previously discussed in Section 3.3.2.2, exposure factors for divers were provided as a directive from EPA in a memorandum dated September 15, 2008 (EPA 2008c). The EPA developed two exposure scenarios to differentiate exposures by divers wearing wet suits from exposures by divers wearing dry suits. For both the RME wet suit and dry suit scenarios, divers were assumed to contact in-water sediment and surface water for 25 years of employment with 5 days of exposure frequency per year. For the CT scenario, which only includes wet suit divers, divers were assumed to contact in-water sediment and surface water for 9 years of employment with 2 days of exposure frequency per year. The event duration for exposure to sediment and surface water for both diver scenarios was 4 hours per diver for the RME and 2 hours per diver for the CT exposure. Whole body exposure was assumed for the skin surface area for the wet suit diver scenario (RME and CT), so that the surface area for the exposed skin was 18,510 square centimeters (cm^2). For the skin surface area for the dry suit diver scenario (RME only), it was assumed that only the head and neck would be exposed, equivalent to a skin surface area of approximately 2,510 cm^2. The sediment dermal adherence factors for both diver exposure scenarios were the same as those for the in-water fishers. The sediment ingestion rates for both diver exposure scenarios were the same as the in-water fishers (RME of 50 mg/day and CT of 25 mg/day), though the sediment contact frequency term was not used for divers. The water ingestion rates for both diver exposure scenarios were the same as those used for the recreational beach swimmers. Tables 3-27 and 3-28 summarize exposure assumptions for the wet suit and dry suit divers for in-water sediment and surface water, respectively, and the reference or rationale for each value.

5.3.1.8 Domestic Water Users

Surface water within the Study Area is not currently used as a domestic water source and there are no known plans to use it as a domestic water source in the future. However, the designated beneficial uses of the Willamette River include domestic water supply, assuming adequate pretreatment of the water prior to consumption. EPA specified that the BHHRA evaluate use of untreated river water as a domestic

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~~water supply. This scenario is considered hypothetical because pretreatment of surface water for domestic use would be required under current state laws.~~

Use of surface water as a household water source was evaluated assuming exposure occurs in a residential setting~~.~~. ~~To evaluate this hypothetical scenario, default EPA intake parameters for residential drinking water were used for both adult and child exposures.~~ Exposure ~~duration~~ frequency~~–~~ ~~was~~ is assumed ~~to be~~as 350 days per year ~~for both adult and child residents~~(7 days/week for 50 weeks) for both the RME and CT evaluations~~.~~. As discussed in Section 3.5.9.5, overall exposure duration for residential exposure was assessed as 30 years for the RME estimate and 9 years for the CT estimate~~.~~. ~~The water ingestion rates used for both adult and child were those recommended for residential ingestion of drinking water (EPA 1989)~~Water ingestion by adults was evaluated at a rate of 2 L/day for the RME estimate, representing the average of the 90th percentiles of two national studies (EPA 1997a)~~.~~. A value of 1.4 L/day was used for the CT estimate, representing the population-weighted means of the same studies~~.~~. These values are representative of water consumed directly from the tap or used in the preparation of food and beverages for~~t~~ adults~~.~~. Ingestion rates representing 50th percentile values of 1.4 L/day for RME and 0.9 L/day for CT were used for children aged 6 years and younger~~.~~.

Dermal exposures during showering or bathing were evaluated assuming a rate of one event per day, with an event duration of 35 minutes (0.58 hr) for the RME and 15 minutes (0.15 hr) for the CT, representing the 95th and 50th percentile values from EPA 1997a~~.~~. A total skin surface area of 18,000 cm^2, representing estimates of the 50th percentile of mean surface area for adult men and women (EPA 1997a), was used for both the RME and CT estimates~~.~~. A corresponding mean surface area of 6,600 cm^2 was used for children aged 6 years and younger. ~~. The event duration and skin surface area were the recommended values for adults and children while showering or bathing (EPA 2004). Event frequency was once per day for both adult and child. None of the chemicals selected as COPCs for the domestic water use scenario were volatile, and therefore the inhalation exposure route was not evaluated for this scenario.~~

Table 3-30 summarizes the exposure assumptions ~~for the hypothetical domestic~~used to evaluate domestic use of surface water~~ water use by adult and child residents, and the reference or rationale for each value~~.

~~5.3.2~~3.5.11 Chemical-Specific Exposure Factors and Assumptions

In calculating chemical intakes, certain assumptions were made that were specific to a given chemical or class of chemicals~~.~~. These chemical-specific assumptions had an effect on both EPCs and intake calculations, and are described below.

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~~**5.3.2.1 Exposure Point Concentrations**~~**Arsenic**

~~**3.5.11.1 Calculations of EPCs are described in Section 3.4 and the resulting EPC values are presented in Tables 3-2 through 3-25. . Inorganic arsenic EPCs were estimated from total arsenic concentrations, as described below. . In addition, PCBs were summed in several different ways, as described below.**~~

A~~l~~though a~~r~~senic was analyzed as total arsenic, the~~, but the~~ toxicity values ~~for arsenic are only relevant~~represent ~~for~~ inorganic arsenic~~, which is most significant for tissue. .~~ . In previous fish tissue studies in the lower Columbia and Willamette Rivers, the percent of inorganic arsenic relative to total arsenic ranged from 0.1~~%~~ percent to 26.6~~%~~ percent with an average ~~average percent inorganic arsenic~~ of 5.3~~%~~ percent inorganic arsenic in ~~the~~ resident fish samples from the Willamette River (Tetra Tech 1995, EVS 2000)~~.~~. Shellfish may have a higher percentage of inorganic arsenic, as measured in studies on the Lower Duwamish River~~.~~. The Columbia River Basin Fish Contaminant Survey (EPA 2002c) concluded that a "value of 10~~%~~ percent is expected to result in a health protective estimate of the potential health effects from arsenic in fish." Therefore, ~~it was assumed that~~ 10~~%~~ percent of total arsenic in tissue was ~~in the form of~~assumed to be inorganic arsenic ~~for purposes of this BHHRA. . The total arsenic concentrations were multiplied by 10% percent and the resulting value was used in~~ when calculating ~~the tissue EPCs for arsenic. .~~ Uncertainties associated with the assumption that 10~~%~~ percent of the total arsenic is in the inorganic fo~~rm RM~~rm~~ in fish and shellfish are discussed further in Section 6.

3.5.11.2 PCBs

PCBs were analyzed as Aroclors and congeners in tissue~~.~~. ~~For~~ Where PCBs were analyzed as Aroclors, the summed concentration of individual Aroclors was used in calculating the EPCs~~, as described in Attachment F2. . For~~ Where PCBs were analyzed as congeners, EPCs were calculated using both the total PCB value (sum of individual congeners) and an adjusted total PCB value~~.~~. The adjusted total PCB value was calculated by subtracting the concentration of the coplanar PCB congeners from the total PCB concentration~~.~~. This was done because the coplanar PCB congeners were evaluated separately (as TCDD toxic equivalents [TEQs]) for cancer risks~~.~~. Further explanation of how PCB congeners were summed is provided in as described in Section 2.2.8~~Attachment F2~~.

~~**Lead**~~

~~Health effects associated with exposure to inorganic lead and compounds are well documented and include neurotoxicity, developmental delays, hypertension, impaired hearing acuity, impaired hemoglobin synthesis, and male reproductive impairment. Importantly, many of lead's health effects may occur without other overt signs of toxicity. Lead has particularly significant effects in children, and it appears that some of these effects, particularly changes in the levels of certain blood enzymes and in aspects of children's neurobehavioral development, may occur at blood lead levels so low as to be essentially without a threshold. Because of the difficulty in accounting~~

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for pre-existing body burdens of lead and the apparent lack of threshold, EPA determined that it was inappropriate to develop a RfD. The Centers for Disease Control (CDC) has identified a blood lead concentration of 10 micrograms per deciliter (µg/dL) as the level of concern above which significant health effects may occur (CDC 1991), and the concentration of lead in the blood is used as an index of the total dose of lead regardless of the route of exposure (EPA 1994). An acceptable risk is generally defined as a less than 5 percent probability of exceeding a blood lead concentration of 10 µg/dL (EPA 1998).

Using the ALM (EPA 2003c), acceptable and the Integrated Exposure Uptake Biokinetic Model for Lead in Children (IEUBK, EPA 2007d), the Columbia River Basin Fish Contaminant Survey (EPA 2002c) calculated lead concentrations in fish tissue that are unlikely to result in fetal and childhood blood lead concentrations greater than 10 µg/dL were calculated using the following equation.

The following equations from the ALM were used in the Columbia River Basin Fish Contaminant Survey (EPA 2002c) to develop tissue concentrations to be protective of fetuses of tribal adults:

$$PbF = \frac{\left(\left[PbB_f / R \times GSD^{1.645}\right] - PbB_o\right) \times AT}{BKSF \times \left(IR_F \times AF_F \times EF_F\right)}$$

Where:

- PbB_o = Central tendency of adult blood lead level
- PbB_o = Adult baseline blood lead level
- PbB_f = Fetal blood lead level
- R = Fetal/maternal blood lead ratio
- GSD = Geometric standard deviation PbB_f
- BKSF = Biokinetic slope factor
- PbF = Lead fish tissue concentration
- IR_F = Fish tissue ingestion rateConsumption rate of fish
- AF_F = GAbsolute gastrointestinal ingestionabsorption of lead from factor for ingested lead infish tissue
- EF_F = Exposure frequency offor fish ingestionconsumption
- AT = Averaging timetime

The EPA (2003c) ALM approach was used to determine protective fish tissue concentrations for the fetuses of both adult fishers and adult tribal fishers in the Study Area, using updated default ALM assumptions for the West Region, which are based on current EPA guidance (EPA 2003c). Differences in default parameter values from the EPA (2003c) application of the ALM to the ALM application for this BHHRA include a change in PbB_o from 2.2 µg/dl to 1.4 µg/dl, and a change in AF_F from 0.1 to 0.12.The values used in this analysis are presented in Attachment F5.

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~~The evaluation of risks from lead is based onBecause the lead models calculate a central tendency or geometric mean levelsblood lead concentration, and associated probabilities, so median values are generallytypically used as inputs to the equations. The mean estimate of national per capita fish consumption of 7.5 g/day (EPA 2000b) was used as the consumption rate for adultsrecreational fishers (EPA 2000b), t. The median consumption fish ingestion rate of 39.2 g/day from the CRITFC study was used for tribal fishers fishers is 39.2 g/day, as stated in the CRITFC Fish Consumption Survey (CRITFC 1994) and used by the EPA (2002c) in calculations of protective lead tissue concentrations. The ALM inputs and results for estimating protective lead tissue concentrations for fetuses of adult fishers and adult tribal fishers consuming fish in the Study Area are provided in Table F5-3 of Attachment F5.~~

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~~Using the above equations presented above, the target lead concentrations in fish are, the ALM predicts that fetal blood lead levels will exceed 10 µg/dl less than 5 percent of the time for adult fishers at a lead fish tissue concentration of 5.25 mg/kg for recreational fishers and 1 mg/kg for tribal fishers.. The maximum fish tissue EPC for lead in the Study Area is 1,100 mg/kg, detected in a smallmouth bass whole body tissue sample. This is above the protective concentration of 5.25 mg/kg. However, this maximum EPC is orders of magnitude greater than all other resident fish EPCs and may be attributable to lead in the gut of the fish due to the ingestion of a metallic object (e.g., sinkers) (Integral 2008). There are no other resident fish tissue EPCs which exceed a protective lead concentration of 5.25 mg/kg. Therefore, while lead is considered a preliminary chemical potentially posing unacceptable risks for fish ingestion by an adult fisher, the uncertainties associated with the maximum detected concentration and evaluations of lead are discussed further in Section 6.~~

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~~The protective lead tissue concentration for fetuses of tribal adults, using the above methods, is 1.01 mg/kg. The maximum fish tissue lead EPC for an adult tribal fisher is 23 mg/kg. However, the tribal fisher tissue ingestion scenario is for a multi-species diet consisting of both resident and anadromous species. There are no detected concentrations in anadromous species exceeding 1.01 mg/kg. Over 99% of the lead in the maximum lead EPC for tribal fishers is attributable to the Study Area-wide EPC for lead in smallmouth bass, which is influenced by the maximum EPC mentioned above for adult fishers. Therefore, while lead is considered a preliminary chemical potentially posing unacceptable risks for fish ingestion by an adult tribal fisher, the~~

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~~EPA's Integrated Exposure Uptake Biokinetic (IEUBK) model was used to calculate tissue lead concentrations unlikely to result in blood lead concentrations greater than 10 µg/dL in children. Because site-specific values for concentration of lead in soil, house dust, air and drinking water were not readily available, default values were used for those inputs. The ratio of child-to-adult consumption rate of 0.42 was applied to the median adult consumption rate of 7.5 g/day to obtain a childhood rate of 3.2 g/day for children of recreational fishers. The corresponding lead concentrations in fish is 2.6 mg/kg. Assuming a tribal consuming tissue at aconsumption rate of 16.2~~

g/day for tribal children, representing the 65th percentile consumption rate from the CRITFC survey, the calculated lead concentration in fish is 0.5 mg/kg. uUncertainties associated with the maximum detected concentration and evaluations of lead are discussed further in Section 6.

5.3.2.2 Dermal Absorption Factors for Sediment

1.0 EPA's Supplemental Guidance for Dermal Risk Assessment (2004) provides chemical-specific values for dermal absorption from contaminated soil. Dermal absorption of chemicals from soil adhered to the skin is dependent on a variety of factors, including the condition of the skin, the nature of adhered soil/sediment, and the chemical concentration. These chemical-specific dDermal absorption factors, representing the fraction of a chemical absorbed from soil or sediment adhered to the skin were used in the intake equations for dermal contact with sediment and are presented in Table 3-31. However, as noted in EPA guidance (2004), the amount of chemical absorbed from sediment may differ from that absorbed from soil due to differences in the relative importance of numerous chemical, physical, and biological factors. A default dermal absorption value was used for semi-volatile organic compounds (SVOCs) that do not have chemical-specific values. Per EPA guidance (2004), only those compounds or classes of compounds for which dermal absorption factors exist were evaluated quantitatively for the dermal contact exposure pathway. For compounds without dermal absorption factors, which are certain metals and perchlorate for the sediment COPCs, dermal intake was assumed to be zero. The uncertainties associated with chemicals lacking dermal absorption factors are discussed in Section Section 6.

3.1.1.4 Dermal Absorption Factors for Surface Water and Groundwater Seeps

2.0 One of the parameters in the intake equations for dermal contact with surface water or groundwater seeps is the absorbed dose per event (DA_{event}). This parameter was derived per EPA guidance (2004) using chemical-specific factors, which are presented in Table 3-32 for scenarios involving direct contact with surface water or groundwater seeps and in Table 3-33 for the hypothetical domestic water use scenario. The chemical-specific factors used in the calculation of DA_{event} were obtained from Appendix B (Screening Tables and Reference Values for the Water Pathway) of EPA's Supplemental Guidance for Dermal Risk Assessment (2004). The uncertainties associated with calculating DA_{event} for chemicals with factors outside of the predictive domain are discussed in Section 6.

3.1.1.53.5.11.3 Oral Bioavailability Factors for Sediment

Consistent with EPA guidance (1989), the chemical intake equations calculate the amount of chemical at the human exchange boundaries, not the amount of chemical available for absorption.—. Therefore, the estimated intakes calculated in this BHHRA are not the same as the absorbed dose of a chemical.—. However, the toxicity of an ingested chemical depends on the degree to which the chemical is absorbed from the

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gastrointestinal tract into the body~~.~~. Per EPA guidance (1989, 2007c), if the exposure medium in the risk assessment differs from the exposure medium assumed by the toxicity value, an adjustment for bioavailability may be appropriate~~.~~. For purposes of this BHHRA, oral bioavailability factors were not used to adjust the estimated exposures from COPCs in sediment~~.~~. The uncertainties associated with not considering bioavailability in this BHHRA are discussed in Section 6~~.~~.

4.0 TOXICITY ASSESSMENT

The toxicity assessment is composed of two steps: (1) hazard identification and (2) dose-response assessment.~~—~~. Hazard identification is the process of determining whether exposure to a chemical may result in a deleterious health effect in humans.~~—~~. It consists of characterizing the nature of the effect and the strength of the evidence that the chemical will cause the observed effect.~~—~~. Dose-response assessment characterizes the relationship between the dose and the incidence and/or severity of the adverse health effect in the exposed population. For risk assessment purposes, chemicals are generally separated into categories based on their toxicological endpoints.~~—~~. The primary basis of this categorization is whether a chemical exhibits potentially carcinogenic or noncarcinogenic health effects.~~—~~. Because chemicals that are suspected carcinogens may also give rise to noncarcinogenic effects, they must be evaluated separately for both effects.~~—~~. ~~Toxicity values provide a quantitative estimate of the potential for adverse effects resulting from exposure to a chemical. Toxicity values are used in risk assessment to quantify the likelihood of adverse effects occurring at different levels of exposure to a chemical.~~

~~Toxicity values were identified for the COPCs that were selected in Section 2.4. The cancer and noncancer toxicity values are shown in Tables 4-1 and 4-2, respectively. The following sections discuss the toxicity values and describe how they were selected.~~

~~5.4~~4.1 TOXICITY VALUES FOR EVALUATING CARCINOGENIC EFFECTS~~TOXICITY VALUES~~

Cancer slope factors are used to estimate the risk of cancer associated with exposure to a chemical known or suspected to be carcinogenic.~~—~~. The slope factor is derived from either human epidemiological or animal studies, and represents an upper bound, generally approximating a 95 percent confidence limit, on the increased cancer risk from a lifetime exposure by ingestion.~~—~~. Slope factors are generally expressed in units of proportion (of a population) affected per mg of substance/kg body weight-day ([(mg/kg-day)$^{-1}$].

In addition to the numerical estimates of carcinogenic potential, a cancer weight-of-evidence (WOE) descriptor is used to describe a substance's potential to cause cancer in humans and the conditions under which the carcinogenic effects may be expressed. This judgment is independent of consideration of the agent's carcinogenic potency.~~—~~. Under EPA's 1986 guidelines for carcinogen risk assessment, the WOE was described by categories "A through E"—Group A for known human carcinogens through Group E for agents with evidence of noncarcinogenicity.~~—~~. Under EPA's 2005 guidelines for carcinogen risk assessment, a narrative approach rather than the alphanumeric categories is used to characterize carcinogenicity.~~—~~. Five standard weight-of-evidence descriptors are used: *Carcinogenic to Humans*, *Likely to Be*

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Carcinogenic to Humans, Suggestive Evidence of Carcinogenic Potential, Inadequate Information to Assess Carcinogenic Potential, and Not Likely to Be Carcinogenic to Humans). ~~–~~. ~~Slope factors (SFs) are used to quantify the dose-response potency of potential carcinogens. SFs are derived from either human epidemiological or animal studies by applying a mathematical model to the dataset to extrapolate from the high doses in studies to the lower exposure levels expected for human contact in the environment (EPA 1989). The SF is an upper-bound estimate or maximum likelihood estimate of the probability of a response over a lifetime.~~

~~Slope factors are available for oral and inhalation exposure pathways. The inhalation exposure pathway was not quantitatively evaluated in this BHHRA, so inhalation unit risk values were not selected as toxicity values. Dermal SFs~~Slope factors for assessing dermal exposure were derived ~~from the oral SFs,~~ as described in Section 4.7, and~~.~~ ~~The~~ oral and dermal ~~cancer~~ slope factors are presented in Table 4-1~~–~~. ~~In accordance with EPA (2005a) guidance, the weight of evidence for carcinogenicity for each COPC is also presented in Table 4-1.~~

~~5.5~~4.2 TOXICITY VALUES FOR EVALUATING NONCARCINOGENIC EFFECTS~~TOXICITY VALUES~~

The reference dose (RfD) provides quantitative information for use in risk assessments for health effects known or assumed to be produced through a nonlinear (possibly threshold) mode of action. The RfD, expressed in units of mg of substance/kg body weight-day (mg/kg-day) is defined as an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime~~.~~. The use of RfDs is based on the concept that there is range of exposures that exist up to a finite value, or threshold, that can be tolerated without producing a toxic effect~~.~~ ~~. Because EPA has not derived toxicity values specific to skin contact, dermal RfDs were derived in accordance with EPA's Supplemental Guidance for Dermal Risk Assessment (EPA 2004). The RfD that reflects the absorbed dose was calculated by using the following equation:~~

~~$RfD_{dermal} = RfD_o \times ABS_{GI}$~~

~~RfD_{dermal} = dermal reference dose (mg/kg-day)~~

~~RfD_o = child exposure duration (years)~~

~~ABS_{GI} = adult exposed skin surface area (cm^2)~~

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~~Most toxicity values are based on either oral or inhalation exposures. For oral exposures, toxicity values are often expressed as the amount of substance administered, whereas dermal exposures are expressed as absorbed dose.~~

~~As recommended by EPA guidance (EPA 2004), an adjustment to the oral toxicity factor to account for the estimated absorbed dose was applied in this BHHRA when the following conditions are met:~~

- ~~The toxicity value derived from the critical study is based on an administered dose (e.g., through diet or by gavage)~~

- ~~A scientifically defensible database demonstrates the GI absorption of the chemical is less than 50 percent in a medium similar to the one used in the critical study.~~

~~If both of these conditions are met, the oral toxicity factor was adjusted to reflect the absorbed dose in this BHHRA. For carcinogenic effects, the oral slope factor was divided by the GI absorption factor to estimate the dermal slope factor. Hexavalent chromium was the only COPC for which the oral slope factor was adjusted to reflect the absorbed dose. For noncarcinogenic effects, the oral reference dose was multiplied by the GI absorption factor to estimate the dermal reference dose. The COPCs for which the oral reference dose was adjusted to reflect the absorbed dose are the metals: antimony, barium, cadmium, trivalent chromium, hexavalent chromium, manganese, mercury, silver, and vanadium.~~

~~If both conditions for adjustment are not met, the oral toxicity value was used as a surrogate for the dermal toxicity value in the BHHRA. Dermal toxicity factors are presented in Tables 4-1 and 4-2.~~

~~EPA recommends adjusting oral toxicity values only when evidence suggests that GI absorption is less than 50 percent. GI absorption efficiencies were obtained from the Supplemental Guidance for Dermal Risk Assessment (EPA 2004). A chemical that exhibits adverse effects other than cancer or mutation-based developmental effects is believed to have a threshold (i.e., a dose below which no adverse effect is expected to occur). Reference doses (RfDs) are typically used as toxicity values for chemicals with noncarcinogenic effects. A chronic RfD is defined as a daily dose to which humans, including sensitive subpopulations, may be exposed throughout their lifetimes without adverse health effects.~~

~~Reference doses are available for oral and inhalation exposure pathways. The inhalation exposure pathway was not quantitatively evaluated in this BHHRA, so inhalation reference concentrations were not selected as toxicity values. Dermal reference doses were derived from oral reference doses, as described in Section 4.7.~~
Reference doses ~~for oral and dermal exposure pathways~~ are presented in Table 4-2.

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~~5.6~~4.3 SOURCES OF TOXICITY VALUES

The following hierarchy of sources of toxicity values is currently recommended for use at Superfund sites (EPA 2003b):

- Tier 1 – EPA's Integrated Risk Information System (IRIS) database (EPA 2010b) is the preferred source of information because it normally represents the official EPA scientific position regarding the toxicity of the chemicals based on the data available at the time of the review~~.~~. IRIS contains RfDs and cancer slope factor (SFs) that have gone through a peer review and EPA consensus review.
- Tier 2 - EPA's Provisional Peer Reviewed Toxicity Values (PPRTVs) are toxicity values derived for use in the Superfund Program when such values are not available in IRIS~~.~~. PPRTVs are derived after a review of the relevant scientific literature using the methods, sources of data and guidance for value derivation used by the EPA IRIS Program~~.~~. The PPRTV database includes RfDs and SFs that have undergone internal and external peer review~~.~~. The Office of Research and Development/National Center for Environmental Assessment/Superfund Health Risk Technical Support Center (STSC) develops PPRTVs on a chemical-specific basis when requested by EPA's Superfund program.
- Tier 3 - Tier 3 includes additional EPA and non-EPA sources of toxicity information~~.~~. Priority is given to those sources of information that are the most current, the basis for which is transparent and publicly available, and which have been peer reviewed~~.~~. Tier 3 sources may include, but need not be limited to, the following sources:
  - The California Environmental Protection Agency (Cal EPA) Toxicity Criteria Database (Cal EPA 2008) includes toxicity values that have been peer reviewed~~.~~.
  - The ATSDR Minimal Risk Levels are similar to RfDs and are peer reviewed~~.~~.
  - Health Effects Assessment Summary Table (HEAST) toxicity values are currently under review by the STSC to derive PPRTVs~~.~~. The toxicity values remaining in HEAST are considered Tier 3 values.

~~Toxicity values were retrieved from the most current version of the Regional Screening Levels for Chemical Contaminants at Superfund Sites (EPA 2010a, values updated November 2010. These values follow the above hierarchy, and present toxicity values from IRIS for both noncarcinogenic and carcinogenic effects were selected when available. If a toxicity value is not available from IRIS, toxicity values from the PPRTV database are presented, if available. In the absence of toxicity values from either IRIS or the PPRTV database, toxicity values from Tier 3 sources are presented, if available. The sources of the cancer or noncancer toxicity value are indicated in Tables 4-1 and 4-2. The dates shown in Tables 4-1 and 4-2 indicate the~~

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~~date of release of the Regional Screening Levels for Chemical Contaminants at Superfund Site table (EPA 2010a).~~

T~~For t~~richloroethylene~~e~~ cancer potency was evaluated ~~,~~ using ~~EPA provided the draft toxicity value equal to~~ the geometric mid-point of the slope factor range from ~~(~~EPA 2001b as recommended by EPA Region 10 (EPA 2007b)~~) to use as the oral cancer slope factor~~. Recommendations were not provided for evaluating oral exposures for noncancer endpoints for trichloroethylene.

~~5.7~~4.4 CHEMICALS WITH SURROGATE TOXICITY VALUES

I~~For some chemicals, i~~f a toxicity value was not available from the above hierarchy for a specific chemical, a structurally similar chemical was identified as a surrogate~~.~~ . The reference dose or slope factor for the surrogate chemical was selected as the toxicity value and the surrogate chemical was indicated in Tables 4-1 and 4-2~~.~~ . The following chemicals ~~have toxicity values from surrogate chemicals~~were evaluated using surrogate toxicity criteria:

- Butyltin ~~ion.~~ . The toxicity of organotin compounds is somewhat determined by the nature and number of groups bound to tin~~.~~. In general, toxicity decreases as the number of linear carbons increases and as the number of substitutions decrease~~;~~.~~oxicity values were identified from the recommended hierarchy for dibutyltin compounds and tributyltin compounds. Toxicity of alkyltin compounds depends on the number of alkyl side chains, with monoalkyl tin being the least and trialkyl tin the most toxic (National Library of Medicine [NLM] 2004). Therefore, dibutyltin is thought to be more similar to butyltin than tributyltin in toxicity, and is more toxic than butyltin.~~ As a health protective approach, ~~the toxicity value~~RfD for dibutyltin compounds was selected as a surrogate for butyltin ~~ion~~.

- ~~Dibutyltin ion. The available toxicity value for dibutyltin is for dibutyltin compounds. However, the BHHRA sample results were for dibutyltin ion. The dibutyltin compounds toxicity value was selected as a surrogate for dibutyltin ion.~~

- ~~Tributyltin ion. The available toxicity value for tributyltin is for tributyltin compounds. However, the BHHRA sample results were for tributyltin ion. The tributyltin compounds toxicity value was selected as a surrogate for tributyltin ion.~~

- Acenaphthylene ~~. IRIS~~ is ~~classifies~~ classified ~~acenaphthylene~~ as ~~a~~ category D ~~carcinogen~~ (not classifiable as to human carcinogenicity)~~, and therefore, is considered a noncarcinogenic polycyclic aromatic hydrocarbon (PAH).~~ . The RfD for ~~Acenaphthene~~ acenaphthene, which is the ~~noncarcinogenic PAH~~ most structurally similar PAH~~in structure and carbon number to acenaphthylene.~~

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~~Therefore, the acenaphthene toxicity value,~~ was selected as a surrogate for acenaphthylene.

- Benzo(e)pyrene~~. . IRIS classifies benzo(e)pyrene as a category D carcinogen (not classifiable as to human carcinogenicity), and therefore, is considered a noncarcinogenic PAH. O~~As a health protective approach, the RfD for p~~~~f the noncarcinogenic PAHs most similar in structure and carbon number to benzo(e)pyrene, p~~yrene ~~has the lowest toxicity value and is therefore, considered the most toxic. As a health protective approach, the pyrene toxicity value~~ was ~~selected~~ used as a surrogate for benzo(e)pyrene.

- Benzo(g,h,i)perylene~~. IRIS classifies benzo(g,h,i)perylene~~ is classified as ~~a~~ category D ~~carcinogen~~ (not classifiable as to human carcinogenicity)~~, and therefore, is considered a noncarcinogenic PAH.~~ As with benzo(e)pyrene, ~~Of the noncarcinogenic PAHs most similar in structure and carbon number to benzo(g,h,i)perylene, pyrene has the lowest toxicity value and is therefore, considered the most toxic. As a health protective approach, the pyrene~~the RfD for pyrene ~~toxicity value~~ was ~~selected~~ used as a surrogate for benzo(g,h,i)perylene.

- Dibenzothiophene~~. . Toxicity values were not available for dibenzothiophene. The chemical with~~ Fluorene the most ~~similar~~ structureally similar PAH with available toxicity values ~~is fluorene.~~ . Hence, t~~T~~he ~~toxicity value~~RfD for fluorene was ~~selected~~ used as a surrogate for dibenzothiophene.

- Dibenzofuran~~. .~~ The RfD for flourene, which represents the most structurally similar compound ~~oxicity values were not available for dibenzofuran. The chemical with the most similar structure with available toxicity values is fluorene. The toxicity value for fluorene~~for which an RfD was available was selected as a surrogate for dibenzofuran.

- Di-n-octyl phthalate~~. . Toxicity values were not available for di-n-octyl phthalate. The chemical with the most similar structure with available toxicity values is dibutyl phthalate.~~ The RfD for ~~toxicity value for~~ dibutyl phthalate was selected as a surrogate for di-n-octyl phthalate.

- Perylene~~. . IRIS classifies perylene as a category D carcinogen (not classifiable as to human carcinogenicity), and therefore, is considered a noncarcinogenic PAH. Of the noncarcinogenic PAHs similar in structure and carbon number to perylene, pyrene has the lowest toxicity value and is therefore, considered the most toxic. As a health protective approach, the~~The RfD for pyrene ~~toxicity value~~ was selected as a surrogate for perylene.

- Phenanthrene~~. . IRIS classifies phenanthrene as a category D carcinogen (not classifiable as to human carcinogenicity), and therefore, is considered a~~

~~noncarcinogenic PAH. Of the noncarcinogenic PAHs similar in structure and carbon number to phenanthrene, pyrene has the lowest toxicity value and is therefore, considered the most toxic. As a health protective approach, the~~The RfD for pyrene ~~toxicity value~~ was selected as a surrogate for phenanthrene.

- Retene. ~~Retene is a PAH classified by IRIS as a category D carcinogen (not classifiable as to human carcinogenicity). Of the noncarcinogenic PAHs similar in structure and carbon number to retene, pyrene has the lowest toxicity value and is therefore, considered the most toxic. As a health protective approach, the~~ The RfD for pyrene ~~toxicity value~~ was selected as a surrogate for retene.

- Endrin aldehyde~~.~~. Endrin aldehyde can occur as an impurity of endrin or as a degradation product (ATSDR 1996)~~.~~. The ~~toxicity value~~RfD for endrin was ~~selected~~ used as a surrogate for endrin aldehyde.

- Endrin ketone~~.~~. Endrin ketone can occur as an impurity of endrin or as a degradation product (ATSDR 1996)~~.~~. The ~~toxicity value~~ RfD for endrin was ~~selected~~ used as a surrogate for endrin ketone.

- 4-Nitrophenol~~.~~. ~~IRIS has toxicity values for 2-methylphenol and 4-methylphenol, but not 4-nitrophenol.~~ The ~~toxicity value~~RfD for 4-methylphenol was ~~selected~~ used as a surrogate for 4-~~-~~nitrophenol.

~~5.8~~4.5 CHEMICALS WITHOUT TOXICITY VALUES

No SF and RfD~~,~~ or other suitable surrogate values were obtained for ~~Only two COPCs,~~ titanium and delta-hexachlorocyclohexane (delta-HCH)~~, did not have available SF and RfD toxicity values or appropriate surrogate chemicals from sources included in the hierarchy.~~. Titanium is a naturally occurring element and has been characterized as having extremely low toxicity (Friberg et al. 1986)~~.~~. An STSC review concluded that the other hexachlorocyclohexane isomers could not be used as surrogates for delta-HCH due to differences in toxicity (EPA 2002d)~~.~~. Accordingly, t~~In this BHHRA, t~~he potential risks from titanium and delta-HCH are discussed qualitatively in the uncertainty assessment in Section 6.

SFs and RfDs were not identified for lead because lead was evaluated through comparison with benchmark concentrations that are based on blood lead levels~~.~~. Benchmark concentrations for child exposure scenarios were predicted by the Integrated Exposure Uptake Biokinetic (IEUBK) model~~.~~. Benchmark concentrations for adult exposure scenarios were predicted by the Adult Lead Methodology (ALM). Uncertainties associated with using these benchmark concentrations are discussed in Section 6.4.4.

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~~5.9~~4.6 TOXICITY VALUES FOR CHEMICAL ~~MIXTURES~~CLASSES

~~Some~~ Certain toxicity values are based on exposure to ~~chemical mixtures~~more than one isomer and not to individual chemicals~~.~~. As a result, the risks were evaluated for the combined exposure ~~to the chemicals and not on~~rather than on an individual chemical basis~~.~~. ~~The chemicals~~COPCs that were evaluated for toxicity as ~~mixtures~~ classes are indicated in Tables 4-1 and 4-2, and are discussed below~~.~~.

- Chlordane~~.~~:~ The chlordane toxicity values were derived for technical chlordane, which is composed of a mixture of chlordane isomers~~.~~. The chlordane isomers analyzed in Round 1, Round 2, and Round 3 samples were alpha-chlordane, *trans*-chlordane, *cis*-nonachlor, *trans*-nonachlor, and oxychlordane~~.~~. These isomers were summed in a total chlordane concentration~~.~~. The SF and RfD for technical chlordane were used to evaluate total chlordane.

- DDD, DDE, and DDT~~.~~:~ Technical DDT includes 2,4'~~'~~-DDT and 4,4'~~'~~-DDT, as well as 2,4'~~'~~-DDE, 4,4'~~'~~-DDE, 2,4'~~'~~-DDD, and 4,4'~~'~~-DDD~~.~~. Although individual slope factors are available for DDD, DDE, and DDT~~-~~ based on studies conducted using the ~~have separate SFs included in IRIS. While the SFs were derived for the~~ 4,4'~~'~~ isomers, ~~the SFs were used to evaluate the sum of the~~the potency of the 2,4'~~'~~ ~~and~~ isomers was assumed to be equal to that of the 4,4'~~'~~ isomers~~-~~, and cancer risks assessed as the sum of the 2,4' and 4,4' isomers~~because toxicity values are not available for the 2,4' isomers.~~ . ~~The~~ Additionally, the ~~DDT~~ RfD for DDT ~~was derived for a mixture of the 2,4' and 4,4' isomers and was used to evaluate the noncancer endpoint of DDT. As an RfD is not available for the DDD or DDE isomers, so the DDT RfD~~ was ~~selected~~ used as a surrogate ~~toxicity value and was used~~ to evaluate the noncancer ~~endpoint~~ effects of DDD and DDE.

- Endosulfan~~.~~:~ The ~~toxicity value (~~RfD~~)~~ for endosulfan was derived from studies using technical endosulfan, which includes alpha-endosulfan, beta-endosulfan, and endosulfan sulfate~~.~~. The individual endosulfan results ~~These compounds~~ were summed ~~in~~ to give a total endosulfan concentration, and t~~.~~ ~~T~~he RfD for technical endosulfan was used to evaluate total endosulfan.

- PCBs~~.~~:~ ~~The PCB cancer SF was derived for PCB mixtures~~The cancer slope factor for PCBs is based on administered doses of Aroclors (Aroclor 1016, 1242, 1254, or 1260) ~~to rats. The cancer SF~~, and was ~~applied to~~ used to assess the cancer risks for total PCBs~~,~~ measured either as congeners or Aroclors~~.~~. As discussed in Section 2.2.8, total PCB concentrations were calculated as either the sum of Aroclors or individual congeners~~.~~. ~~The~~ Where PCBs were reported as individual congeners,~ ~~PCB SF was applied to the~~an adjusted PCB concentration was calculated ~~total PCB~~ by subtracting the sum of total dioxin-like PCB congener concentrations from the sum of all congeners~~congener concentration after subtracting the total dioxin-like PCB~~

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~~congener concentration. –~~. ~~-~~Dioxin-like PCB congeners ~~concentrations~~ were evaluated separately using the slope factor for 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD) ~~SF,~~ as described below ~~for dioxins and furans. –~~. This approach may double-count a portion of the toxicity of the dioxin-like PCBs, as discussed in Section 6.3.6.~~ –~~. The RfD for Aroclor 1254 ~~RfD~~ was used to evaluate the noncancer endpoint for total PCBs, measured either as total unadjusted congeners or as Aroclors.

- Dioxins and furans.~~ –:–~~ Toxic Equivalency Factors (TEFs) from the World Health Organization (WHO) (Van den Berg 2006) were used to evaluate carcinogenic effects of dioxin and furan congeners and for dioxin-like PCB congeners (see Table 4-3).~~ –~~. Concentrations of individual congeners are multiplied by their respective TEF~~s~~ to provide a ~~estimate the toxicity of these congeners relative to~~ 2,3,7,8-TCDD-equivalant concentration (TEQ).~~:~~ the resulting ~~concentrations~~ TEQs are then summed into a total 2,3,7,8-~~–~~TCDD ~~TEQ~~TEQ.~~ –~~. ~~The~~ Cancer risk were assessed using the slope factor for 2,3,7,8-~~–~~TCDD ~~SF~~ was used to evaluate the cancer endpoint of the TEQ for dioxin and furan congeners, as well as ~~and~~ for dioxin-like PCB congeners.~~ –~~. The ATSDR MRL for 2,3,7,8-~~–~~TCDD ~~RfD~~ was used ~~with the same approach to evaluate the noncancer endpoint of the~~in conjunction with the TEQ approach for dioxin and furan congeners, and for dioxin-like PCB congeners.

- Carcinogenic PAHs.~~ –:– Carcinogenic~~ Individual carcinogenic PAHs ~~can be~~were evaluated for toxicity based on their potency equivalency factor (PEF), which estimates ~~toxicity~~ cancer potency relative to benzo(a)pyrene (EPA 1993).~~ –~~. The toxicity values for individual PAHs shown in Table 4-1 incorporate their respective PEFs.~~ –~~. Risk from both individual and total carcinogenic PAHs was assessed in this BHHRA.

~~5.10~~4.7 DERMAL ~~TOXICITY~~ ASSESSMENT

Toxicity is a function of contaminant concentration at critical sites-of-action.~~ –~~. However, most oral reference doses and slope factors are expressed ~~Most toxicity values are based on either oral, not dermal, or inhalation exposures. TFor oral exposures, toxicity values for oral exposure are often expressed as the amount of substancebased on~~as an administered ~~rather than an absorbed~~ dose, whereas exposure estimates for dermal exposures are ~~expressed as~~based on the absorbed dose.~~ -~~ Anatomical differences between the gastrointestinal tract and the skin can affect rate as well as the extent of absorption.~~ –~~. Thus, the route of exposure may significantly affect the critical dose at the site-of-action.~~ –~~. A further complication is that an orally administered dose experiences "hepatic first-pass" metabolism, ~~and~~ which may significantly alter the toxicity of the administered chemical.~~ –~~. ~~Gastrointestinal and pulmonary tracts is typically much greater than absorption through intact skin. Thus, for evaluating the effects of dermal exposure to contaminants in soil, it may be necessary to adjust the oral toxicity value from an administered dose to an absorbed dose by accounting for the absorption efficiency of the chemical.~~

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~~However~~Additionally~~,~~ some chemicals can cause cancer or other effects through direct action at the point of application~~.~~. For such locally active compounds, it may be inappropriate to evaluate risks based on oral response data~~.~~. ~~EPA has developed a simplified method for oral-to-dermal extrapolations (EPA 2004). These extrapolations involve an adjustment to the oral toxicity value based on the GI absorption factor of the specific chemical in the same administration vehicle (e.g., corn oil, food) as used in the critical toxicity study to derive an estimated dermal dose.~~

As recommended by EPA guidance (EPA 2004), an adjustment to the oral toxicity factor to account for the estimated absorbed dose was applied ~~in this BHHRA~~ when ~~the following conditions are met:~~

- ~~T~~he toxicity value derived from the critical study ~~is~~ was based on an ~~administered~~ oral dose ~~(e.g., through diet or by gavage)~~and

- ~~A scientifically defensible database demonstrates the~~ GI absorption of the chemical is less than 50~~%~~ percent ~~in~~ from a medium similar to the one used in the critical study.

~~If both of these conditions are met, the oral toxicity factor was adjusted to reflect the absorbed dose in this BHHRA~~Dermal RfDs for assessing dermal exposure ~~that~~ were calculated ~~by~~ using the following equation:

$$RfD_{dermal} = RfD_o \times ABS_{GI}$$

RfD_{dermal} = dermal reference dose (mg/kg-day)
RfD_o = child exposure duration (years)
ABS_{GI} = ~~adult exposed skin surface area (cm^2)~~fraction of contaminant absorbed in gastrointestinal tract

Cancer slope factors for assessing dermal exposure were calculated as follows:

$$SF_{dermal} = \frac{SF_o}{ABS_{GI}}$$

SF_{dermal} = dermal cancer slope factor (mg/kg-day)$^{-1}$
SF_o = oral cancer slope factor (mg/kg-day)$^{-1}$
ABS_{GI} = fraction of contaminant absorbed in gastrointestinal tract

~~. For carcinogenic effects, the oral slope factor was divided by the GI absorption factor to estimate the dermal slope factor. Hexavalent chromium was the only COPC~~

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~~for which the oral slope factor was adjusted to reflect the absorbed dose. For noncarcinogenic effects, the oral reference dose was multiplied by the GI absorption factor to estimate the dermal reference dose. The COPCs for which the oral reference dose was adjusted to reflect the absorbed dose are the metals: antimony, barium, cadmium, trivalent chromium, hexavalent chromium, manganese, mercury, silver, and vanadium.~~

~~If both conditions for adjustment are not met, the oral toxicity value was used as a surrogate for the dermal toxicity value in the BHHRA. Dermal toxicity factors are presented in Tables 4-1 and 4-2.~~

5.0 RISK CHARACTERIZATION

Risk characterization integrates the information from the exposure assessment and toxicity assessment, using a combination of qualitative and quantitative information~~. .~~ to provide numerical estimates of potential adverse health effects~~With this information, risk characterization estimates the potential health risk, based on the dose of a chemical, that a person may receive under certain site-specific exposure conditions and based on the toxicity of that chemical. ~~. Risk characterization is performed separately for carcinogenic and noncarcinogenic effects~~.~~ . Carcinogenic risk is expressed as the probability that an individual will develop cancer over a lifetime as a result of exposure to a potential carcinogen~~.~~ . Noncarcinogenic hazards are evaluated by comparing an estimated exposure level or dose with a reference dose that is without appreciable risk of adverse health effects.

~~3.0 Consistent with DEQ (DEQ 2000a) and EPA guidance (EPA 1989), noncarcinogenic and carcinogenic effects were evaluated separately. To characterize potential noncarcinogenic effects, comparisons were made between projected intakes of substances and toxicity values (Section 5.1.1). To characterize potential carcinogenic effects, projected intakes and chemical-specific, dose-response data were used to estimate the probability that an individual will develop cancer over a lifetime of exposure (Section 5.1.2).~~

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~~5.1~~5.1 RISK CHARACTERIZATION ~~ESTIMATES~~METHODOLOGY

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This section describes how noncancer hazards and cancer risks were estimated in this BHHRA~~. .~~

~~5.1.1~~5.1.1 Noncancer Hazard Estimates

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The potential for adverse noncancer health effects ~~resulting from exposure to chemicals with noncarcinogenic effects~~ is generally addressed by comparing the CDI ~~or absorbed dose for a specific COPC~~ to ~~its~~ the ~~RfD. This comparison was made by calculating the ratio of the estimated CDI (or absorbed dose) to the~~ corresponding RfD to yield a hazard quotient (HQ~~):~~; EPA 1989):

$$HQ = \frac{CDI}{RfD}$$

The calculation of a HQ~~s~~ assumes that exposures less than the RfD are unlikely to result in adverse health effects, even for sensitive populations~~. .~~ By definition, when the HQ is less than 1, the estimated exposure is less than the RfD and adverse health effects are unlikely~~. .~~ Unlike cancer risks, the HQ does not represent a statistical probability, and the likelihood of adverse effects does not increase ~~linearly~~in a linear fashion relative to a HQ of 1~~. .~~ Rather, exposures greater than the RfD may result in

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adverse health effects, but all RfDs do not have equal precision and are not based on the same severity of effects.—. HQs for individual chemicals were summed to yield a cumulative hazard ~~indices~~ index (HI~~s~~) ~~that provides an estimate of total hazard. .~~ ~~Per EPA guidance (1989), HQs should only be summed for chemicals with common toxicological endpoints. Toxicological endpoints for COPCs are summarized in Table 5-1. Endpoint-specific HIs (e.g., neurological or immune system effects) were calculated for each exposure area in this BHHRA where the cumulative HI was greater than 1. The Columbia River Fish Contaminant Study performed a similar analysis for fish tissue collected from the Columbia River Basin (EPA 2002c). Toxicity endpoints were retrieved from EPA's Integrated Risk Information System (EPA 2010b), and may differ from the endpoints used in CRITFC due to updates in the IRIS database since the CRITFC study.~~Although a HI provides an overall indication of the potential for noncancer hazards, dose additivity is most appropriately applied to chemicals that induce the same effect via the same mechanism of action.—. When the HI is greater than- 1 due the sum of several HQs of similar value, it is appropriate to segregate the chemical-specific HQs by effect and mechanism of action.—. In this BHHRA, when the calculated HI was greater than 1, HQs based on the same target organ system were calculated.—. The target organs or systems on which the RfDs are based are presented in Table 5-1.

~~4.0 Estimated HIs were compared to a target HI of 1, below which remedial action at a Superfund site is generally not warranted (EPA 1991a).~~

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~~5.11.2~~5.1.2 Cancer Risk Estimates

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The cancer slope factor converts the estimated daily intakes averaged over a lifetime directly to an incremental cancer risk.—. C~~Potential c~~ancer risks ~~were assessed~~are calculated by multiplying the estimated LADI ~~or absorbed dose~~ of a carcinogen by ~~its~~ the SF (EPA 1989):. ~~This calculated risk is expressed as the probability of an individual developing cancer over a lifetime as a result of exposure to the potential carcinogen, and is a health protective estimate of the incremental probability of excess individual lifetime cancer risk.~~

$$Risk = LADI \times SF$$

The dose-response relationship is generally assumed to be linear through the low-dose portion of the dose-response curve.—. That is, the risk of developing cancer is assumed to be directly associated with the amount of exposure.—. ~~Initially, potential cancer risks were estimated separately for each chemical. The separate potential cancer risk estimates were summed across chemicals for each exposure area to obtain the cumulative excess lifetime cancer risk for the exposure scenario.~~

However, this linear relationship is valid only when the estimated risk is less than 0.01 (1×10^{-2})~~0.01.—~~. Where contaminant concentrations result in an estimated risk greater than 1×10^{-2}, the following equation was used (EPA, 1989):

$Risk = 1\text{-}e^{-LADI \times SF}$ ~~Cancer risks were calculated using this same linear model, even though risk estimates for some scenarios exceed 1 x x 10^{-2}, in which case, EPA guidance (EPA 1989) states that risks should be calculated using an exponential model. Where cancer risks exceeded 1 x x 10^{-2}, the exponential model was used.~~

~~Estimated total cancer risks were compared to 1 x x 10^{-4}, 1 x x 10^{-5}, and 1 x x 10^{-6} cancer risk targets based upon the following language in EPA's National Contingency Plan (NCP): "For known or suspected carcinogens, acceptable exposure levels are generally concentration levels that represent an excess upper bound lifetime cancer risk to an individual of between 1 x x 10^{-4} and 1 x x 10^{-6}." The point of departure for cancer risks is 1 x x 10^{-6}.~~ Because the slope factor typically represents an upper confidence limit, carcinogenic risk estimates generally represent an upper-bound estimate, and EPA is confident that the true risk will not be greater than risk estimates obtained using this model, and they may be less than that predicted~~.~~. Cancer risk estimates for individual chemicals and different exposure pathways were summed where exposure was assumed to be concurrent to obtain the cumulative excess lifetime cancer risk for each receptor and/or exposure scenario~~.~~.

~~5.11.3 Combined Adult/Child Scenarios~~

~~5.0~~ ~~Cancer risks were calculated separately for adult and child receptors for the recreational beach user and fisher scenarios. To assess risks to individuals exposed as both a child and an adult, cancer risks were also calculated for a combined adult and child receptors for the recreational beach user and fisher scenarios. The combined adult and child receptor was based on EPA guidance (1991b, 2010a), in which 6 years of exposure is assumed to occur as a child and 24 years of exposure is assumed to occur as an adult for a total of 30 years for the non-tribal fisher scenario and the RME exposure duration for the beach user scenario. For the tribal fisher scenario, the combined adult and child scenario assumed 6 years of exposure as a child and 64 years of exposure as an adult. For the CT exposure duration for the beach user scenario, the combined adult and child scenario assumed 6 years of exposure as a child and 9 years of exposure as an adult.~~

~~For chemicals not acting by a mutagenic mode of action (i.e., all chemicals evaluated in this BHHRA other than carcinogenic PAHs), the cancer risks for the combined adult and child receptor were calculated by adding the cancer risks for the adult to the cancer risks for the child. For the non-tribal fisher and the RME beach sediment exposure scenarios, the adult cancer risk was multiplied by a factor of 24/30 to account for the 24 years of exposure as an adult in the combined scenario versus the 30 years used in the adult only scenario and then added to the child cancer risk. For the tribal fisher scenario, the adult cancer risk was multiplied by a factor of 64/70 to account for the 64 years of exposure as an adult in the combined scenario versus the 70 years used in the adult only scenario and then added to the child cancer risk.~~

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~~For chemicals acting by a mutagenic mode of action (i.e., carcinogenic PAHs), the cancer risks were calculated for the combined adult and child receptor by incorporating EPA's guidance (2005b) on early-life exposures to carcinogens. Specifically, age-dependent adjustment factors (ADAFs) were used to account for the increased carcinogenic potency during early life exposures. For ages 0 to 2 years, an ADAF of 10 was used. For ages 2 to 6 years and 6 to 16 years, an ADAF of 3 was used. For ages over 16 years, an ADAF of 1 was used. The ADAFs were incorporated into the risk calculations through the use of age-adjusted factors. The exposure factors used for the ages 0 to 2 and 2 to 6 years were the same as the child receptor and the exposure factors used for the ages 6 to 16 years and over 16 years were the same as the adult receptor.~~

~~6.0 The cancer risk estimates for the combined adult and child receptor are presented in the beach sediment and fish consumption risk characterization results below.~~

~~5.11.4~~5.1.3 Infant Consumption of Human Milk

As discussed in Section 3.3.7, infant exposure to persistent, lipophilic contaminants via breastfeed was quantitatively evaluated in the BHHRA~~.~~. Using the methodology presented in Section 3.5.5, DEQ determined that the magnitude of the difference in the risk and hazard estimates between the infant and the mother remain constant regardless of the maternal exposure pathway or dose, and can be expressed as~~For bioaccumulative chemicals, exposure to the mother can lead to the presence of those chemicals in human milk, which can pose a risk to breastfeeding infants. Per agreement with EPA and DEQ, risks to infants through the consumption of human milk were included for all receptors where PCBs, dioxins, and/or DDX were identified as COPCs. Risks were assessed in accordance with DEQ guidance (2010).~~

~~To assess risks to infants,~~ infant risk adjustment factors (IRAFs~~)~~, DEQ 2010) ~~were applied to the mother's risk~~ where:

$$Risk_{infant} = Risk_{mother} \times IRAF_{ca}$$

$$HQ_{infant} = HQ_{mother} \times IRAF_{nc}$$

where:

HQ_{infant} = hazard quotient for breast--fed infant
HI_{mother} = hazard quotient for the mother
$Risk_{infant}$ = cancer risks to breast--fed infant
$Risk_{mother}$ = cancer risks to the mother
$IRAF_{ca}$ = infant risk adjustment factor for carcinogenic effects
$IRAF_{nc}$ = infant risk adjustment factor for noncancer effects

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~~. For~~ Where combined child and adult exposures were evaluated~~cancer risks~~, the combined ~~adult~~ child/adult ~~and child~~ risks were used ~~for~~ as the ~~mother~~ maternal cancer risk for assessing risks to infants~~receptors where both adult and child exposures could occur.~~ . ~~C~~The chemical-specific IRAFs ~~used~~ are presented in the following table:

Chemical	$IRAF_{ca}$	$IRAF_{nc}$
PCBs	1	25
Dioxins/Furans	1	2
DDx	0.007	2
PBDEs	1	2

5.1.4 Risk Characterization for Lead

Health effects associated with exposure to inorganic lead and compounds are well documented and include neurotoxicity, developmental delays, hypertension, impaired hearing acuity, impaired hemoglobin synthesis, and male reproductive impairment. Importantly, many of lead's health effects may occur without other overt signs of toxicity. Lead has particularly significant effects in children, and it appears that some of these effects, particularly changes in the levels of certain blood enzymes and in aspects of children's neurobehavioral development, may occur at blood lead levels so low as to be essentially without a threshold. Because of the difficulty in accounting for pre-existing body burdens of lead and the apparent lack of threshold, EPA determined that it was inappropriate to develop a RfD. The Centers for Disease Control (CDC) has identified a blood lead concentration of 10 micrograms per deciliter (µg/dL) as the level of concern above which significant health effects may occur (CDC 1991), and the concentration of lead in the blood is used as an index of the total dose of lead regardless of the route of exposure (EPA 1994). An acceptable risk is generally defined as a less than 5 percent probability of exceeding a blood lead concentration of 10 µg/dL (EPA 1998).

Using the ALM (EPA 2003c), acceptable lead concentrations in fish tissue that are unlikely to result in fetal blood lead concentrations greater than 10 µg/dL were calculated using the following equation:

$$PbF = \frac{\left(\left[PbB_f / R \times GSD^{1.645}\right] - PbB_o\right) \times AT}{BKSF \times \left(IR_F \times AF_F \times EF_F\right)}$$

Where:

PbB_a = Central tendency of adult blood lead level
PbB_o = Adult baseline blood lead level
PbB_f = Fetal blood lead level
R = Fetal/maternal blood lead ratio

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GSD = Geometric standard deviation PbB
BKSF = Biokinetic slope factor
PbF = Lead fish tissue concentration
IR_F = Consumption rate of fish
AF_F = Gastrointestinal absorption of lead from fish
EF_F = Exposure frequency for fish consumption
AT = Averaging time

The values used in this analysis are presented in Attachment F5. Because the lead models calculate a central tendency or geometric mean blood lead concentration, median values are typically used as inputs.~~–~~. The mean estimate of national per capita fish consumption of 7.5 g/day (EPA 2000b) was used as the consumption rate for recreational fishers, the median consumption rate of 39.2 g/day from the CRITFC study was used for tribal fishers. Using the equation presented above, the target lead concentrations in fish are 5.2 mg/kg for recreational fishers and 1 mg/kg for tribal fishers.

EPA's Integrated Exposure Uptake Biokinetic (IEUBK) model was used to calculate tissue lead concentrations unlikely to result in blood lead concentrations greater than 10 µg/dL in children. Because site-specific values for concentration of lead in soil, house dust, air and drinking water were not readily available, default values were used for those inputs. The ratio of child-to-adult consumption of 0.42 was applied to the median adult consumption rate of 7.5 g/day to obtain a childhood rate of 3.2 g/day for children of recreational fishers The corresponding lead concentrations in fish is 2.6 mg/kg.~~–~~. Assuming a consumption rate of 16.2 g/day for tribal children, representing the 65th percentile consumption rate from the CRITFC survey, the calculated lead concentration in fish is 0.5 mg/kg. Uncertainties associated with the evaluation of lead are discussed further in Section 6.~~–~~. ~~A great o a predicted probability of no more than 5 percent greater than the 10 µg/dl level (EPA 1998).~~

~~For receptors where only adult exposure was evaluated, the adult cancer risk was used for the mother cancer risk. For noncancer hazards, the adult hazard quotient was used for the mother hazard quotient.~~When assessing cancer risks, an

~~The IRAFs used to assess risks were from DEQ guidance (2010). Specifically, IRAFs of 1 were~~ was used for PCB, PCB TEQ, and dioxin TEQ, ~~cancer risks. An IRAF of 0.007 was used for DDX~~ DDx~~cancer risks. IRAFs of 2 were used for PCB TEQ, dioxin TEQ, and DDX~~ DDx ~~noncancer hazards. An IRAF of 25 was used for PCB noncancer hazards.~~

~~7.0 The risks to infants through consumption of human milk are presented in the risk characterization results below.~~

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~~5.11.5~~5.1.5 Cumulative Risk Estimates for Contaminants Analyzed by More Than One Method

~~Noncancer HQs and cancer risks were calculated for all individual contaminants for which EPCs were available, as described above.~~ In some ~~cases~~instance~~,~~ s specific contaminants were analyzed by ~~different~~ more than one method~~s~~, ~~so~~ and thus more than one ~~there were multiple~~ EPC~~s~~ calculated for that contaminant~~.~~. C~~In calculating the c~~umulative risks ~~, only the risk associated with the EPC~~are presented using the EPC from only one method ~~for one method was included in the sum~~ to avoid double-counting the risks from a given contaminant~~.~~.

When assessing risks associated with sediment exposures, ~~For example, total PCBs were analyzed both as congeners and as Aroclors. In sediment, the~~ Aroclor data was used because the data set was larger than for congeners. ~~, so the risk from total PCBs as Aroclors was included in the cumulative risk estimate for sediment. For~~However ~~tissue~~, because the congener analysis ~~provides~~ provided ~~better~~ lower detection limits, it was preferentially used when available for assessing risks associated with consumption of fish and shellfish. ~~. Therefore, the risk from total PCBs as congeners was included in the cumulative risk estimate for tissue, if congener data were available. If no congener data were not available for tissue, the risk from total PCBs as Aroclors was used in when estimating the cumulative risk for tissue~~from ~~consumption of fish.~~.

Where ~~metals~~metals were analyzed as both total and dissolved fractions ~~In~~ in surface water and ~~most of the~~ groundwater seep samples, the EPCs ~~for~~based on total metals were used in the cumulative risk estimates ~~as a conservative approach, b metals were analyzed as both total and dissolved. Because total concentrations are were typically higher~~greater than the results for dissolved concentrations~~s~~because unfiltered data is generally more representative of typical human exposure~~, the EPCs for total metals were included in the cumulative risk estimates as a conservative approach~~.

~~8.0 The individual risks from the EPCs for all of the analytical methods are presented in the risk characterization result tables (Tables 5-2 through 5-98). The tables also indicate which results were included in the cumulative risks when multiple EPCs were available for a given chemical.~~

~~5.12~~5.2 RISK CHARACTERIZATION RESULTS

This section presents ~~the results~~a summary of the risk characterization results ~~for each of~~ the scenarios described in Section 3~~.~~. ~~Consistent with~~ EPA policy (EPA 1991a)~~,~~ states that CERCLA actions are generally warranted when where the baseline risk assessment indicates that a cumulative site risk to an individual using RME assumptions for either current or future land use is greater than the 1 x 10^{-4} lifetime excess cancer risk end of the cancer risk range of 1 x 10^{-4} to 1 x x 10^{-6}, or the HI is greater than 1. Accordingly, risk and hazard estimates are generally presented in terms of whether they are greater than the upper end of the cancer risk range of

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1 x 10^{-4} or the HI is greater than 1. Uncertainties associated with the assumptions in each exposure scenario are discussed in detail in Section 6.. Risks from exposures to PBDEs in in-water sediment and tissue were assessed separately, and are presented in Attachment F3. If actual exposures for each scenario were less than the exposures assumed in the risk calculations, the estimated risks would also decrease correspondingly.

5.2.1 Dockside Workers

Risks forto dockside workers were estimated separately for each of the eight beaches designated as a potential dockside worker use areas, which are shown in Map 2-1. The results of the risk evaluation for dockside worker exposure to beach sediment are presented in Tables 5-2 through 5-3.

The dockside worker RME scenario for beach sediment results in exceedances of aThe estimated CT and RME cancer risks are less than is cumulative cancer risk level of 1 x 10^{-6} at beaches 91 x 10^{-45} at beach 06B025 (9 x 10^{-5} riskadjacent to NW Natural at approximately RM 6.5W), and 2 x 10^{-6} andat beach B004 (2 x 10^{-6} riskadjacent to Oregon Steel Mills at RM 2E). The primary contributors to the estimated cancer risksePAHs in beach sediment, including In addition to benzo(a)pyrene, other chemicals contributing to a calculated individual cancer risk greater than 1 x 10^{-6} for at least one exposure area include: benzo(a)anthracene, benzo(b)flouranthene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene are the primary contributors to the estimated risks.. The estimated RME cancer risk was less than 1 x 10^{-6} at all other locationsbeach areas. There are no exposure areas that result in an exceedance of 1 x 10^{-4} cancer risk for the dockside worker RME scenario. The maximum cumulative cancer risk for an individual exposure area occurs at 06B025 and is primarily due to incidental ingestion of beach sediment containing benzo(a)pyrene. In addition to benzo(a)pyrene, other chemicals contributing to a calculated individual cancer risk greater than 1 x 10^{-6} for at least one exposure area include: benzo(a)anthracene, benzo(b)flouranthene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene. The, and the HIs for the dockside worker RME scenario do not exceedis less than 1 for adults and breastfed infants for all beaches evaluated. .

The dockside workerestimated cancer risk for CT exposures iis less thans 61 x 10^{-64} scenario at beach 06B025. cPAHs in beach sediment are the primary contributors to the estimated risk. for beach sediment results in one exceedance of 1 x 10^{-6} cumulative cancer risk (at beach 06B025, 6 x 10^{-6} risk), which is primarily due to the incidental ingestion of sediment containing benzo(a)pyrene. There are no exposure areas that result in an exceedance of 1 x 10^{-4} cancer risk for the dockside worker CT beach sediment scenario. The dockside worker CT scenario results in no exceedances of aThe HI ofwas less than 1at all beaches, and the HI is less than 1 .. Figures 5-1 shows risks to the dockside worker from exposure to beach sediment per beach, and shows the relative contribution of individual chemicals to total risk.

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5.2.2 In-Water Workers

~~—~~As discussed in Section 3.2.1.2, in-water workers are described as typically working around in-water structures such as docks, and primarily exposed to in-water sediments~~.~~. In-water sediment exposure by in-water workers was evaluated in half-mile increments along each side of the river. ~~The results of the risk evaluation for in-water worker exposure to in-water sediment are presented in Tables 5-21 through 5-22.~~

~~The in-water worker RME scenario for in-water sediment results in cumulative cancer risk greater than~~The estimated CT and RME cancer risks ~~was~~are ~~greater~~less than 1 x 10^{-46} at ~~three~~all ~~RM~~-RM segments, ~~-4.5E, 6W, and 7W. The estimated cancer risk at 2 x 10^{-6} at RM 4.5E and 9 x 10^{-6} is at RM 6W 2 x 10^{-6}, and cPAHs in river sediment are the primary contributors the risk estimate. The estimated RME cancer risk is 2 x 10^{-5} at RM 7W, where dioxins and furans in river sediment are the primary contributors to the estimated risks. There are no exceedances of 1 x 10^{-4} cancer risk for the in-water worker RME scenario. The maximum cumulative cancer risk for an individual exposure area occurs at RM 7W (2 x 10^{-5}) and is primarily due to incidental ingestion of sediment containing dioxins/furans. The only other individual contaminant resulting in a cancer risk greater than 1 x 10^{-6} within the Study Area is benzo(a)pyrene. T~~and the RME HIs for ~~in-water~~ adults ~~worker RME scenario do not exceed~~are less than 1 at any location.~~, t~~The HI for infants is 2 at ~~RM~~ RM 7W, and dioxin and furans are the primary contributors to the estimate.~~.~~

~~The in-water worker RME scenarios do not result in an exceedance of 1 x 10^{-6} cumulative cancer risk or an HI greater than 1 for exposure to in-water sediment from river segments assessed outside of the Study Area.~~

~~The in-water worker~~ The estimated cancer risks for the CT scenario for in-water sediment results in no exceedances of are less than 1 x 10^{-46} cancer risk and no exceedances of an at all locations, and the HI of~~is~~ less than 1. These results ~~of the risk evaluation for in-water workers and their children exposure to in-water sediment~~ are presented in Tables 5-21~~-~~, ~~and~~ 5-22, 5-34 and 5-35.~~.~~

5.2.3 Transients

Risks ~~for~~to transients were estimated separately for each beach designated as a potential transient use area, as well as the use of surface water as a source of drinking water and for bathing~~.~~. Beaches where sediment exposure was evaluated are shown ~~i~~on Map- 2-~~-~~1. Year-round exposure to surface water for four individual transect stations, Willamette Cove, Multnomah Channel, and for the four transects grouped together to represent Study Area-wide exposure are shown on Map 2-3. The CT and ~~The transient~~ RME ~~scenario~~risk~~s~~ estimates for beach sediment ~~results in no exceedances of~~was are less than 1 x 10^{-64} ~~cancer risk and no exceedances of a~~for all locations, and the HI is ~~of~~less than 1. The ~~transient CT scenario for beach sediment results in no exceedances of 1 x 10^{-6} cancer risk and no exceedances of a HI of 1. The~~

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~~results of the risk evaluation for transient exposure to beach sediment~~results of the RME and CT evaluations for exposure to beach sediments are ~~are~~ presented in Tables 5-4 ~~through~~and 5-5, respectively.

Estimated CT and RME cancer risks associated with surface water exposures are less than 1 x 10^{-64} at all individual and transect locations, and the HI is less than 1. The results of the RME and CT evaluations are ~~Risks to transients from surface water were evaluated for drinking water and bathing scenarios. The risks were evaluated for year-round exposure to surface water for four individual transect stations, for the four transects grouped together (to represent Study Area-wide exposure), and for Willamette Cove. In addition to these exposure areas within the Study Area, risk was evaluated for exposure to surface water for a transect in Multnomah Channel, which is outside of the Study Area. The results of the risk evaluation for transient exposure to surface water are~~ presented in Tables 5-46 ~~through~~and 5-47, respectively. ~~With the exception of the surface water sample collected from Willamette Cove, data used to evaluate exposure to beach sediments and surface water exposures are not co-located. The cumulative risk associated with concurrent exposure to beach sediments and surface water at Willamette Cove is approximatelyis less than 1 x 10^{-46}.~~

~~The transient RME and CT scenarios for surface water result in no exceedances of 1 x 10^{-6} cancer risk and no exceedances of an HI of 1 inside or outside of the Study Area.~~

~~Risks to transients from the~~As noted in Section 3.3.4, exposure to surface water by transients was also evaluated at the groundwater seep at Outfall 22B~~.~~. All risk and hazard estimates ~~were~~are less than 1 x 10^{-64} and 1, respectively, and t~~evaluated for direct contact scenarios. There were multiple uncertainties associated with the exposure parameters for the direct exposure to groundwater seeps scenario. To evaluate the risks from exposure to the groundwater seep without stormwater influence, outfall data from stormwater sampling events was excluded from the dataset. T~~he results ~~of the risk evaluation for transient exposure to the groundwater seep~~ are presented in Tables- 5-64 ~~through~~and 5-65.

5.2.4 Divers

C~~Risks were evaluated for c~~ommercial divers were evaluated for exposure to surface water and in-water sediment, and assuming the diver was wearing either a wet ~~suit~~ or a dry suit~~.~~. ~~a~~As described in Section 3.4.2, in-water sediment exposure by divers is evaluated in half-mile exposure areas for each side of the river, and on a Study Area wide basis. Risks associated with exposure to surface water were evaluated for four individual transect stations, and at single-point sampling stations grouped together in one-half mile increments per side of river~~. The results of the risk evaluation for commercial wet suit diver exposure to in-water sediment are presented in Tables 5-31 through 5-32. The results of the risk evaluation for a commercial dry suit diver exposure to in-water sediment are presented in Table 5-33.~~

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5.2.4.1 Diver in Wet Suit

The ~~commercial diver in a wet suit~~estimated CT and RME ~~and CT~~ cancer risk associated with exposure to in-water sediments is less than ~~scenario for in-water sediment results in exceedances of~~ 1 x 10^{-64} ~~cumulative cancer risk in~~at ~~10~~all ~~of 40~~ ~~½~~half-~~-~~mile river ~~mile~~ segments ~~within the Study Area~~ and for Study Area-wide exposure, and the HI is also less than 1 for adults. The HI for infants is 2 at ~~RM~~ RM 8.5W for the RME evaluation, and PCBs are the primary contributor to the hazard estimate. The ~~results of the~~ RME and CT estimates for adults are presented in Tables 5-31 and 5-32, respectively~~.—~~. RME and CT risk and hazard estimates for infant exposures are presented in Tables 5-42 and 5-43, respectively.

The estimated CT and RME ~~and CT~~ cancer risk associated with exposure to surface water is less than 1 x 10^{-4} for all half-mile river segments, and the HI is less than 1~~.—~~. ~~Infant exposure to contaminants in surface water via breastfeeding was not evaluated.~~ These results are presented in Tables 5-54 and 5-55, respectively, for the RME and CT evaluations. Indirect exposure to contaminants in surface water by infants via breastfeeding was not evaluated~~.—~~. ~~(see Table 5-31). There are no exceedances of 1 x 10^{-4} cancer risk for this scenario. The maximum cumulative cancer risk (3 x 10^{-5}) occurs at RM 6W and RM 7W. At RM 6W, the risk is primarily due to dermal adsorption of sediment containing benzo(a)pyrene. At RM 7W, the risk is primarily due to dermal absorption of sediment containing dioxins and furans. In addition to these two chemicals, the following individual analytes also result in a cancer risk greater than 1 x 10^{-6} in at least one exposure area: PCBs, benzo(b)fluoranthene, dibenzo(a,h)anthracene, benzo(a)anthracene, and indeno(1,2,3-cd)pyrene. The commercial diver in a wet suit RME scenario for in-water sediment results in no HIs greater than 1.~~

~~There are no exposure areas outside of the Study Area that result in risks above 1 x 10^{-6} or HIs greater than 1 for this scenario.~~

~~The commercial diver in a wet suit CT scenario for in-water sediment results in no exceedances of 1 x 10^{-6} cumulative cancer risk and no exceedances of an HI of 1 for exposure areas assessed inside and outside of the Study Area (see Table 5-32).~~

5.2.4.2 Diver in Dry Suit

The estimated RME cancer risk is less than 1 x 10^{-4} at all half-mile river segments and for Study Area-wide exposure, and the HI is also less than 1 for adults and infants~~.—~~. The results of the adult RME risk and hazard estimates are presented in Table 5-33, ~~The commercial diver in a dry suit RME scenario for in-water sediment results in exceedances of 1 x 10^{-6} cumulative cancer risk in two of 40 river mile segments within the Study Area (see Table 5-33). The maximum cumulative cancer risks occur at RM 7W (1 x 10^{-5}) and RM 6W (6 x 10^{-6}). At RM 7W, risk is primarily due to incidental ingestion of sediment containing dioxins/furans. At RM 6W, risk is~~

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primarily due to dermal contact with sediment containing benzo(a)pyrene. No other analytes result in a cancer risk greater than 1 x 10^{-6} for this scenario. The commercial diver in a dry suit RME scenario for in-water sediment results in no HIs greater than 1. There are no river mile segments outside of the Study Area that result in risk above 1 x 10^{-6} or an HI greater than 1. Aa CT scenarioevaluation was not evaluateddone for a commercial diver in a dry suit, per direction from EPA.

The estimated RME cancer and CT cancer risk associated with exposure to surface water is less than 1 x 10^{-4} for all half-mile river segments, and the HI is less than 1.—. Infant exposure to contaminants in surface water via breastfeeding was not evaluated. These results are presented in Tables 5-56. Indirect exposure to contaminants in surface water by infants via breastfeeding was not evaluated.—. Risks to commercial divers from surface water were evaluated for year-round exposure to four individual transect stations, and to single-point sampling stations within the Study Area grouped together on a ½ river mile basis, per side of river (E, W). In addition to these exposure areas within the Study Area, risk was evaluated for exposure to surface water for a transect in Multnomah Channel, which is outside of the Study Area. Risks were evaluated for commercial divers in wet suits and in dry suits. The results of the risk evaluation for commercial divers in wet suits exposure to surface water are presented in Tables 5-54 through 5-55. The results of the risk evaluation for commercial divers in dry suits are presented in Table 5-56.

Diver in Wet Suit

The commercial diver in a wet suit RME scenario for surface water results in exceedances of 1 x 10^{-6} cumulative cancer risk in one exposure area (RM 6W). There are no exceedances of 1 x 10^{-4} cancer risk for the commercial diver in a wet suit RME scenario. The maximum cumulative cancer risk occurs at RM 6W (1 x 10^{-5}) and is primarily due to dermal contact with surface water containing benzo(a)pyrene. There are no other analytes resulting in a cancer risk greater than 1 x 10^{-6}. The commercial diver in a wet suit RME scenario for surface water resulted in no HIs greater than 1. There are no exceedances of 1 x 10^{-6} risk or an HI of 1 for surface water exposure to river segments assessed outside of the Study Area.

The commercial diver in a wet suit CT scenario for surface water results in no exceedances of 1 x 10^{-6} cumulative cancer risk and no exceedances of an HI of 1 for exposure inside or outside of the Study Area.

Diver in Dry Suit

The commercial diver in a dry suit RME scenario for surface water results in exceedances of 1 x 10^{-6} cumulative cancer risk in one exposure area (RM 6W). This exposure area is the location of the maximum cumulative cancer risk (2 x 10^{-6}) and is primarily due to dermal contact with surface water containing benzo(a)pyrene. There are no individual analytes resulting in a cancer risk greater than 1 x 10^{-6}. The

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~~commercial diver in a dry suit RME scenario for surface water resulted in no HIs greater than 1. There are no exceedances of 1 x 10^{-6} risk or an HI of 1 for surface water exposure to river segments assessed outside of the Study Area.~~

~~The commercial diver in a dry suit was not evaluated for CT exposure, as directed by EPA.~~

5.2.5 Recreational Beach Users

~~**Recreational Beach Users**~~

Risks ~~for~~associated with exposure to beach sediment were evaluated ~~the recreational beach users were estimated~~ separately for each beach designated as a potential recreational use area, ~~which are~~ shown ~~in~~on Map ~~2-~~1. Exposure to surface water was evaluated ~~at~~using data collected from three transect locations and three single-point locations (Cathedral Park, Willamette Cove, and Swan Island Lagoon) shown on Map 2-3.

The estimated CT and RME ~~and CT~~ cancer risks associated with exposure to beach sediments ~~is~~are less than 1 x 10^{-4} at all recreational beach areas, and the HI is also less than 1. ~~Cancer risks and noncancer hazards were evaluated for both children (ages 0-6 years) and adults (ages 7-30 years) and child recreational beach users. In addition, as described in carcinogenic risks were calculated for a combined child and adult for a combined 30-year scenario.~~ These results ~~of the risk evaluation for recreational beach user exposure to beach sediment~~ are presented in Tables ~~5-~~6 through 5~~-~~11. Indirect exposure to contaminants in beach sediment to infants via breastfeeding was not evaluated~~.~~.

~~**Adult Recreational Beach Users**~~

~~The adult recreational beach user RME scenario for beach sediment results in cumulative cancer risk exceedances of 1 x 10^{-6} at the following beaches: 04B024 (risk is 3 x 10^{-6}), 06B030 (risk is 4 x 10^{-6}), B003 (risk is 3 x 10^{-6}), and B005 (risk is 2 x 10^{-6}). There are no exceedances of 1 x 10^{-4} cancer risk for the adult recreational beach user RME scenario. The maximum cumulative cancer risk from RME occurs at Beach 06B030 and is primarily due to incidental ingestion of beach sediment containing arsenic. The adult recreational beach user RME scenario for beach sediment resulted in no HIs greater than 1. Figures 5-2 and 5-3 show the relative risk contribution of individual COPCs for each beach, as well as total risk by river mile for adult recreational beach user exposure to beach sediment.~~

~~Arsenic is a naturally occurring metal. The concentration for arsenic in soil recognized by DEQ to represent background levels in Oregon is 7 milligrams per kilogram (mg/kg) (DEQ 2007). At this background concentration, the calculated risk from arsenic would exceed 1 x 10^{-6} for the adult recreational beach user RME scenario. When a background concentration of 7 mg/kg is subtracted from detected concentrations of arsenic in beach sediment, resulting cumulative risks for the adult recreational beach user RME scenario exceed 10^{-6} at beaches 04B024 and B003. Beaches with risk exceedances of 1 x 10^{-6}~~

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excluding risks from background arsenic are shown for all exposure scenarios for beach sediment in Maps 5-2-1 and 5-2-2. In addition to risks from exposure to arsenic in beach sediment, risks from exposure to total cPAHs in beach sediment exceed 1 x 10^{-6} at two beach locations: 04B024 (2 x 10^{-6}) and B003 (2 x 10^{-6}). At each of these beaches, benzo(a)pyrene is the cPAH with the highest contribution to total risks from cPAHs.

The adult recreational beach user CT scenario for beach sediment results in no exceedances of 1 x 10^{-6} cumulative cancer risk and no exceedances of an HI of 1.

Child Recreational Beach Users

The child recreational beach user RME scenario for beach sediment results in cumulative risk exceedances of 1 x 10^{-6} at all 15 of the exposure areas. There are no exceedances of 1 x 10^{-4} cancer risk for the child recreational beach user RME scenario. The maximum cumulative cancer risk from RME occurs at beaches B003, and 04B024 (4 x 10^{-5}) and is primarily due to dermal absorption of soil containing arsenic and benzo(a)pyrene. The child recreational beach user RME scenario resulted in no HIs greater than 1.

The cumulative risk exceedances are due in part to arsenic, which is naturally occurring. At the DEQ background soil concentration of 7 mg/kg, the calculated risk from arsenic would exceed 1 x 10^{-6} for the child recreational beach user RME scenario. When a background arsenic concentration of 7 mg/kg is subtracted from detected arsenic concentrations in beach sediment from potential human use areas, resulting cumulative risks for the child recreational beach user RME scenario exceed 1 x 10^{-6} at five beaches, as shown in Map 5-2-1. These exceedances are due to exposure to arsenic at one beach, and exposure to benzo(a) pyrene or total cPAHs at the other four. Cancer risks above 1 x 10^{-6} from exposures to cPAHs in beach sediment range from 2 x 10^{-8} to 4 x 10^{-5}, due primarily to contributions from benzo(a)pyrene. Figures 5-4 and 5-5 show the relative risk contribution of individual COPCs forat each beach, as well as total risk by river mile for child recreational beach user exposure to beach sediment.

The child recreational beach user CT scenario for beach sediment results in an exceedance of 1 x 10^{-6} cumulative cancer risk at two beaches (risk of 2 x 10^{-6} at 04B024 and B003). There are no exceedances of an HI of 1.

Combined Child/Adult Recreational Beach Users

Cancer risks were calculated for the combined child and adult recreational beach users to incorporate early life exposures in accordance with EPA (2005b) and DEQ (2010) guidance. Cumulative risks per exposure area for RME scenarios ranged from 2 x 10^{-6} to 5 x 10^{-5}. For the CT scenarios, risks ranged from 2 x 10^{-7} to 2 x 10^{-6}. The highest risk was at Beach 04B024, primarily due to exposures to benzo(a)pyrene in beach sediment.

Risks to recreational beach users fromassociated with exposure to surface water were evaluated for swimming scenarios, using data from summer monthsassociated with

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recreational activities . Risks were evaluated for exposure to surface water forusing data from the three transects grouped together (to represent Study Area-wide exposure) and for exposure to surface water for three individual quiescent areas during summer months. Risks for both adults and children were evaluated, as well as cancer risks to a combined child and adult receptor, in order to incorporate early life exposures. The results of the risk evaluation for exposure to surface water by adult recreational beach user exposure to surface water are presented in Tables 5-48 through 5-4953. The estimated CT and RME and CT cancer risks associated with exposure to surface water are less than 1 x 10^{-4} at all recreational beach areas, and the HI is also less thanThe results of the risk evaluation for child recreational beach user exposure to surface water are presented 1. These results are presented in Tables 5-50 through 5-51. The results of the combined child and adult receptor are presented in Tables 5-52 through 5-53.

The adult, child, and combined recreational beach user RME and CT scenarios for surface water result in no exceedances of 1 x 10^{-6} cancer risk and no exceedances of an HI of 1.

5.2.6 Recreational/Subsistence Fishers

Recreational and subsistence fishers were evaluated forassuming exposures associated with direct exposure to contaminants in sediment and via consumption of fish and shellfish. As discussed in Section 3.2.1.6, Risksexposures associated with beach sediment exposures were assessed at individual beaches designated as potential transient or recreational use areas, risks associated with in-water sediment exposures were evaluated on a one-half river mile basis per side of the river and as an averaged, Study Area-wide evaluation. Sediment exposures were further assessed as CT and RME evaluations byand based on the fishing frequency as assuming either a low-frequency (RME and CT) or a high-frequency rate of fishingy (CT and RME). Unlike other exposures, such as contact with contaminants in soil, The results of the risk evaluation for high-frequency fisher exposure to beach sediment are presented in Tables 5-14 through 5-15

5.2.6.1 Beach Sediment-Direct Contact

The estimated CT and RME cancer risks associated with low-frequency fishing exposures to either beach or in-water sediments are less than 1 x 10^{-4} at all areas evaluated. Noncancer hazards associated with combined child and adult exposures are less than 1 at all locations evaluated, the noncancer hazard associated with indirect exposures to infants via breastfeeding is greater than 1 at two locations: RM RM 7W (2), where dioxin/furan TEQ concentrations are the primary contributor, and RM RM 8.5W (2), where PCBs are the primary contributor, with a HQ of 1. Cancer risks and noncancer hazards associated with exposure to beach sediments These results are

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presented in Tables 5-16 and 5-17 for beach sediment exposures, and Tables 5-29 and 5-30 for in-water sediment exposures.~~.~~

The estimated CT and RME cancer risks associated with high-frequency fishing exposures to either beach or in-water sediments are less than 1 x 10^{-4} at all areas evaluated. Noncancer hazards associated with ~~combined child and~~ adult exposures ~~is~~are greater than 1 at ~~RM~~ RM 7W (2), with dioxin/furan TEQ concentrations as the primary contributor the noncancer hazard. ~~-~~The noncancer hazard associated with indirect exposures to infants via breastfeeding is also greater than 1 at ~~RM~~ RM 7W (3), where dioxin/furan TEQ concentrations are the primary contributor, and ~~RM~~ RM 8.5W (2), where PCBs are the primary contributor with a HQ of 2. These results ~~of the risk evaluation for high-frequency fisher exposure to beach sediment~~ are presented in Tables 5-14 ~~through~~and 5-15 for beach sediment exposures, and Tables 5-26 through 5-28 for in-water sediment exposures.

5.2.6.2 Consumption of Smallmouth Bass

Consumption of both whole body and fillet-only smallmouth bass was evaluated on a river mile basis to account for their relatively small home range. An additional analysis averaging consumption over the entire Study Area was also conducted. The estimated CT and RME ~~RME~~ cancer risks associated with combined child and adult consumption of whole body smallmouth bass ~~consumption associated with~~are greater than 1 x 10^{-4} ~~at~~for all ~~areas~~river miles evaluated, and ~~.~~ RME cancer risk estimates are greater than 1 x 10^{-3} for each river mile except ~~RM~~ RM 5, where the estimated risk is 9 x 10^{-4} for the recreational fisher. CT cancer risk estimates are greater than 1 x 10^{-3} at RM 7, RM 11, and at Swan Island Lagoon. Study Area-wide RME risks for recreational and subsistence fishers are 7 x 10^{-3} and 4 x 10^{-3}, the CT estimate for recreational fishers is 9 x 10^{-4}. Values for river miles having the highest estimated RME risks are as follows (for recreational and subsistence fishers, respectively): RM 7 (5 x 10^{-3} and 1 x 10^{-2}), Swan Island Lagoon (5 x 10^{-3} and 1 x 10^{-2}), and RM- 11 (8 x 10^{-3} and 2 x 10^{-2}). Dioxins/furans, PCBs and DDx are the primary contributors to the overall risk at RM 7; PCBs, and to a lesser degree dioxins/furans, are the primary contributors in Swan Island Lagoon and at RM 11.

RME risk estimates for fillet-only consumption ~~range upwards from 9 x 10^{-5} and~~are all greater than ~~2~~1 x 10^{-4}, the CT estimate is greater than 1 x 10^{-4} at RM 7 and RM 11 ~~respectively, at RM 5~~. Study Area-wide RME risks for recreational and subsistence fishers are 2 x 10^{-3} and 9 x 10^{-4}, the CT estimate for recreational fishers is 2 x 10^{-4}. River miles having the highest estimated risks are (for recreational and subsistence fishers, respectively): RM- 7 (8 x 10^{-4} and 2 x 10^{-3}) and RM- 11 (1 x 10^{-3} and 3 x 10^{-3}), fillet-only data ~~are not available~~were not collected ~~for~~in Swan Island Lagoon. ~~Study Area-wide RME risks for recreational and subsistence fishers are 3 x 10^{-3} and 6 x 10^{-3}.~~ Dioxins/furans and PCBs are the primary contributors to the overall risk as ~~RM~~ RM 7, PCBs, and to a lesser degree dioxins/furans, are the primary contributors in Swan Island Lagoon and at RM- 11. These results are presented in Table 5-114.

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RME ~~for . n~~Noncancer hazards associated with childhood ~~combined child and adult~~ consumption of whole body smallmouth bass are greater than ~~50~~1 ~~and 100 at RM 5, respectively, for recreational and subsistence fishing~~ at all river miles evaluated. A~~The pattern of a~~reas with the ~~greatest~~highest estimated hazard displays a pattern similar to those with highest cancer risks. -Values for river miles having the highest estimated hazard are as follows (for recreational and subsistence fishers, respectively): RM- ~~2~~7 (300 and 600), Swan Island Lagoon (500 and 1,000), and RM 11 (700 and 1,000). The highest values for the CT noncancer hazard estimates for recreational fishers are 70 (RM 7), 200 (RM 11), and 100 (Swan Island Lagoon). Study Area-wide RME hazards for recreational and subsistence fishers are 200 and 500, respectively, the CT estimate for recreational fishers is 60. Dioxins/furans and PCBs are the primary contributors at RM 7, while PCBs are predominantly the contributor in Swan Island Lagoon and at RM 11.

-RME hazard estimates for fillet-only consumption are also greater than 1 at all river miles. ~~The lowest hazard estimate is 9, at RM 5.~~ Values for river miles having the highest estimated RME hazard for fillet-only consumption are as follows (for recreational and subsistence fishers, respectively): ~~RM 4 (30 and 60),~~ RM- 7 (50 and 90), and RM- 11 (100 and 300); fillet-only data were not collected in Swan Island Lagoon. Study Area-wide RME hazards for recreational and subsistence fishers are 70 and 100, respectively, the CT estimate for recreational fishers is 20. PCBs and dioxin/furans are the primary contributors to the hazard estimates at RM 7 while PCBs are the primary contributor to the hazard estimate at RM 11. ~~PCBs and dioxin/furans are the primary contributors to the hazard estimates.~~ These results are presented in Table 5-94.

~~N~~RME and CT noncancer hazard associated with indirect exposure to infants via breastfeeding was also assessed. Values for river miles having the highest estimated RME hazard due to consumption of whole body smallmouth bass are as follows (for infant children of recreational and subsistence fishers, respectively): ~~RM 2 (400 and 2,000),~~ RM- 7 (~~6~~3,000 and ~~3~~5,000), Swan Island Lagoon (~~1,000 and~~ 6,000 and 10,000), and RM- 11 (~~2,000 and~~ 8,000 and 20,000). The associated CT estimates for recreation fishers are 600 at RM 7, 1,000 at Swan Island Lagoon, and 2,000 at RM 11. The ~~comparable~~ RME hazard estimates associated with fillet-only consumption are: ~~RM 4 300 and 600),~~ RM- 7 (300 and 600), and RM- 11 (2,000 and 4,000), fillet-only data were not collected in Swan Island Lagoon. The comparable CT estimates for recreational fishers are 70 at RM 7, and 500 at RM 11. PCBs are the primary contributors to the estimated noncancer hazard estimates. These results are presented in Table 5-119.~~exposures are less than 1 at all locations evaluated, the noncancer hazard associated with indirect exposures to infants via breastfeeding is greater than 1 at two locations: RM 7W (2), where dioxin/furan TEQ concentrations are the primary contributor, and RM 8.5W (2), where PCBs are the primary contributor, with a HQ of 1. Cancer risks and noncancer hazards associated with exposure to beach sediments are presented in Tables 5-16 and 5-17~~

5.2.6.3 Consumption of Common Carp

The estimated ~~CT and~~ RME cancer risks associated with combined child and adult consumption of whole body ~~smallmouth bass~~common carp are greater than 1 x 10^{-4} ~~for all river miles at~~in each fishing zone evaluated, and RME cancer risk estimates are greater than 1 x 10^{-3}~~4~~. ~~for each river mile except RM 5, where the estimated risk is 9 x 10^{-4} for the recreational fisher.~~ Values for ~~river miles~~fishing zones having the highest estimated risks are as follows (RME estimates for recreational and subsistence fishers, respectively): ~~RM~~FZ- ~~7~~3-6 (~~5~~1 x 10^{-3}~~2~~ and ~~1~~2 x 10^{-2}), ~~Swan Island Lagoon~~FZ- 4-8 (~~5~~3 x 10^{-3}~~2~~ and ~~1~~7 x 10^{-2}, and ~~RM~~FZ 8-12 ~~11~~ (~~8~~2 x 10^{-3} and 5 x 10^{-3}). The ~~associated~~ Study Area-wide risk estimates are 4 x 10^{-2} and 2 x 10^{-2}. CT estimates for recreational fishers are greater than 1 x 10^{-4} ~~at~~in all fishing zones, and is 5 x 10^{-3} when evaluated Study Area-wide. PCBs, dioxins/furans, and DDx are the primary contributors in FZ 4-8 and PCBs are the primary contributors in FZ 3-6 (dioxins/furans were not analyzed in this FZ).

The ~~comparable~~RME risk estimates for fillet-only consumption (for recreational and subsistence fishers, respectively) are:~~are~~ FZ- 3-6 (1 x 10^{-3} and 2 x 10^{-3}), FZ- 4-8 (2 x 10^{-2} and 4 x 10^{-2}, and FZ 8-12 (1 x 10^{-3} and 2 x 10^{-3}). The Study Area-wide RME risk estimates are 4 x 10^{-2} and 2 x 10^{-2}. The CT estimate for recreational fishers is 1 x 10^{-4} ~~at~~in FZ 0-4, all other CT estimates are greater than 1 x 10^{-4}. ~~The associated Study Area-wide risk estimates assuming fillet-only consumption are 4 x 10^{-2} and 2 x 10^{-2}.~~ These results are presented in Table 5-115.

RME noncancer hazards associated with childhood consumption of whole body common carp are greater than 1 ~~at~~in each fishing zone evaluated. Values for fishing zones having the highest estimated ~~risks~~hazard are as follows (RME estimates for recreational and subsistence fishers, respectively):- FZ 3-6 (900 and 2,000) and FZ 4-8 (3,000 and 5,000). The Study Area-wide estimates are 2,000 and 4,000. The associated CT estimates for recreational fishers is 200 at FZ 3-6, 600 ~~at~~in FZ 4-8, and 500 Study Area-wide. The comparable hazard estimates for fillet-only consumption are: FZ 3-6 (200 and 100), FZ 4-8 (4,000 and 2,000), and 500 Study Area-wide. CT estimates for recreational fishers are 30 ~~at~~in FZ 3-6~~-~~, 500 ~~at~~in FZ 4-8, and 500 Study Area-wide.~~FZ 3-6 (2,000 and 900), FZ 4-8 (5,000 and 3,000, and FZ 8-12 (400 and 200). The comparable hazard estimates for fillet-only consumption are: FZ 3-6 (200 and 100), FZ 4-8 (4,000 and 2,000, and FZ 8-12 (200 and 90).~~ PCBs are the primary contributors to the hazard estimates. These results are presented in Table 5-98

RME noncancer hazards associated with indirect exposure to infants via breastfeeding are greater than 100 ~~at~~in each fishing zone evaluated. Values for fishing zones having the highest estimated ~~risks~~hazard are as follows (infant children of recreational and subsistence fishers, respectively): ~~FZ~~ FZ 3-6 (~~2~~10,000 and ~~1~~20,000)~~,~~ and ~~FZ~~ FZ 4-8 (~~6~~30,000 and ~~3~~60,000)~~, and FZ 8-12 (3,000 and 1,000)~~; ~~.~~Study Area-wide estimates are 30,000 and 50,000, respectively. The comparable CT estimates for infants of recreational fishers are 3,000 ~~at~~in FZ 3-6, 8,000 ~~at~~in FZ 4-8, and 6,000 Study Area-wide.

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~~The comparable~~ RME ~~comparable~~ hazard estimates associated with fillet-only consumption are (for infants of recreational and subsistence fishers, respectively): ~~FZ~~ FZ 3-6 (~~3~~1,000 and ~~1~~3,000),~~ FZ~~ FZ 4-8 (~~5~~30,000 and ~~3~~50,000); the Study Area-wide estimates are 30,000 and 50,000~~, and FZ 8-12 (2,000 and 1,000)~~. ~~The~~ CT estimates for infants of recreational fishers are 400 ~~at~~in FZ 3-6, 6,000 at FZ 4-~~-~~8, and 6,000 Study Area-wide. PCBs are the primary contributors to the hazard estimates. ~~The comparable hazard estimates Study Area-wide are 30,000 and 50,000, respectively.~~ These results are presented in Table 5-120.

5.2.6.4 Consumption of Brown Bullhead

Data from brown bullhead was combined across two fishing zones, encompassing RMs 3-6 and 6-9, was well as combining these data to provide a Study Area wide assessment. The RME estimates ~~for~~assuming whole body consumption are (for recreational and subsistence fishers, respectively~~,~~) are 6 x 10^{-4} and 1 x 10^{-3} ~~at~~in ~~FZ~~ FZ 3-6, 6 x 10^{-4} and 4 x 10^{-3} ~~at~~in ~~FZ~~ FZ 6-9, and 2 x 10^{-3} and 4 x 10^{-3} Study Area-wide. The associated CT estimates for recreational fishers are 2 x 10^{-4} ~~at~~in FZ 3-6, 6 x 10^{-4} ~~at~~in FZ 6-9, and 5 x 10^{-4} Study Area wide.

RME r~~The comparable r~~isk estimates for recreational and subsistence fishers, respectively, assuming fillet-only consumption are 7 x 10^{-5} and 1 x 10^{-4} ~~at~~in ~~FZ~~ FZ 3-6, and 1 x 10^{-3} and 2 x 10^{-3} ~~at~~in ~~FZ~~ FZ 6-9. The ~~associated~~ Study Area-wide risk estimates ~~assuming fillet-only consumption~~ are 1 x 10^{-3} and 2 x 10^{-3}. The associated CT estimates for recreational fishers are 2 x 10^{-5} ~~at~~in FZ 3-6, 3 x 10^{-4} ~~at~~in FZ 6-9, and 3 x 10^{-4} Study Area wide. These results are presented in Table 5-116.

RME noncancer hazards associated with childhood consumption of whole body brown bullhead are greater than 1 in all instances. The RME estimates for recreational and subsistence fishers, respectively, are 40 and 70 ~~at~~in FZ 3-6, 200 and 400 ~~at~~in FZ 6-9, and 200 and 300 Study Area-wide. CT estimates for recreational fishers are 8 ~~at~~in FZ 3-6, 50 ~~at~~in FZ 6-9, and 40 Study Area-wide.

~~The comparable~~ RME hazard estimates ~~for~~assuming fillet-only consumption are 7 and 10 ~~at~~in FZ 3-6, ~~and~~ 100 and 300 ~~at~~in FZ- 6-9, and ~~. The associated Study Area-wide risk estimates assuming fillet-only consumption are~~ 100 and 300 Study Area-wide. CT estimates for recreational fishers assuming fillet-only consumption are 2 at FZ- 3-6, 30 at FZ- 6-9, and 30 Study Area-wide. ~~.~~These results are presented in Table 5-102.

~~Assuming whole body consumption of brown bullhead, the RME noncancer hazards associated with indirect exposure infants to infant children of recreational and subsistence fishers, respectively, via breastfeeding are 300 and 600 at FZ 3-6, 2,000 and 5,000 at FZ 6-9, and 2,000 and 4,000 Study Area-wide. The comparable hazard estimates assuming parental fillet on~~Assuming whole body consumption of brown bullhead, the RME noncancer hazards associated with indirect exposure ~~infants~~ to

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infant children of recreational and subsistence fishers, respectively, via breastfeeding are 300 and 600 ~~at~~in FZ 3-6, 2,000 and 5,000 ~~at~~in FZ 6-9, and 2,000 and 4,000 Study Area-wide. CT estimates for infants of recreational fishers are 70 at FZ 3-6, 600 at FZ 6-9, and 500 Study Area-wide. The RME~~comparable~~ hazard estimates assuming parental fillet-only consumption are 70 and 100 ~~at~~in FZ 3-6, ~~and~~ 2,000 and 3,000 ~~at~~in FZ- 6-9, and 2,000 and 3,000 Study Area-wide. ~~The~~ CT estimates for infants of recreational fishers are 20 at FZ 3-6, 400 at FZ- 6-9, and 400 Study Area-wide. ~~. The associated Study Area-wide risk estimates assuming fillet-only consumption are 2,000 and 3,000ly consumption are 70 and 100 at FZ 3-6, and 2,000 and 3,000 at FZ 6-9. The associated Study Area-wide risk estimates assuming fillet-only consumption are 2,000 and 3,000.~~ These results are presented in Table 5-121.~~The estimated CT and RME cancer risks associated with combined child and adult consumption of whole body common carp are greater than 1 x 10^{-4} at each fishing zone evaluated, and RME cancer risk estimates are greater than 1 x 10^{-4}. Values for fishing zones having the highest estimated risks are as follows (RME estimates for recreational and subsistence fishers, respectively): FZ 3-6 (1 x 10^{-2} and 2 x 10^{-2}), FZ 4-8 (3 x 10^{-2} and 7 x 10^{-2}, and FZ 8-12 (2 x 10^{-3} and 5 x 10^{-3}). The associated Study Area-wide risk estimates are 4 x 10^{-2} and 2 x 10^{-2}. The comparable risk estimates for fillet-only consumption are FZ 3-6 (1 x 10^{-3} and 2 x 10^{-3}), FZ 4-8 (2 x 10^{-2} and 4 x 10^{-2}, and FZ 8-12 (1 x 10^{-3} and 2 x 10^{-3}). The associated Study Area-wide risk estimates assuming fillet-only consumption are 4 x 10^{-2} and 2 x 10^{-2}.~~

~~RME noncancer hazards associated with childhood consumption of whole body common carp are greater than 1 at each fishing zone evaluated. Values for fishing zones having the highest estimated risks are as follows (RME estimates for recreational and subsistence fishers, respectively): FZ 3-6 (2,000 and 900), FZ 4-8 (5,000 and 3,000, and FZ 8-12 (400 and 200). The comparable hazard estimates for fillet-only consumption are: FZ 3-6 (200 and 100), FZ 4-8 (4,000 and 2,000, and FZ 8-12 (200 and 90). PCBs are the primary contributors to the hazard estimates.~~

~~RME noncancer hazards associated with indirect exposure to infants via breastfeeding are greater than 100 at each fishing zone evaluated. Values for fishing zones having the highest estimated risks are as follows (infant children of recreational and subsistence fishers, respectively): FZ 3-6 (20,000 and 10,000), FZ 4-8 (60,000 and 30,000, and FZ 8-12 (3,000 and 1,000). The comparable hazard estimates associated with fillet-only consumption are: FZ 3-6 (3,000 and 1,000), FZ 4-8 (50,000 and 30,000, and FZ 8-12 (2,000 and 1,000). PCBs are the primary contributors to the hazard estimates.~~

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5.2.6.5 Consumption of Black Crappie

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Data from black crappie was also combined across two fishing zones, encompassing RMs 3-6 and 6-9, was well as combining these data to provide a Study Area wide assessment. ~~The~~ RME estimates assuming whole body consumption for recreational and subsistence fishers, respectively, are 3 x 10^{-4} and 6 x 10^{-4} ~~at~~in FZ 3-6, 6 x 10^{-4} and 1 x 10^{-3} ~~at~~in FZ 6-9, and 6 x 10^{-4} and 1 x 10^{-3} Study Area-wide. The

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comparable CT estimates for recreational fishers are 9 x 10^{-5} in FZ 3-6, 2 x 10^{-4} in FZ 6-9, and 2 x 10^{-4} Study Area-wide.

RME risk estimates ~~for~~assuming fillet-only consumption are 3 x 10^{-5} and 6 x 10^{-5} at FZ 3-6~~, and~~ 4 x 10^{-5} and 8 x 10^{-5} ~~at~~in FZ 6-9, and ~~.~~4 x 10^{-5} and 8 x 10^{-5} ~~T~~. ~~he associated Study Area-wide risk estimates assuming fillet-only consumption are 4 x 10^{-5} and 8 x 10^{-5}.~~ CT estimates for recreational fishers are 9 x 10^{-6} in FZ 3-6, 1 x 10^{-5} in FZ 6-9, and 1 x 10^{-5} Study Area-wide These results are presented in Table 5-117.

RME noncancer hazards associated with childhood consumption of whole body black crappie are greater than 1 in all instances. The RME estimates for recreational and subsistence fishers, respectively, are 20 and 40 ~~at~~in FZ 3-6, 40 and 80 ~~at~~in FZ 6-9, and 40 and 80 Study Area-wide. CT estimates for recreational fishers are 8 in FZ 3-6, 50 in FZ 6-9, and 40 Study Area-wide.

~~The comparable hazard estimates~~RME hazard estimates assuming childhood ~~for~~ fillet-only consumption for recreational and subsistence fishers, respectively, are 4 and 8 at FZ 3-6, and 6 and 10 at FZ-6-9. The associated Study Area-wide risk estimates assuming fillet-only consumption are 6 and 10.- CT estimates for recreational fishers assuming fillet-only consumption are 2 in FZ 3-6, 30 in FZ 6-9, and 30 Study Area-wide. These results are presented in Table 5-102.

Assuming adult whole body consumption of black crappie, the RME noncancer hazards associated with indirect exposure infants to infant children of recreational and subsistence fishers, respectively, via breastfeeding are 100 and 300 at FZ 3-6, 400 and 700 at FZ 6-9, and 400 and 700 Study Area-wide. CT estimates for infants of recreational fishers assuming fillet-only consumption are 70 in FZ 3-6, 600 in FZ 6-9, and 500 Study Area-wide.

~~The comparable~~RME hazard estimates for infants of recreational and subsistence fishers, respectively, assuming parental fillet-only consumption are 30 and 60 at FZ 3-6, and 40 and 80 at FZ- 6-9. The associated Study Area-wide risk estimates assuming fillet-only consumption are 40 and 80. These results are presented in Table 5-121.

5.2.6.6 Multi-Species Diet

A multi-species diet, comprised of equal proportions of each of smallmouth bass, common carp, brown bullhead, and black crappie was evaluated on a harbor-wide basis. The estimated recreational fisher CT and RME cancer risk~~s~~ estimates for combined child and adult consumption of whole body fish are 2 x 10^{-3} and 7 x 10^{-3}, respectively, and the estimated risk~~s~~ for subsistence fishers is 1 x 10^{-2}. The corresponding CT and RME risk ~~risks~~estimates for recreational fishers based on fillet-only ~~-~~consumption are ~~are~~ 1 x 10^{-3} and 6 ~~-~~x 10^{-3} ~~-~~, respectively. The estimated risk~~s~~ for subsistence fishers is 1 x 10^{-2}. PCBs, dioxins/furans, and ~~organochlorine~~

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~~pesticides~~DDx are the primary contributor to the risk estimates~~.~~. These results are presented in Table 5-118.~~.~~

The RME noncancer hazard estimates for childhood consumption of whole body fish for recreational and subsistence fishers are 600 and 1,000, respectively. The associated RME estimates for fillet-only consumption are 500 and 1,00, respectively. PCBs are the primary contributors to the hazard estimates. These results are presented in Table 5-110.

The RME noncancer hazard estimates for indirect exposure by infants via breastfeeding assuming maternal consumption of whole body fish are 8,000 for recreational fishing and 10,000 for subsistence fishing. The associated RME estimates associated with maternal fillet-only consumption are 7,000 for recreational fishing and 1,000 for subsistence. PCBs are the primary contributors to the hazard estimates. These results are presented in Table 5-123

~~The CT and RME noncancer hazard estimates for childhood consumption of whole body fish are 100 and 600, respectively, for recreational fishers. . The estimated RME hazard estimate for subsistence fishers is 1,000. . The associated CT and RME estimates for fillet-only consumption are 100 and 500 for recreational fishers, and the RME estimate for subsistence fishers is 1,000. . PCBs are the primary contributors to the hazard estimates. These results are presented in Table 5-110.~~

~~The CT and RME noncancer hazard estimates for indirect exposure by infants via breastfeeding assuming maternal consumption of whole body fish are 2,000 and 8,000, respectively, for recreational fishing. . The estimated RME hazard estimate associated with subsistence fishing is 10,000. . The associated CT and RME estimates associated with maternal fillet-only consumption are 2,000 and 7,000 for recreational fishing, and the RME estimate for subsistence fishing is 1,000. . PCBs are the primary contributors to the hazard estimates. These results are presented in Table 5-123.~~

5.2.6.7 Consumption of Clams

The estimated ~~CT and~~ RME cancer risks associated ~~with combined child and adult consumption of whole body smallmouth bass~~consumption of undepurated clams by subsistence fishers are greater than 1×10^{-4} ~~for all~~at 10 of the 22 river miles~~s~~ sections evaluated~~, and RME cancer risk estimates are greater than 1×10^{-3} for each river mile except RM 5, where the estimated risk is 9×10^{-4} for the recreational fisher~~. Values for river miles having the highest estimated risks are as follows~~ ~~(for recreational and subsistence fishers, respectively)~~: RM ~~7~~5W ($5\text{~~6~~} \times 10^{-3}$~~4~~ ~~and 1×10^{-2}~~), ~~Swan Island Lagoon (5×10^{-3} and 1×10^{-2}, and RM~~ RM ~~11~~6E ($\text{~~8~~}7 \times 10^{-3}$~~4~~ ~~and 2×10^{-2}~~), and ~~RM~~ RM 6W (7×10^{-4}). ~~RME risk estimates for fillet-only consumption range upwards from 9×10^{-5} and 2×10^{-4}, respectively, at RM 5. River miles having the highest estimated risks are: RM 7 (8×10^{-4} and 2×10^{-3}) and RM 11 (1×10^{-3} and 3×10^{-3}), fillet-only data were not collected in Swan Island Lagoon. Study Area-wide RME~~

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~~risks for recreational and subsistence fishers are 3 x 10^{-3} and 6 x 10^{-3}.~~ Other areas where the estimated risk is equal to or greater than 1 x 10^{-4} are RM~~s~~ 2E, 3E, 4E, 4W, 7W, 8W, Swan Island Lagoon, 9W, and 11E. ~~The~~ The estimated risk Study Area-wide is 4 x 10^{-4}. ~~Dioxins/furans~~Carcinogenic PAHs and PCBs are generally the primary contributors to the overall risk, cPAHs are the primary contributors to the risk estimates at RM~~s~~ 5W and 6W. ~~As~~t RM 7, PCB~~s~~, and ~~to a lesser degree~~ dioxins/furans~~,~~ are the primary contributors in Swan Island Lagoon and at RM 11. These results are presented in Table 5-126.

The estimated RME noncancer hazards associated consumption of undepurated clams by subsistence fishers are greater than 1 at 20 of the 22 river mile sections evaluated. Values for river miles having the highest noncancer hazard are as follows: ~~RM~~ RM 3E (8), ~~RM~~ RM 6E (40), ~~RM~~ RM 9W (8), and ~~RM~~ RM 11E (10). The estimated noncancer hazard Study Area-wide is 9. ~~C~~Although ~~arcinogenic~~ cPAHs and PCBs are generally the primary contributors to the overall ~~risk~~hazard, cPAHs are the primary contributors to the ~~risk~~hazard estimates at RMs 5W and 6W. ~~at RM RM 7,~~ PCBs and dioxins/furans are the primary contributors in Swan Island Lagoon at RM 7 and at ~~RM~~ RM 11.~~RME noncancer hazards associated with childhood consumption of whole body smallmouth bass are greater than 1 at all river miles evaluated. Areas with the highest estimated hazard displays a pattern similar to those with highest cancer risks. Values for river miles having the highest estimated hazard are as follows (for recreational and subsistence fishers, respectively): RM 2 (300 and 600), Swan Island Lagoon (500 and 1,000), and RM 11 (700 and 1,000). RME hazard estimates for fillet only consumption are also greater than 1 at all river miles. The lowest hazard estimate is 9, at RM 5. Values for river miles having the highest estimated hazard for fillet only consumption are as follows (for recreational and subsistence fishers, respectively): RM 4 (30 and 60), RM 7 (50 and 90), and RM 11 (100 and 300); fillet only data were not collected in Swan Island Lagoon. PCBs and dioxin/furans are the primary contributors to the hazard estimates.~~ These results are presented in Table 5-126.

RME noncancer hazard associated with indirect exposure to infants via breastfeeding was also assessed, and the estimated hazard is greater than 1 at each river ~~middle~~mile evaluated.~~:~~ Values for river miles having the highest estimated hazard due to parental consumption of ~~whole body smallmouth bass~~clams are as follows (for infant children of ~~recreational and~~ subsistence fishers~~, respectively~~): ~~RM~~ RM 2E (~~400 and 2,000~~20), ~~RM~~ RM ~~7~~6E (~~600 and 3,000~~200), ~~Swan Island Lagoon (1,000 and 6,000),~~ and ~~RM~~ RM 11E (~~2,000 and 8,000~~50)~~). The comparable hazard estimates associated with fillet only consumption are: RM 4 300 and 600), RM 7 (300 and 600), and RM 11 (2,000 and 4,000), fillet only data were not collected in Swan Island Lagoon. PCBs are the primary contributors to the estimated noncancer hazard estimates~~. These results are presented in Table 5-132.

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5.2.6.8 Consumption of Crayfish

The estimated RME cancer risks associated consumption of crayfish by subsistence fishers are greater than 1 x 10^{-4} at ~~2~~two of the 32 individual stations evaluated: 07R006 ~~-~~(3 x 10^{-4}) located at ~~RM~~ RM 7W, and CR11E (3 x 10^{-4}) located at ~~RM~~ RM 11E. When evaluated Study Area-wide, the estimated risk is 3 x 10^{-4}. ~~Carcinogenic PAHs and PCBs are generally the primary contributors to the overall risk, cPAHs are the primary contributors to the risk estimates at RMs 5W and 6W. at RM 7, PCBs and dioxins/furans are the primary contributors in Swan Island Lagoon and at RM 11~~Dioxins/furans are the primary contributors to the estimated risk at 07R006, PCBs are the primary contributors at CR11E. These results are presented in Table 5-129.

The estimated RME noncancer hazards associated consumption of ~~undepurated clams~~ crayfish by subsistence fishers are greater than 1 at ~~at 20 of the 22 river mile sections evaluated~~six of the 32 individual stations. ~~Values for river miles having the noncancer hazard are as follows: RM 3E (8), RM 6E (40), RM 9W (8), and RM 11E (10).~~Stations having the highest estimated hazard are 03R005 (4) located at the end of the International Slip, 07R006 (6), and CR11E (20). The estimated noncancer hazard Study Area-wide is ~~9~~10. ~~Carcinogenic PAHs and~~ PCBs are generally the primary contributors to the ~~overall risk, cPAHs are the primary contributors to the risk estimates at RMs 5W and 6W. at RM 7,~~ noncancer hazard at 03R005 and CR11E, ~~PCBs and~~ dioxins/furans are the primary contributors ~~in Swan Island Lagoon and at RM 11. PCBs and dioxin/furans are the primary contributors to the hazard estimates~~at 07R006. These results are presented in Table 5-129.

RME noncancer hazard associated with indirect exposure to infants via breastfeeding ~~was also assessed, and the estimated hazard~~ is greater than 1 at ~~each~~17 of the 32 stations ~~river middle~~ evaluated. Values ~~for river miles~~at locations having the highest estimated hazard due to parental consumption of clams are as follows (for infant children of subsistence fishers): ~~RM 2E (20), RM 6E (200), and RM 11E (50)~~02R001 (20) at ~~RM~~ RM 2E, 03R003 (20) at ~~RM~~ RM 3E, 03R005 (60) at ~~RM~~ RM 3E, 07R006 (20) at ~~RM~~ RM 7W. 09R002 (30) at ~~RM~~ RM 9W, and CR11E (400) at ~~RM~~ RM 11E. The hazard is 200 when evaluated Study Area-wide. These results are presented in Table 5-133.

5.2.7 Tribal Fishers

~~Recreational and subsistence~~Tribal fishers were evaluated ~~for exposures associated with~~assuming direct exposure to contaminants in sediment and via consumption of fish ~~and shellfish~~. E~~As discussed in Section 3.2.1.6,~~ exposures associated with beach sediment were assessed at individual beaches ~~designated as potential transient or recreational use areas~~, in-water sediment exposures were evaluated on a one-half river mile basis per side of the river and as an averaged, Study Area-wide evaluation. Fish consumption was evaluated assuming a multi-species diet consisting of anadromous and resident fish species, and fishing was evaluated on a Study Area-wide basis. –

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5.2.7.1 Sediment – Direct Contact

The estimated CT and RME cancer risks associated with direct contact to beach sediment is less than 1 x 10^{-4} at all beaches evaluated. The estimated RME cancer risk associated with exposure to in-water sediment is greater than 1 x 10^{-4} at two locations: ~~RM~~ RM 6W (2 x 10^{-4}) and ~~RM~~ RM 7W (3 x 10^{-4}). PAHs are the primary contributors to the risk estimate at ~~RM~~ RM 6W, dioxins/furans are the primary contributors at ~~RM~~ RM 7W~~.~~. These results are presented in Table 5-12 and 5-13.

With the exception of in-water sediment exposure at ~~RM~~ RM 7W, the estimated non-cancer hazard is less than one at all beach and in-water locations evaluated~~.~~. The estimated hazard is 3 at ~~RM~~ RM 7W, and dioxins/furans are the primary contributors to the estimate. These results are presented in Tables 5-12 and 5-13.

Noncancer RME hazard estimates associated with indirect exposure to infants via breastfeeding was evaluated ~~only for~~assuming maternal exposure to ~~contamination found in~~ in-water sediment. The estimated hazard is greater than 1 at 3 locations, ~~RM~~ RM 7W (5), ~~RM~~ RM 8.5 (4), and ~~RM~~ RM 11E (2). These results are presented in Table 5-40.~~———~~

5.2.7.2 Fish Consumption

The estimated RME cancer risks ~~associated consumption of crayfish by subsistence fishers are greater than~~for the combined child and adult exposure is ~~1~~2 x 10^{-42} ~~at two of the 32 individual stations evaluated: 07R006 (3 x 10^{-4}) located at RM 7W, and CR11E (3 x 10^{-4}) located at RM 11E. When evaluated Study Area-wide, the estimated risk~~assuming whole body consumption, and ~~is 3~~1 x 10^{-42} assuming consumption of fillets only~~.~~. PCBs, and to a lesser extent ~~D~~dioxins/furans are the primary contributors to the overall risk estimates. These results are presented in Table 5-71.

The RME noncancer hazard associated with childhood consumption of whole body fish is 800, and is 600 assuming consumption of fillets only. PCBs, and to a lesser extent dioxins/furans, arsenic, and DDx are the primary contributors to the overall risk estimates. These results are presented in Table 5-69.

The RME noncancer hazard associated with indirect exposure of tribal infants via breastfeeding assuming maternal consumption of whole body fish is 9,000, and is 8,000 assuming maternal fillet-only consumption. PCBs are the primary contributors to the hazard estimates. These results are presented Table 5-72.

5.2.8 Domestic Water Use

Use of surface water as a source of household water for drinking and other domestic uses was evaluated using data from five transect and 15 single point sampling locations, as well as averaged over a Study Area-wide basis. ~~T~~The estimated cancer risk for combined child and adult exposures is greater than 1 x 10^{-4} at W031

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(3 x 10^{-4}), located at ~~RM~~ RM 6W. PAHs are the primary contributor to the estimated cancer risk. However, dermal exposure is the primary pathway contributing to the risk estimate, and as described in EPA 2004, the physical-chemical properties of several PAHs, including benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenzo(a,h)anthracene, and indeno(1,2,3-c,d)pyrene), place them outside of the Effective Prediction Domain used to estimate the absorbed dermal dose from water. Although PAHs are direct-acting carcinogens, the risk estimates associated with estimating dermal absorption from water have a greater degree of uncertainty than the other risk estimates presented in this BHHRA. These results are presented in Table 5-62.

The estimated noncancer hazard based on childhood exposure is equal to or greater than 1 at several sampling locations: W005 (1) at ~~RM~~ RM 4E, W023 (1) at ~~RM~~ RM 11, W027 (2) near the mouth of Multnomah Channel, and W035 (2) in Swan Island Lagoon.- I~~N~~n all instances, MCPP is the primary contributor to the estimated hazard. These results are presented in Table 5-59.

~~Sediment exposures were further assessed as CT and RME evaluations by assuming either a low- or a high-frequency rate of fishing. The estimated CT and RME cancer risks associated with combined child and adult consumption of whole body common carp are greater than 1 x 10^{-4} at each fishing zone evaluated, and RME cancer risk estimates are greater than 1 x 10^{-4}. Values for fishing zones having the highest estimated risks are as follows (RME estimates for recreational and subsistence fishers, respectively): FZ 3-6 (1 x 10^{-2} and 2 x 10^{-2}), FZ 4-8 (3 x 10^{-2} and 7 x 10^{-2}, and FZ 8-12 (2 x 10^{-3} and 5 x 10^{-3}). The associated Study Area-wide risk estimates are 4 x 10^{-2} and 2 x 10^{-2}. The comparable risk estimates for fillet-only consumption are FZ 3-6 (1 x 10^{-3} and 2 x 10^{-3}), FZ 4-8 (2 x 10^{-2} and 4 x 10^{-2}, and FZ 8-12 (1 x 10^{-3} and 2 x 10^{-3}). The associated Study Area-wide risk estimates assuming fillet-only consumption are 4 x 10^{-2} and 2 x 10^{-2}.~~

~~RME noncancer hazards associated with childhood consumption of whole body common carp are greater than 1 at each fishing zone evaluated. Values for fishing zones having the highest estimated risks are as follows (RME estimates for recreational and subsistence fishers, respectively): FZ 3-6 (2,000 and 900), FZ 4-8 (5,000 and 3,000, and FZ 8-12 (400 and 200). The comparable hazard estimates for fillet-only consumption are: FZ 3-6 (200 and 100), FZ 4-8 (4,000 and 2,000, and FZ 8-12 (200 and 90). PCBs are the primary contributors to the hazard estimates.~~

~~RME noncancer hazards associated with indirect exposure to infants via breastfeeding are greater than 100 at each fishing zone evaluated. Values for fishing~~

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~~zones having the highest estimated risks are as follows (infant children of recreational and subsistence fishers, respectively): FZ 3-6 (20,000 and 10,000), FZ 4-8 (60,000 and 30,000, and FZ 8-12 (3,000 and 1,000). The comparable hazard estimates associated with fillet-only consumption are: FZ 3-6 (3,000 and 1,000), FZ 4-8 (50,000 and 30,000, and FZ 8-12 (2,000 and 1,000). PCBs are the primary contributors to the hazard estimates. The comparable hazard estimates Study Area-wide are 30,000 and 50,000, respectively.~~

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~~The estimated CT and RME cancer risks associated with combined child and adult consumption of whole body common carp are greater than 1×10^{-4} at each fishing zone evaluated, and RME cancer risk estimates are greater than 1×10^{-4}. Values for fishing zones having the highest estimated risks are as follows (RME estimates for recreational and subsistence fishers, respectively): FZ 3-6 (1×10^{-2} and 2×10^{-2}), FZ 4-8 (3×10^{-2} and 7×10^{-2}, and FZ 8-12 (2×10^{-3} and 5×10^{-3}). The associated Study Area-wide risk estimates are 4×10^{-2} and 2×10^{-2}. The comparable risk estimates for fillet-only consumption are FZ 3-6 (1×10^{-3} and 2×10^{-3}), FZ 4-8 (2×10^{-2} and 4×10^{-2}, and FZ 8-12 (1×10^{-3} and 2×10^{-3}). The associated Study Area-wide risk estimates assuming fillet-only consumption are 4×10^{-2} and 2×10^{-2}.~~

~~RME noncancer hazards associated with childhood consumption of whole body common carp are greater than 1 at each fishing zone evaluated. Values for fishing zones having the highest estimated risks are as follows (RME estimates for recreational and subsistence fishers, respectively): FZ 3-6 (2,000 and 900), FZ 4-8 (5,000 and 3,000, and FZ 8-12 (400 and 200). The comparable hazard estimates for fillet-only consumption are: FZ 3-6 (200 and 100), FZ 4-8 (4,000 and 2,000, and FZ 8-12 (200 and 90). PCBs are the primary contributors to the hazard estimates.~~

~~RME noncancer hazards associated with indirect exposure to infants via breastfeeding are greater than 100 at each fishing zone evaluated. Values for fishing zones having the highest estimated risks are as follows (infant children of recreational and subsistence fishers, respectively): FZ 3-6 (20,000 and 10,000), FZ 4-8 (60,000 and 30,000, and FZ 8-12 (3,000 and 1,000). The comparable hazard estimates associated with fillet-only consumption are: FZ 3-6 (3,000 and 1,000), FZ 4-8 (50,000 and 30,000, and FZ 8-12 (2,000 and 1,000). PCBs are the primary contributors to the hazard estimates.~~

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~~**Subsistence FishersConsumption of Smallmouth Bass**~~

~~The high-frequency fisher CT scenario for beach sediment results in no exceedances of 1×10^{-6} cumulative cancer risk and no exceedances of an HI of 1.~~

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~~**Recreational Beach Users**~~

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Tribal Fishers

As was done for recreational/subsistence fishers, tribal fishers were evaluated for exposures associated with direct exposure to contaminants in sediment and via consumption of fish and shellfish. Risks associated with beach sediment exposures were assessed at individual beaches designated as potential transient or recreational use areas, risks associated with in-water sediment exposures were evaluated on a one-half river mile basis per side the river and as an averaged, Study Area-wide evaluation. . The estimated RME cancer risk is 3 x 10^{-4} at RM 7Ws (primarily due to dioxins and furans), the associated HIs at this location are 3 based on adult exposure, and 5 based on infant exposures via breastfeeding. Dioxins and furans are the primary contributors to the estimated hazard, and the HQ is greater than 1. are greater than 1 x 10^{-4} at Tribal Fishers

Risks for the tribal fishers were estimated separately for each beach designated as a potential transient or recreational use area, which are shown in Map 2-1. The results of the risk evaluation for tribal fisher exposure to beach sediment are presented in Tables 5-12 through 5-13.

The estimated RME cancer risks associated with low-frequency fishing exposures to either beach or in-water sediments are less than 1 x 10^{-4} at all areas evaluated. Noncancer hazards associated with combined child and adult exposures are less than 1 at all locations evaluated, the noncancer hazard associated with indirect exposures to infants via breastfeeding is greater than 1 at two locations: RM 7W (2), where dioxin/furan TEQ concentrations are the primary contributor, and RM 8.5W (2), where PCBs are the primary contributor with a HQ of 1.

The tribal fisher RME scenario for beach sediment results in exceedances of 1 x 10^{-6} cumulative cancer risk at 18 of 18 exposure areas. There are no exceedances of 1 x 10^{-4} cancer risk for the tribal fisher RME scenario. The maximum cumulative cancer risk occurs at beaches 06B030, B003 and 04B024 (2 x 10^{-5}) and is primarily due to incidental ingestion of sediment containing arsenic or benzo(a)pyrene. The tribal fisher RME scenario for beach sediment resulted in no HIs greater than 1. Figures 5-6 and 5-7 show the relative risk contribution of individual COPCs for each beach, as well as total risk by river mile for tribal fisher exposure to beach sediment.

The tribal fisher CT scenario for beach sediment results in exceedances of 1 x 10^{-6} cumulative cancer risk at one of the 18 exposure areas (beach 06B030) primarily due to incidental ingestion of sediment containing arsenic. There are no exceedances of 1 x 10^{-4} cancer risk or HI of 1 for the tribal fisher CT scenario.

The cumulative risk exceedances of 1 x 10^{-6} are primarily due to arsenic, which is naturally occurring. At the DEQ background soil concentration of 7 mg/kg, the calculated risk from arsenic would exceed 1 x 10^{-6} for the tribal fisher RME

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~~scenarios. When a background arsenic concentration of 7 mg/kg is subtracted from detected arsenic concentrations in beach sediment from potential human use areas, resulting cumulative risks for the tribal fisher RME scenario exceed 1 x 10^{-6} at eight beaches, due primarily to exposure to benzo(a)pyrene and total cPAHs, as shown in Map 5-2-1. Risks from exposure to cPAHs in sediment at these eight beaches range from 2 x 10^{-6} to 1 x 10^{-5}. Excluding background arsenic concentrations, exposure to beach sediment results in risks exceeding 1 x 10^{-6} from exposure to arsenic at one beach location. The maximum cumulative risk to tribal fishers from potential exposure to beach sediment excluding background contribution from arsenic is 1 x 10^{-5}, which occurs at beaches 04B024 and B003.~~

~~The results of the risk evaluation for tribal fisher exposure to in-water sediment are presented in Tables 5-23 through 5-25.~~

~~The tribal fisher RME scenario for in-water sediment results in exceedances of 1 x 10^{-6} cumulative cancer risk in 33 of 40 river mile segments within the Study Area, and from Study Area-wide exposure (see Table 5-23). The tribal fisher RME scenario for in-water sediment results in cumulative cancer risk greater than 1 x 10^{-4} at RM 6W and RM 7W. RM 7W is the location of the maximum cumulative cancer risk (3 x 10^{-4}). Risk at RM 7W is primarily due to incidental ingestion of sediment containing dioxins/furans (risk from dioxins/furan exposure is 3 x 10^{-4}); risk at RM 6W is primarily due to dermal contact with sediment containing benzo(a)pyrene (risk from benzo(a)pyrene exposure is 1 x 10^{-4}). In addition to these two contaminants, the following individual analytes also result in an individual cancer risk greater than 1 x 10^{-6} in at least one exposure area: arsenic, PCBs, benzo(b)fluoranthene, dibenzo(a,h)anthracene, benzo(a)anthracene, indeno(1,2,3-cd)pyrene.~~

~~Exposure areas including river mile segments outside of the Study Area that result in risks above 1 x 10^{-6} from the tribal fisher RME scenario for in-water sediment are: RM 12W (includes samples from RM 12.0W – 12.2W), Multnomah Channel, and RM 1.5E (includes samples from RM 1.5E – RM 1.9E), RM 1E, and RM1W. Tribal fisher exposure to in-water sediment from river segments outside of the Study Area do not result in HIs greater than 1.~~

~~The tribal fisher CT scenario for in-water sediment results in exceedances of 1 x 10^{-6} cumulative cancer risk at two of the 40 river mile segments (RM 6W and RM 7W). There are no exceedances of 1 x 10^{-4} cancer risk for the tribal fisher CT scenario. The maximum cumulative cancer risk occurs at RM 6W (6 x 10^{-6}) and is primarily due to exposure to sediment containing benzo(a)pyrene. The tribal fisher CT scenario for in-water sediment results in no HIs greater than 1.~~

~~There are no risks greater than 1 x 10^{-6} or HIs greater than 1 for CT tribal fisher exposure to in-water sediment from river segments assessed outside of the Study Area.~~

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Tribal Fishers

Risks to tribal fishers who consume fish caught within the Study Area were evaluated for a multi-species diet that includes salmon, lamprey, and sturgeon, in addition to resident fish species. A single ingestion rate for the multi-species diet was used to evaluate risks to the tribal fish consumer. Risks were evaluated using both 95 percent UCL/max and mean Study Area-wide tissue concentrations for both fillet and whole body tissue (see Section 3.4.5). Risks were higher for whole body tissue than for fillet tissue; however, fillet tissue was not analyzed for PCB or dioxin/furan congeners in all resident species. The results of the risk evaluation for adult tribal fish consumption are presented in Tables 5-67 through 5-70. The results of the risk evaluation for child tribal fish consumption are presented in Tables 5-71 through 5-74, and the results of the risk evaluation for the combined child and adult tribal consumers of fish are presented in Tables 5-75 through 5-76.

Tribal Adult, Fish Consumption

The risks ranged from a cumulative cancer risk of 2×10^{-2} for the 95 percent UCL/max EPCs of whole body tissue to a cumulative cancer risk of 2×10^{-3} for the mean EPCs of fillet tissue. For all scenarios, estimated risks are above a 1×10^{-4} cumulative cancer risk and are primarily due to PCBs and dioxins/furans. Figure 5-8 shows the relative risk contribution of individual COPCs for both whole body and fillet tissue diets of an adult tribal consumer, and Figure 5-9 shows a comparison of total risk per tissue type.

The cumulative HIs ranged from 400 for the 95 percent UCL/max EPCs of whole body tissue to 50 for the mean EPCs of fillet tissue. For the whole body tissue, 95 percent UCL/max EPC scenario, the PCB HQ is approximately 26 times higher than any other HQ. The toxicity endpoint for PCBs is immunological and skin. The immunological- and skin-specific HIs for tribal adult consumption are the highest endpoint-specific HIs, and exceed the next highest HI by a factor of 10. Additional endpoints that exceed an HI of 1 for the tribal adult 95 percent UCL/max consumption scenario are reproduction, central nervous system (CNS), and blood.

The multi-species diet evaluated in this BHHRA included resident fish as well as salmon, sturgeon, and lamprey. Because salmon, sturgeon, and lamprey spend time outside the Study Area, the risks from ingestion of salmon, sturgeon, and lamprey cannot be conclusively associated with sources within the Study Area. However, resident fish accounted for approximately 95 percent of the cumulative risk in the whole body diet. Of the four resident fish species included in the multi-species diet, risks from ingestion of smallmouth bass and common carp were the primary contributors to the cumulative risk.

Tribal Child, Fish Consumption

The risks ranged from a cumulative cancer risk of 3×10^{-3} for the 95 percent UCL/max EPCs of whole body tissue to a cumulative cancer risk of 4×10^{-4} for the

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mean EPCs of fillet tissue. For all scenarios, risks are above a 1 x 10^{-4} cumulative cancer risk and are primarily due to PCBs and dioxins/furans.

The cumulative HIs ranged from 800 for the 95 percent UCL/max EPCs of whole body tissue to 100 for the mean EPCs of fillet tissue. The PCB HQ for the whole body tissue diet is approximately 26 times higher than any other HQ. The immunological and skin specific HIs for tribal child consumption are the maximum endpoint specific HIs, and exceed the next highest HI by a factor of 10. Additional health endpoints that exceed an HI of one for the tribal child 95 percent UCL/max consumption scenario are reproduction, CNS, liver, and blood.

The multi species diet evaluated in this BHHRA included resident fish as well as salmon, sturgeon, and lamprey. Because salmon, sturgeon, and lamprey spend time outside the Study Area, the calculated risks from ingestion of salmon, sturgeon, and lamprey cannot be conclusively associated with sources within the Study Area. However, resident fish accounted for approximately 95 percent of the cumulative risk associated with this scenario.

Combined Tribal Child and Adult, Fish Consumption

Cancer risks were calculated for the combined child and adult tribal fisher scenarios in order to incorporate early life exposures (EPA 2005, DEQ 2010). Cumulative cancer risks from fish consumption for the combined child and adult tribal fisher ranged from 3 x 10^{-3} (fillet tissue consumption, mean scenario) to 2 x 10^{-2}, (whole body tissue consumption, 95 percent UCL/Max scenario) primarily due to ingestion of PCBs in tissue. The results of the combined tribal child and adult cancer risks for consumption of fish tissue are presented in Tables 5-75 and 5-76.

Breastfeeding Infant of Tribal Adult Who Consumes Fish

Risks and hazards to an infant consuming human milk of a tribal adult who consumes fish were calculated for bioaccumulative compounds, consistent with EPA (2005) and DEQ (2010) guidelines. These risks are presented in Tables 5-77 and 5-78. Cancer risks range from 2 x 10^{-3} to 2 x 10^{-2}, and noncancer hazards range from 1,000 to 9,000.

Summary of Risks from Tribal Consumption of Fish

A summary of risks from tribal consumption of fish is provided in Table 5-79. Both cancer risks and noncancer hazards exceed the target risk values of 1 x 10^{-6} and 1, respectively, for all tribal receptors.

Recreational/Subsistence Fishers

Fishers

Risks for the high and low frequency fishers were estimated separately for each beach designated as a potential transient or recreational use area, which are shown in

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Map 2-1. The results of the risk evaluation for high-frequency fisher exposure to beach sediment are presented in Tables 5-14 through 5-15. The results of the risk evaluation for low-frequency fisher exposure to beach sediment are presented in Tables 5-16 through 5-17.

High-Frequency Fishers

The high-frequency fisher RME scenario for beach sediment results in exceedances of 1 x 10^{-6} cumulative cancer risk at 9 of 18 exposure areas (see Table 5-14). There are no exceedances of 1 x 10^{-4} cancer risk for the high-frequency fisher RME scenario. The maximum cumulative cancer risk occurs at beaches 04B024 and 06B030 (6 x 10^{-6}) and is primarily due to incidental ingestion of sediment containing arsenic. In addition to arsenic, benzo(a)pyrene is the only other individual analyte resulting in a cancer risk greater than 1 x 10^{-6} at some exposure areas. The high-frequency fisher RME scenario for beach sediment resulted in no HIs greater than 1.

The cumulative risk exceedances of 1 x 10^{-6} are primarily due to arsenic, which is naturally occurring. At the DEQ background soil concentration of 7 mg/kg, the calculated risk from arsenic would exceed 1 x 10^{-6} for the high-frequency fisher RME scenarios. When a background arsenic concentration of 7 mg/kg is subtracted from detected arsenic concentrations in beach sediment from potential human use areas, resulting cumulative risks for the high-frequency fisher RME scenario exceed 1 x 10^{-6} at three beaches, as shown in Map 5-2-1. The maximum cumulative risk to high-frequency fishers from potential exposure to beach sediment excluding background contribution from arsenic is 3 x10^{-6}, which occurs at beaches 04B024 and B003.

The high-frequency fisher CT scenario for beach sediment results in no exceedances of 1 x 10^{-6} cumulative cancer risk and no exceedances of an HI of 1.

Low-Frequency Fishers

The low-frequency fisher RME scenario for beach sediment results in exceedances of 1 x 10^{-6} cumulative cancer risk at six of 18 exposure areas (see Table 5-16). There are no exceedances of 1 x 10^{-4} cancer risk for the low-frequency fisher RME scenario. The maximum cumulative cancer risk occurs at beaches 06B030 and 04B024 (4 x 10^{-6}), and is primarily due to incidental ingestion of sediment containing arsenic. Besides arsenic, there are no individual analytes resulting in a cancer risk greater than 1 x 10^{-6}. The low-frequency fisher RME scenario for beach sediment resulted in no HIs greater than 1.

The cumulative risk exceedances of 1 x 10^{-6} are primarily due to arsenic, which is naturally occurring. When a background arsenic concentration of 7 mg/kg is subtracted from detected arsenic concentrations in beach sediment from potential human use areas, resulting cumulative risks for the low-frequency fisher RME scenario exceed 1 x 10^{-6} at three beaches, as shown in Map 5-2-1. The RME cumulative risk to low-frequency fishers from potential exposure to beach sediment,

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excluding background contributions from arsenic, is 2 x10^{-6} at all three of these beaches.

The low-frequency fisher CT scenario for beach sediment results in no exceedances of 1 x 10^{-6} cumulative cancer risk and no exceedances of an HI of 1.

Breastfeeding Infants of Adults Exposed to Beach Sediment

Risks and hazards to breastfeeding infants from exposure to bioaccumulative compounds in human milk were assessed for scenarios resulting in bioaccumulative compounds as COPCs. In the case of the beach sediment exposure scenarios, only the dockside worker exposures include bioaccumulative compounds as COPCs. The assessment of risks to infants entails applying a compound-specific infant risk adjustment factor (IRAF) to risks and hazards to the adult mother, in accordance with DEQ guidance (2010). Cumulative cancer risks to an infant consuming human milk from a dockside worker range from 5 x 10^{-10} to 1 x 10^{-6} across both CT and RME scenarios. Noncancer hazards range from 6 x 10^{-3} to 1 across both CT and RME scenarios. Risks to breastfeeding infants of dockside workers exposed to beach sediment are shown in Tables 5-18 through 5-19.

Fisher

To evaluate differences in fishing frequencies, risks were evaluated for both high-frequency and low-frequency fishers. High-frequency fishers were assumed to fish from the same 1/2-mile river segment three days per week for the entire year (156 days/year) for the default residential exposure duration (30 years) for the RME. Low-frequency fishers were assumed to fish from the same 1/2-mile river segment for two days per week for the entire year (104 days/year) for the default residential exposure duration (30 years) for the RME. The results of the risk evaluation for high-frequency fisher exposure to in-water sediment are presented in Tables 5-26 through 5-28. The results of the risk evaluation for low-frequency fisher exposure to in-water sediment are presented in Tables 5-29 through 5-30.

High-Frequency Fisher

The high-frequency fisher RME scenario for in-water sediment results in exceedances of 1 x 10^{-6} cumulative cancer risk in 17 of 40 river mile segments within the Study Area and from Study Area-wide exposure (see Table 5-26). There are no exceedances of 1 x 10^{-4} cancer risk for the high-frequency fisher RME scenario. The maximum cumulative cancer risks occur at RM 7W (8 x 10^{-5}) and RM 6W (5 x 10^{-5}). At RM 7W, risk is primarily due to incidental ingestion of sediment containing dioxins/furans. At RM 6W, risk is primarily due to dermal contact with sediment containing benzo(a)pyrene. In addition to these chemicals, the following individual analytes also result in a cancer risk greater than 1 x 10^{-6} in at least one exposure area: arsenic, PCBs, benzo(b)fluoranthene, dibenzo(a,h)anthracene, benzo(a)anthracene, and indeno(1,2,3-cd)pyrene.

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For river mile segments outside of the Study Area, RM 12W is the only exposure area that results in risk above 1 x 10^{-6} for the high-frequency fisher RME scenario for in-water sediment. Risk at RM 12W is 2 x 10^{-6}, primarily due to exposure to benzo(a)pyrene. There are no exposure areas outside of the Study Area resulting in an HI greater than 1.

The high-frequency fisher CT scenario for in-water sediment results in no exceedances of 1 x 10^{-6} cumulative cancer risk and no exceedances of an HI of 1 for exposure areas assessed inside and outside of the Study Area.

Low-Frequency Fisher

The low-frequency fisher RME scenario for in-water sediment results in exceedances of 1 x 10^{-6} cumulative cancer risk at 12 of 40 river mile segments within the Study Area, and from Study Area-wide exposure (see Table 5-29). There are no exceedances of 1 x 10^{-4} cancer risk for the low-frequency fisher RME scenario. The maximum cumulative cancer risks occur at RM 7W (6 x 10^{-5}) and RM 6W (3 x 10^{-5}). At RM 7W, risk is primarily due to incidental ingestion of sediment containing dioxins/furans. At RM 6W, risk is primarily due to dermal contact with sediment containing benzo(a)pyrene. In addition to these chemicals, the following individual analytes also result in a cancer risk greater than 1 x 10^{-6} in at least one exposure area: PCBs, dibenzo(a,h)anthracene, benzo(a)anthracene, benzo(b)fluoranthene, and indeno(1,2,3-cd)pyrene. The low-frequency fisher RME scenario for in-water sediment results in no HIs greater than 1.

There are no risks greater than 1 x 10^{-6} or HIs greater than 1 for the low-frequency fisher RME scenario for exposure to in-water sediment from river segments assessed outside of the Study Area.

The low-frequency fisher CT scenario for in-water sediment results in no exceedances of 1 x 10^{-6} cumulative cancer risk and no exceedances of an HI of 1 for exposure areas inside and outside of the Study Area.

Domestic Water Use

6.0

5.12.1 Beach Sediment Risk Characterization Results

Potential risks from exposure to beach sediment through incidental ingestion and dermal absorption were estimated for the dockside workers, transients, recreational beach users, fishers, and tribal fishers. . There were multiple uncertainties associated with the direct exposure to beach sediment scenarios such as the spatial scale of the individual beaches and the exposure parameters, which are further described in the following sections. . Beaches with cumulative cancer risks greater than 1 x x 10^{-6} and 1 x x 10^{-5} are summarized by exposure point and receptor in Maps 5-1-1 and 5-

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1-2. . There were no beach areas associated with cancer risk levels greater than 1 x x 10^{-4} or HIs greater than 1. .

5.12.1.1 Dockside Worker

1.0 Risks for the dockside workers were estimated separately for each beach designated as a potential dockside worker use area, which are shown in Map 2-1. . The results of the risk evaluation for dockside worker exposure to beach sediment are presented in Tables 5-2 through 5-3. .

2.0 The dockside worker RME scenario for beach sediment results in exceedances of a cumulative cancer risk level of 1 x x 10^{-6} at beaches 06B025 (9 x x 10^{-5} risk) and B004 (2 x x 10^{-6} risk). . There are no exposure areas that result in an exceedance of 1 x x 10^{-4} cancer risk for the dockside worker RME scenario. . The maximum cumulative cancer risk for an individual exposure area occurs at 06B025 and is primarily due to incidental ingestion of beach sediment containing benzo(a)pyrene. . In addition to benzo(a)pyrene, other chemicals contributing to a calculated individual cancer risk greater than 1 x x 10^{-6} for at least one exposure area include: benzo(a)anthracene, benzo(b)flouranthene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene. . The HIs for the dockside worker RME scenario do not exceed 1. .

3.0 The dockside worker CT scenario for beach sediment results in one exceedance of 1 x x 10^{-6} cumulative cancer risk (at beach 06B025, 6 x x 10^{-6} risk), which is primarily due to the incidental ingestion of sediment containing benzo(a)pyrene. . There are no exposure areas that result in an exceedance of 1 x x 10^{-4} cancer risk for the dockside worker CT beach sediment scenario. . The dockside worker CT scenario results in no exceedances of a HI of 1. . Figures 5-1 shows risks to the dockside worker from exposure to beach sediment per beach, and shows the relative contribution of individual chemicals to total risk.

5.12.1.2 Transients

Risks for the transients were estimated separately for each beach designated as a potential transient use area, which are shown in Map 2-1. . The results of the risk evaluation for transient exposure to beach sediment are presented in Tables 5-4 through 5-5.

The transient RME scenario for beach sediment results in no exceedances of 1 x x 10^{-6} cancer risk and no exceedances of a HI of 1. . The transient CT scenario for beach sediment results in no exceedances of 1 x x 10^{-6} cancer risk and no exceedances of a HI of 1. The results of the risk evaluation for transient exposure to beach sediment are presented in Tables 5-4 through 5-5.

5.12.1.3 Recreational Beach Users

Risks for the recreational beach users were estimated separately for each beach designated as a potential recreational use area, which are shown in Map 2-1. . Cancer

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risks and noncancer hazards were evaluated for both adult and child recreational beach users. . In addition, carcinogenic risks were calculated for a combined child and adult scenario. . The results of the risk evaluation for recreational beach user exposure to beach sediment are presented in Tables 5-6 through 5-11.

5.12.1.3.1 Adult Recreational Beach Users

The adult recreational beach user RME scenario for beach sediment results in cumulative cancer risk exceedances of 1 x x 10^{-6} at the following beaches: 04B024 (risk is 3 x x 10^{-6}), 06B030 (risk is 4 x x 10^{-6}), B003 (risk is 3 x x 10^{-6}), and B005 (risk is 2 x x 10^{-6}). . There are no exceedances of 1 x x 10^{-4} cancer risk for the adult recreational beach user RME scenario. . The maximum cumulative cancer risk from RME occurs at Beach 06B030 and is primarily due to incidental ingestion of beach sediment containing arsenic. . The adult recreational beach user RME scenario for beach sediment resulted in no HIs greater than 1. . Figures 5-2 and 5-3 show the relative risk contribution of individual COPCs for each beach, as well as total risk by river mile for adult recreational beach user exposure to beach sediment.

Arsenic is a naturally occurring metal. . The concentration for arsenic in soil recognized by DEQ to represent background levels in Oregon is 7 milligrams per kilogram (mg/kg) (DEQ 2007). . At this background concentration, the calculated risk from arsenic would exceed 1 x x 10^{-6} for the adult recreational beach user RME scenario. . When a background concentration of 7 mg/kg is subtracted from detected concentrations of arsenic in beach sediment, resulting cumulative risks for the adult recreational beach user RME scenario exceed 10^{-6} at beaches 04B024 and B003. . Beaches with risk exceedances of 1 x x 10^{-6} excluding risks from background arsenic are shown for all exposure scenarios for beach sediment in Maps 5-2-1 and 5-2-2. . In addition to risks from exposure to arsenic in beach sediment, risks from exposure to total cPAHs in beach sediment exceed 1 x x 10^{-6} at two beach locations: 04B024 (2 x x 10^{-6}) and B003 (2 x x 10^{-6}) . At each of these beaches, benzo(a)pyrene is the cPAH with the highest contribution to total risks from cPAHs.

The adult recreational beach user CT scenario for beach sediment results in no exceedances of 1 x x 10^{-6} cumulative cancer risk and no exceedances of an HI of 1. .

5.12.1.3.2 Child Recreational Beach Users

The child recreational beach user RME scenario for beach sediment results in cumulative risk exceedances of 1 x x 10^{-6} at all 15 of the exposure areas. . There are no exceedances of 1 x x 10^{-4} cancer risk for the child recreational beach user RME scenario. . The maximum cumulative cancer risk from RME occurs at beaches B003, and 04B024 (4 x x 10^{-5}) and is primarily due to dermal absorption of soil containing arsenic and benzo(a)pyrene. . The child recreational beach user RME scenario resulted in no HIs greater than 1.

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The cumulative risk exceedances are due in part to arsenic, which is naturally occurring. . At the DEQ background soil concentration of 7 mg/kg, the calculated risk from arsenic would exceed 1 x x 10^{-6} for the child recreational beach user RME scenario. . When a background arsenic concentration of 7 mg/kg is subtracted from detected arsenic concentrations in beach sediment from potential human use areas, resulting cumulative risks for the child recreational beach user RME scenario exceed 1 x x 10^{-6} at five beaches, as shown in Map 5-2-1. . These exceedances are due to exposure to arsenic at one beach, and exposure to benzo(a) pyrene or total cPAHs at the other four. . Cancer risks above 1 x x 10^{-6} from exposures to cPAHs in beach sediment range from 2 x x 10^{-8} to 4 x x 10^{-5}, due primarily to contributions from benzo(a)pyrene. . Figures 5-4 and 5-5 show the relative risk contribution of individual COPCs for each beach, as well as total risk by river mile for child recreational beach user exposure to beach sediment.

The child recreational beach user CT scenario for beach sediment results in an exceedance of 1 x x 10^{-6} cumulative cancer risk at two beaches (risk of 2 x x 10^{-6} at 04B024 and B003). There are no exceedances of an HI of 1. .

5.12.1.3.3 Combined Child/Adult Recreational Beach Users

Cancer risks were calculated for the combined child and adult recreational beach users to incorporate early life exposures in accordance with EPA (2005b) and DEQ (2010) guidance. . Cumulative risks per exposure area for RME scenarios ranged from 2 x x 10^{-6} to 5 x x 10^{-5}. . For the CT scenarios, risks ranged from 2 x x 10^{-7} to 2 x x 10^{-6}. . The highest risk was at Beach 04B024, primarily due to exposures to benzo(a)pyrene in beach sediment.

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5.12.1.4 Tribal Fishers

Risks for the tribal fishers were estimated separately for each beach designated as a potential transient or recreational use area, which are shown in Map 2-1. . The results of the risk evaluation for tribal fisher exposure to beach sediment are presented in Tables 5-12 through 5-13. .

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The tribal fisher RME scenario for beach sediment results in exceedances of 1 x x 10^{-6} cumulative cancer risk at 18 of 18 exposure areas. . There are no exceedances of 1 x x 10^{-4} cancer risk for the tribal fisher RME scenario. . The maximum cumulative cancer risk occurs at beaches 06B030, B003 and 04B024 (2 x x 10^{-5}) and is primarily due to incidental ingestion of sediment containing arsenic or benzo(a)pyrene. . The tribal fisher RME scenario for beach sediment resulted in no HIs greater than 1. . Figures 5-6 and 5-7 show the relative risk contribution of individual COPCs for each beach, as well as total risk by river mile for tribal fisher exposure to beach sediment.

The tribal fisher CT scenario for beach sediment results in exceedances of 1 x x 10^{-6} cumulative cancer risk at one of the 18 exposure areas (beach 06B030) primarily due to incidental ingestion of sediment containing arsenic. . There are no exceedances of 1 x x 10^{-4} cancer risk or HI of 1 for the tribal fisher CT scenario.

The cumulative risk exceedances of 1 x 10^{-6} are primarily due to arsenic, which is naturally occurring. At the DEQ background soil concentration of 7 mg/kg, the calculated risk from arsenic would exceed 1 x 10^{-6} for the tribal fisher RME scenarios. When a background arsenic concentration of 7 mg/kg is subtracted from detected arsenic concentrations in beach sediment from potential human use areas, resulting cumulative risks for the tribal fisher RME scenario exceed 1 x 10^{-6} at eight beaches, due primarily to exposure to benzo(a)pyrene and total cPAHs, as shown in Map 5-2-1. Risks from exposure to cPAHs in sediment at these eight beaches range from 2 x 10^{-6} to 1 x 10^{-5}. Excluding background arsenic concentrations, exposure to beach sediment results in risks exceeding 1 x 10^{-6} from exposure to arsenic at one beach location. The maximum cumulative risk to tribal fishers from potential exposure to beach sediment excluding background contribution from arsenic is 1 x 10^{-5}, which occurs at beaches 04B024 and B003.

5.12.1.5 Fishers

Risks for the high- and low- frequency fishers were estimated separately for each beach designated as a potential transient or recreational use area, which are shown in Map 2-1. The results of the risk evaluation for high-frequency fisher exposure to beach sediment are presented in Tables 5-14 through 5-15. The results of the risk evaluation for low-frequency fisher exposure to beach sediment are presented in Tables 5-16 through 5-17.

5.12.1.5.1 High-Frequency Fishers

The high-frequency fisher RME scenario for beach sediment results in exceedances of 1 x 10^{-6} cumulative cancer risk at 9 of 18 exposure areas (see Table 5-14). There are no exceedances of 1 x 10^{-4} cancer risk for the high-frequency fisher RME scenario. The maximum cumulative cancer risk occurs at beaches 04B024 and 06B030 (6 x 10^{-6}) and is primarily due to incidental ingestion of sediment containing arsenic. In addition to arsenic, benzo(a)pyrene is the only other individual analyte resulting in a cancer risk greater than 1 x 10^{-6} at some exposure areas. The high-frequency fisher RME scenario for beach sediment resulted in no HIs greater than 1.

The cumulative risk exceedances of 1 x 10^{-6} are primarily due to arsenic, which is naturally occurring. At the DEQ background soil concentration of 7 mg/kg, the calculated risk from arsenic would exceed 1 x 10^{-6} for the high-frequency fisher RME scenarios. When a background arsenic concentration of 7 mg/kg is subtracted from detected arsenic concentrations in beach sediment from potential human use areas, resulting cumulative risks for the high-frequency fisher RME scenario exceed 1 x 10^{-6} at three beaches, as shown in Map 5-2-1. The maximum cumulative risk to high-frequency fishers from potential exposure

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to beach sediment excluding background contribution from arsenic is 3 x10^{-6}, which occurs at beaches 04B024 and B003.

- The high-frequency fisher CT scenario for beach sediment results in no exceedances of 1 x 10^{-6} cumulative cancer risk and no exceedances of an HI of 1.

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5.12.1.5.2 Low-Frequency Fishers

- The low-frequency fisher RME scenario for beach sediment results in exceedances of 1 x 10^{-6} cumulative cancer risk at six of 18 exposure areas (see Table 5-16). There are no exceedances of 1 x 10^{-4} cancer risk for the low-frequency fisher RME scenario. The maximum cumulative cancer risk occurs at beaches 06B030 and 04B024 (4 x 10^{-6}), and is primarily due to incidental of sediment containing arsenic. Besides arsenic, there are no individual analytes resulting in a cancer risk greater than 1 x 10^{-6}. The low-frequency fisher RME scenario for beach sediment resulted in no HIs greater than 1.

- The cumulative risk exceedances of 1 x 10^{-6} are primarily due to arsenic, which is naturally occurring. When a background arsenic concentration of 7 mg/kg is subtracted from detected arsenic concentrations in beach sediment from potential human use areas, resulting cumulative risks for the low-frequency fisher RME scenario exceed 1 x 10^{-6} at three beaches, as shown in Map 5-2-1. The RME cumulative risk to low-frequency fishers from potential exposure to beach sediment, excluding background contributions from arsenic, is 2 x10^{-6} at all three of these beaches.

- The low-frequency fisher CT scenario for beach sediment results in no exceedances of 1 x 10^{-6} cumulative cancer risk and no exceedances of an HI of 1.

5.12.1.6 Breastfeeding Infants of Adults Exposed to Beach Sediment

- Risks and hazards to breastfeeding infants from exposure to bioaccumulative compounds in human milk were assessed for scenarios resulting in bioaccumulative compounds as COPCs. In the case of the beach sediment exposure scenarios, only the dockside worker exposures include bioaccumulative compounds as COPCs. The assessment of risks to infants entails applying a compound-specific infant risk adjustment factor (IRAF) to risks and hazards to the adult mother, in accordance with DEQ guidance (2010). Cumulative cancer risks to an infant consuming human milk from a dockside worker range from 5 x 10^{-10} to 1 x 10^{-6} across both CT and RME scenarios. Noncancer hazards range from 6 x 10^{-3} to 1 across both CT and RME scenarios. Risks to

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breastfeeding infants of dockside workers exposed to beach sediment are shown in Tables 5-18 through 5-19.

5.12.1.7 Summary of Beach Sediment Risk Characterization

Direct contact with beach sediment resulted in cumulative cancer risks ranging from 8 x 10^{-9} to 9 x 10^{-5}. Cumulative HIs for direct exposure to beach sediment were at or below the EPA target HI of 1 for all exposure scenarios. The highest cumulative cancer risks at industrial use beaches were for the dockside worker scenario, and the highest cumulative cancer risks at residential use beaches were for the tribal fisher scenario. Two chemicals resulted in a cancer risk greater than 1 x 10^{-6} for at least one of the scenarios evaluated for direct contact with beach sediment: arsenic and PAHs. Arsenic occurs both naturally and as a result of environmental releases. A summary of risks from beach sediment per beach is shown in Maps 5-1-1 and 5-1-2, and risks after subtracting an assumed background arsenic concentration of 7 mg/kg from the EPCs are shown in Maps 5-2-1 and 5-2-2. Table 5-20 provides a summary of risks from exposure to beach sediment, per receptor and exposure area.

5.12.2 In-Water Sediment Risk Characterization Results

Potential risks from exposure to in-water sediment through incidental ingestion and dermal absorption were estimated for the in-water workers, fishers, tribal fishers, and divers. There were multiple uncertainties associated with the direct exposure to in-water sediment scenarios such as the spatial scale of the exposure areas and the exposure parameters, which are further described in the following sections. Risks were estimated separately for in-water sediment for each of the ½ mile river segment exposure areas (east (E) and west (W)) and for Study Area-wide exposure. In addition to calculating risks from in-water sediment exposure within the Study Area (which includes exposure areas from RM 1.9 to RM 11.8, including Swan Island Lagoon), risks from in-water sediment exposure were calculated for three river segments outside of the Study Area: the downstream reach (RM 1.0-1.9), the downtown river segment (RM 11.8 – 12.2), and Multnomah Channel. The exposure area from RM 11.5 to 12.0 encompasses samples from both inside and outside of the Study Area. However, Study Area-wide risks were calculated only for samples within the Study Area. Cumulative risk exceedances for in-water sediment scenarios are summarized by exposure area in Maps 5-3-1 through 5-3-2. In addition, risks from exposures to PBDEs in in-water sediment were evaluated separately and are presented in Attachment F3, following the general methodology discussed in this BHHRA.

5.12.2.1 In-Water Worker

The results of the risk evaluation for in-water worker exposure to in-water sediment are presented in Tables 5-21 through 5-22.

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The in-water worker RME scenario for in-water sediment results in cumulative cancer risk greater than 1 x x 10^{-6} at RM segments 4.5E, 6W, and 7W. . There are no exceedances of 1 x x 10^{-4} cancer risk for the in-water worker RME scenario. . The maximum cumulative cancer risk for an individual exposure area occurs at RM 7W (2 x x 10^{-5}) and is primarily due to incidental ingestion of sediment containing dioxins/furans. . The only other individual contaminant resulting in a cancer risk greater than 1 x x 10^{-6} within the Study Area is benzo(a)pyrene. . The HIs for in-water worker RME scenario do not exceed 1. .

The in-water worker RME scenarios do not result in an exceedance of 1 x x 10^{-6} cumulative cancer risk or an HI greater than 1 for exposure to in-water sediment from river segments assessed outside of the Study Area.

The in-water worker CT scenario for in-water sediment results in no exceedances of 1 x x 10^{-6} cancer risk and no exceedances of an HI of 1.

5.12.2.2 Tribal Fisher

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The results of the risk evaluation for tribal fisher exposure to in-water sediment are presented in Tables 5-23 through 5-25.

The tribal fisher RME scenario for in-water sediment results in exceedances of 1 x x 10^{-6} cumulative cancer risk in 33 of 40 river mile segments within the Study Area, and from Study Area-wide exposure (see Table 5-23). . The tribal fisher RME scenario for in-water sediment results in cumulative cancer risk greater than 1 x x 10^{-4} at RM 6W and RM 7W. RM 7W is the location of the maximum cumulative cancer risk (3 x x 10^{-4}). . Risk at RM 7W is primarily due to incidental ingestion of sediment containing dioxins/furans (risk from dioxins/furan exposure is 3 x x 10^{-4}); risk at RM 6W is primarily due to dermal contact with sediment containing benzo(a)pyrene (risk from benzo(a)pyrene exposure is 1 x x 10^{-4}). . In addition to these two contaminants, the following individual analytes also result in an individual cancer risk greater than 1 x x 10^{-6} in at least one exposure area: arsenic, PCBs, benzo(b)fluoranthene, dibenzo(a,h)anthracene, benzo(a)anthracene, indeno(1,2,3-cd)pyrene. .

Exposure areas including river mile segments outside of the Study Area that result in risks above 1 x x 10^{-6} from the tribal fisher RME scenario for in-water sediment are: RM 12W (includes samples from RM 12.0W – 12.2W), Multnomah Channel, and RM 1.5E (includes samples from RM 1.5E – RM 1.9E), RM 1E, and RM1W. . Tribal fisher exposure to in-water sediment from river segments outside of the Study Area do not result in HIs greater than 1.

The tribal fisher CT scenario for in-water sediment results in exceedances of 1 x x 10^{-6} cumulative cancer risk at two of the 40 river mile segments (RM 6W and RM 7W). . There are no exceedances of 1 x x 10^{-4} cancer risk for the tribal fisher CT scenario. . The maximum cumulative cancer risk occurs at RM 6W (6 x x 10^{-6}) and

is primarily due to exposure to sediment containing benzo(a)pyrene. . The tribal fisher CT scenario for in-water sediment results in no HIs greater than 1.

There are no risks greater than 1 x x 10^{-6} or HIs greater than 1 for CT tribal fisher exposure to in-water sediment from river segments assessed outside of the Study Area.

5.12.2.3 Fisher

To evaluate differences in fishing frequencies, risks were evaluated for both high-frequency and low-frequency fishers. . High-frequency fishers were assumed to fish from the same 1/2-mile river segment three days per week for the entire year (156 156 days/year) for the default residential exposure duration (30 years) for the RME. . Low-frequency fishers were assumed to fish from the same 1/2-mile river segment for two days per week for the entire year (104 days/year) for the default residential exposure duration (30 years) for the RME. . The results of the risk evaluation for high-frequency fisher exposure to in-water sediment are presented in Tables 5-26 through 5-28. . The results of the risk evaluation for low-frequency fisher exposure to in-water sediment are presented in Tables 5-29 through 5-30. .

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5.12.2.3.1 High-Frequency Fisher

The high-frequency fisher RME scenario for in-water sediment results in exceedances of 1 x x 10^{-6} cumulative cancer risk in 17 of 40 river mile segments within the Study Area and from Study Area-wide exposure (see Table 5-26). . There are no exceedances of 1 x x 10^{-4} cancer risk for the high-frequency fisher RME scenario. . The maximum cumulative cancer risks occur at RM 7W (8 x x 10^{-5}) and RM 6W (5 x x 10^{-5}). . At RM 7W, risk is primarily due to incidental ingestion of sediment containing dioxins/furans. . At RM 6W, risk is primarily due to dermal contact with sediment containing benzo(a)pyrene. . In addition to these chemicals, the following individual analytes also result in a cancer risk greater than 1 x x 10^{-6} in at least one exposure area: arsenic, PCBs, benzo(b)fluoranthene, dibenzo(a,h)anthracene, benzo(a)anthracene, and indeno(1,2,3-cd)pyrene. .

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For river mile segments outside of the Study Area, RM 12W is the only exposure area that results in risk above 1 x x 10^{-6} for the high-frequency fisher RME scenario for in-water sediment. . Risk at RM 12W is 2 x x 10^{-6}, primarily due to exposure to benzo(a)pyrene. . There are no exposure areas outside of the Study Area resulting in an HI greater than 1.

The high-frequency fisher CT scenario for in-water sediment results in no exceedances of 1 x x 10^{-6} cumulative cancer risk and no exceedances of an HI of 1 for exposure areas assessed inside and outside of the Study Area. .

5.12.2.3.2 Low-Frequency Fisher

The low-frequency fisher RME scenario for in-water sediment results in exceedances of 1 x x 10^{-6} cumulative cancer risk at 12 of 40 river mile segments within the Study

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Area, and from Study Area-wide exposure (see Table 5-29). . There are no exceedances of 1 x x 10^{-4} cancer risk for the low-frequency fisher RME scenario. . The maximum cumulative cancer risks occur at RM 7W (6×10^{-5}) and RM 6W (3×10^{-5}). . At RM 7W, risk is primarily due to incidental ingestion of sediment containing dioxins/furans. . At RM 6W, risk is primarily due to dermal contact with sediment containing benzo(a)pyrene. . In addition to these chemicals, the following individual analytes also result in a cancer risk greater than 1 x x 10^{-6} in at least one exposure area: PCBs, dibenzo(a,h)anthracene, benzo(a)anthracene, benzo(b)fluoranthene, and indeno(1,2,3-cd)pyrene. . The low-frequency fisher RME scenario for in-water sediment results in no HIs greater than 1.

There are no risks greater than 1 x x 10^{-6} or HIs greater than 1 for the low-frequency fisher RME scenario for exposure to in-water sediment from river segments assessed outside of the Study Area.

The low-frequency fisher CT scenario for in-water sediment results in no exceedances of 1 x x 10^{-6} cumulative cancer risk and no exceedances of an HI of 1 for exposure areas inside and outside of the Study Area. .

5.12.2.4 Diver

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Risks were evaluated for commercial divers wearing either a wet suit or a dry suit. . The results of the risk evaluation for commercial wet suit diver exposure to in-water sediment are presented in Tables 5-31 through 5-32. . The results of the risk evaluation for a commercial dry suit diver exposure to in-water sediment are presented in Table 5-33.

5.12.2.4.1 Diver in Wet Suit

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The commercial diver in a wet suit RME scenario for in-water sediment results in exceedances of 1 x x 10^{-6} cumulative cancer risk in 10 of 40 ½ mile river mile segments within the Study Area and for Study Area-wide exposure (see Table 5-31). . There are no exceedances of 1 x x 10^{-4} cancer risk for this scenario. . The maximum cumulative cancer risk (3×10^{-5}) occurs at RM 6W and RM 7W. . At RM 6W, the risk is primarily due to dermal adsorption of sediment containing benzo(a)pyrene. . At RM 7W, the risk is primarily due to dermal absorption of sediment containing dioxins and furans. . In addition to these two chemicals, the following individual analytes also result in a cancer risk greater than 1 x x 10^{-6} in at least one exposure area: PCBs, benzo(b)fluoranthene, dibenzo(a,h)anthracene, benzo(a)anthracene, and indeno(1,2,3-cd)pyrene. . The commercial diver in a wet suit RME scenario for in-water sediment results in no HIs greater than 1.

There are no exposure areas outside of the Study Area that result in risks above 1 x x 10^{-6} or HIs greater than 1 for this scenario.

The commercial diver in a wet suit CT scenario for in-water sediment results in no exceedances of 1 x 10^{-6} cumulative cancer risk and no exceedances of an HI of 1 for exposure areas assessed inside and outside of the Study Area (see Table 5-32).

5.12.2.4.2 Diver in Dry Suit

The commercial diver in a dry suit RME scenario for in-water sediment results in exceedances of 1 x 10^{-6} cumulative cancer risk in two of 40 river mile segments within the Study Area (see Table 5-33). The maximum cumulative cancer risks occur at RM 7W (1 x 10^{-5}) and RM 6W (6 x 10^{-6}). At RM 7W, risk is primarily due to incidental ingestion of sediment containing dioxins/furans. At RM 6W, risk is primarily due to dermal contact with sediment containing benzo(a)pyrene. No other analytes result in a cancer risk greater than 1 x 10^{-6} for this scenario. The commercial diver in a dry suit RME scenario for in-water sediment results in no HIs greater than 1. There are no river mile segments outside of the Study Area that result in risk above 1 x 10^{-6} or an HI greater than 1. A CT scenario was not evaluated for a commercial diver in a dry suit, per direction from EPA.

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5.12.2.5 Breastfeeding Infants of Adults Exposed to In-Water Sediment

Risks to infants consuming breastmilk from adults exposed to in-water sediment were calculated for all adult receptors for which bioaccumulative compounds were COPCs. This included all receptors assessed in this BHHRA for direct exposure to in-water sediment. These risk results are shown in Tables 5-34 through 5-44. The highest cumulative cancer risk to breastfeeding infants of adults exposed to in-water sediment occurs at RM 7W, due to consumption of dioxin/furans in human milk of a tribal fisher exposed to in-water sediment. The highest noncancer hazard to an infant also occurs at RM 7W (HI is 5).

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5.12.2.6 Summary of In-Water Sediment Risk Characterization

Direct contact with in-water sediment resulted in cumulative cancer risks ranging from 5 x 10^{-9} to 3 x 10^{-4} across all scenarios. The only HI that was greater than 1 was for the tribal fisher and high frequency fisher RME scenario due to dioxin/furans, which occurred at the ½ mile exposure area at RM 7 west (W). The highest cumulative cancer risks and HIs from direct contact with in-water sediment were for the tribal fisher scenario. Four contaminants resulted in a cancer risk greater than 1 x 10^{-6} or hazard quotient greater than 1 for at least one of the in-water sediment scenarios: PCBs, dioxins, arsenic, and PAHs. A summary of in-water sediment risks by receptor and analyte are shown in Table 5-45.

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5.12.3 Surface Water Risk Characterization Results

Potential risks from exposure to surface water through ingestion and dermal absorption were estimated for transients, recreational beach users, and divers. In addition, potential risks were estimated for a hypothetical future use of surface water as a domestic water source. There were multiple uncertainties associated with the direct exposure to surface water scenarios such as the exposure parameters, which are

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further described in the following sections, and contributions from background sources.

5.12.3.1 Transients

Risks to transients from surface water were evaluated for drinking water and bathing scenarios. . The risks were evaluated for year-round exposure to surface water for four individual transect stations, for the four transects grouped together (to represent Study Area-wide exposure), and for Willamette Cove. . In addition to these exposure areas within the Study Area, risk was evaluated for exposure to surface water for a transect in Multnomah Channel, which is outside of the Study Area. . The results of the risk evaluation for transient exposure to surface water are presented in Tables 5-46 through 5-47.

The transient RME and CT scenarios for surface water result in no exceedances of 1 x -x 10^{-6} cancer risk and no exceedances of an HI of 1 inside or outside of the Study Area. .

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5.12.3.2 Recreational Beach Users

Risks to recreational beach users from surface water were evaluated for swimming scenarios, using data from summer months. . Risks were evaluated for exposure to surface water for three transects grouped together (to represent Study Area-wide exposure) and for exposure to surface water for three individual quiescent areas during summer months. . Risks for both adults and children were evaluated, as well as cancer risks to a combined child and adult receptor, in order to incorporate early-life exposures. . The results of the risk evaluation for adult recreational beach user exposure to surface water are presented in Tables 5-48 through 5-49. . The results of the risk evaluation for child recreational beach user exposure to surface water are presented in Tables 5-50 through 5-51. . The results of the combined child and adult receptor are presented in Tables 5-52 through 5-53.

The adult, child, and combined recreational beach user RME and CT scenarios for surface water result in no exceedances of 1 x -x 10^{-6} cancer risk and no exceedances of an HI of 1. .

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5.12.3.3 Diver

Risks to commercial divers from surface water were evaluated for year-round exposure to four individual transect stations, and to single-point sampling stations within the Study Area grouped together on a ½ river mile basis, per side of river (E, W). . In addition to these exposure areas within the Study Area, risk was evaluated for exposure to surface water for a transect in Multnomah Channel, which is outside of the Study Area. . Risks were evaluated for commercial divers in wet suits and in dry suits. . The results of the risk evaluation for commercial divers in wet suits exposure to surface water are presented in Tables 5-54 through 5-55. . The results of the risk evaluation for commercial divers in dry suits are presented in Table 5-56.

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~~5.12.3.3.1 Diver in Wet Suit~~

~~The commercial diver in a wet suit RME scenario for surface water results in exceedances of 1 x 10^{-6} cumulative cancer risk in one exposure area (RM 6W). There are no exceedances of 1 x 10^{-4} cancer risk for the commercial diver in a wet suit RME scenario. The maximum cumulative cancer risk occurs at RM 6W (1 x 10^{-5}) and is primarily due to dermal contact with surface water containing benzo(a)pyrene. There are no other analytes resulting in a cancer risk greater than 1 x 10^{-6}. The commercial diver in a wet suit RME scenario for surface water resulted in no HIs greater than 1. There are no exceedances of 1 x 10^{-6} risk or an HI of 1 for surface water exposure to river segments assessed outside of the Study Area.~~

~~The commercial diver in a wet suit CT scenario for surface water results in no exceedances of 1 x 10^{-6} cumulative cancer risk and no exceedances of an HI of 1 for exposure inside or outside of the Study Area.~~

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~~5.12.3.3.2 Diver in Dry Suit~~

~~The commercial diver in a dry suit RME scenario for surface water results in exceedances of 1 x 10^{-6} cumulative cancer risk in one exposure area (RM 6W). This exposure area is the location of the maximum cumulative cancer risk (2 x 10^{-6}) and is primarily due to dermal contact with surface water containing benzo(a)pyrene. There are no individual analytes resulting in a cancer risk greater than 1 x 10^{-6}. The commercial diver in a dry suit RME scenario for surface water resulted in no HIs greater than 1. There are no exceedances of 1 x 10^{-6} risk or an HI of 1 for surface water exposure to river segments assessed outside of the Study Area.~~

~~The commercial diver in a dry suit was not evaluated for CT exposure, as directed by EPA.~~

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~~5.12.3.4 Domestic Water User~~

~~There is no known or anticipated future use of surface water within the Study Area for a domestic water supply. Because the designated beneficial use of the Willamette River is as a domestic water supply with adequate pretreatment, EPA directed that surface water be evaluated as a future domestic water source for both adult and child residents. For purposes of this BHHRA, untreated surface water was used to assess risks from future domestic water uses, so the risks are considered hypothetical. Risks were calculated for year-round exposure to surface water for the four transect stations within the Study Area and single point vertically integrated samples from Cathedral Park, Willamette Cove, and Swan Island Lagoon. In addition, Study Area-wide risk was calculated by combining the data from all vertically integrated samples to estimate Study Area-wide exposure. The results of~~

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the risk evaluation for surface water as a hypothetical future domestic water source are presented in Tables 5-57 through 5-58 for adult residents, Tables 5-59 through 5-60 for child residents, and Tables 5-61 through 5-62 for combined child and adult residents.

5.12.3.4.1 Adult Resident

The adult resident RME scenario for hypothetical future use of untreated surface water as a domestic water source results in cumulative risk exceedances of 1 x 10^{-6} at all 20 of the 20 exposure areas, and for Study Area-wide exposure (see Table 5-57). There is one exceedance of 1 x 10^{-4} cancer risk for the adult resident RME future hypothetical domestic water scenario, which occurs at RM 6.1 (cumulative risk is 3 x 10^{-4}, primarily due to benzo(a)pyrene in drinking water). Risks from untreated surface water exposure to both total and dissolved arsenic exceed 1 x 10^{-6} for all exposure areas. The adult resident RME scenario results in no HIs greater than 1.

Arsenic is a naturally occurring metal, and background concentrations in surface water may contribute to risk resulting from the hypothetical future use of untreated surface water as a domestic water source. Background concentrations for some chemicals in surface water were calculated using data collected from upstream of the Study Area, as described in Section 6 of the RI Report. The 95% percent UCL concentration of total arsenic in surface water upstream of the Study Area is 0.402 ug/l, and the 95th percentile value is 0.485 ug/l, which are both above the EPA tap water RSL for arsenic of 0.045 ug/l but below the EPA MCL of 10 ug/l. The 95% percent UCL/max EPCs for total arsenic for the hypothetical future use of untreated surface water for domestic use within the Study Area range from 0.32 to 0.60 ug/l, which include both maximum concentrations for an exposure area and 95% percent UCLs for an exposure area. EPCs at 17 out of 21 locations within the Study Area exceed 0.402 ug/l (the 95% percent UCL concentration of total arsenic in surface water upstream of the Study Area), and seven out of 21 of the EPCs exceed 0.485 ug/l (the 95th percentile value of total arsenic in surface water upstream of the Study Area). These concentrations are similar to the upstream arsenic concentration statistics. The 95% percent UCL concentration of total arsenic upstream of the Study Area (0.402 ug/l) results in a cancer risk of 7 x 10^{-6} for the adult resident exposure scenario.

The adult resident CT scenario for hypothetical use of untreated surface water as a future domestic water source results in cumulative risk exceedances of 1 x 10^{-6} at 17 of the 20 exposure areas, and for Study Area-wide exposure (see Table 5-58). There are no exceedances of 1 x 10^{-4} cancer risk for the adult resident CT future hypothetical domestic water scenario. The maximum cumulative cancer risk for the CT scenario is 3 x 10^{-5}, which occurs at RM 6.1. This exceedance is due to the hypothetical ingestion of untreated surface water containing benzo(a)pyrene. The adult resident CT scenario results in no HIs greater than 1.

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5.12.3.4.2 Child Resident

The child resident RME scenario for hypothetical future use of untreated surface water as a domestic water source results in cumulative risk exceedances of 1 x 10^{-6} at all 20 of the 20 exposure areas, and for Study Area-wide exposure (see Table 5-59). There is one exceedance of 1 x 10^{-4} cancer risk for the child resident RME future hypothetical domestic water scenario, which occurs at RM 6.1 (cumulative risk is 7 x 10^{-4}, primarily due to benzo(a)pyrene in drinking water). The child resident RME scenario results in HIs greater than 1 at two locations: RM 2.9 (Multnomah Channel) and RM 8.5. The HI at both of these locations is 2, due primarily to exposures to MCPP in drinking water.

The child resident CT scenario for hypothetical use of surface water as a future domestic water source results in cumulative risk exceedances of 1 x 10^{-6} at all 20 of the 20 exposure areas, and for Study Area-wide exposure (see Table 5-60). There is one exceedance of 1 x 10^{-4} cancer risk for the child resident CT future hypothetical domestic water scenario, which occurs at RM 6.1 (cumulative risk is 2 x 10^{-4}, primarily due to benzo(a)pyrene in drinking water). The child resident CT scenario results in no HIs greater than 1.

5.12.3.4.3 Combined Child and Adult Resident

Cancer risks for a combined child and adult resident were calculated to incorporate early life exposures, per EPA (2005) and DEQ (2010) guidance. The maximum cancer risk for the combined child and adult receptor is 9 x 10^{-4}, occurring at RM 6.1, primarily from exposures to benzo(a)pyrene in drinking water. Risks from RME and CT scenarios exceed 1 x 10^{-6} for all exposure areas evaluated.

5.12.3.5 Summary of Surface Water Risk Characterization

Direct contact with surface water resulted in cumulative cancer risks ranging from 8 x 10^{-10} to 9 x 10^{-4} across all scenarios, including hypothetical future use as a domestic water source. The only HIs that were greater than 1 were for hypothetical future use as a domestic water source by a child resident under the RME scenario. The HI was 2 at Multnomah Channel and RM 8.5, due primarily to ingestion of MCPP in surface water. Eight contaminants resulted in a cancer risk greater than 1 x 10^{-6} or hazard quotient greater than 1 for at least one of the surface water scenarios, including: benzo(a)pyrene, benzo(a)anthracene, benzo(b)fluoranthene, dibenzo(a,h)anthracene, indeno(1,2,3-cd)pyrene, MCPP, arsenic, hexavalent chromium, and total PAHs. A summary of risks from exposure to surface water is provided in Table 5-63.

5.12.4 Groundwater Seep Risk Characterization Results

Only one groundwater seep was identified in a transient or recreational use area where upland COIs were potentially discharging. The seep identified is actually the potential groundwater discharge that could occur from Outfall 22B, which discharges

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into a transient use area. . As a result, risks to transients from potential exposure to groundwater seeps were evaluated at that beach (07B024). .

5.12.4.1 Transients

Risks to transients from the groundwater seep were evaluated for direct contact scenarios. . There were multiple uncertainties associated with the exposure parameters for the direct exposure to groundwater seeps scenario. . To evaluate the risks from exposure to the groundwater seep without stormwater influence, outfall data from stormwater sampling events was excluded from the dataset. . The results of the risk evaluation for transient exposure to the groundwater seep are presented in Tables 5-64 through 5-65.

The transient RME and CT scenarios for the groundwater seep results in no exceedances of 1 x 10^{-6} cancer risk and no exceedances of an HI of 1. .

6.1.1.1 Summary of Groundwater Seep Risk Characterization

There were no cancer risk or noncancer hazard exceedances from exposure to the groundwater seep. . A summary of groundwater seep risks is provided in Table 5-66.

5.12.5 Fish Consumption Risk Characterization Results

Potential risks from fish consumption were estimated for fisher and tribal fisher scenarios. . There were multiple uncertainties associated with the fish consumption scenarios such as assumptions regarding fish consumption rates, tissue type and fish species consumed, EPCs, and the use of cooking and preparation methods[7]. . Uncertainties associated with this scenario are discussed further in Section 6.

5.12.5.1 Tribal Fishers

Risks to tribal fishers who consume fish caught within the Study Area were evaluated for a multi-species diet that includes salmon, lamprey, and sturgeon, in addition to resident fish species. . A single ingestion rate for the multi-species diet was used to evaluate risks to the tribal fish consumer. . Risks were evaluated using both 95% percent UCL/max and mean Study Area-wide tissue concentrations for both fillet and whole body tissue (see Section 3.4.5). . Risks were higher for whole body tissue than for fillet tissue; however, fillet tissue was not analyzed for PCB or dioxin/furan congeners in all resident species. . The results of the risk evaluation for adult tribal fish consumption are presented in Tables 5-67 through 5-70. . The results of the risk evaluation for child tribal fish consumption are presented in Tables 5-71 through 5-74, and the results of the risk evaluation for the combined child and adult tribal consumers of fish are presented in Tables 5-75 through 5-76.

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[7] For the purposes of the risk calculations, reference to "uncooked" fish tissue is the same as not accounting for reductions in contaminant concentrations from cooking or other food preparation.

5.12.5.1.1 Tribal Adult, Fish Consumption

The risks ranged from a cumulative cancer risk of 2 x 10^{-2} for the 95% percent UCL/max EPCs of whole body tissue to a cumulative cancer risk of 2 x 10^{-3} for the mean EPCs of fillet tissue. For all scenarios, estimated risks are above a 1 x 10^{-4} cumulative cancer risk and are primarily due to PCBs and dioxins/furans. Figure 5-8 shows the relative risk contribution of individual COPCs for both whole body and fillet tissue diets of an adult tribal consumer, and Figure 5-9 shows a comparison of total risk per tissue type.

The cumulative HIs ranged from 400 for the 95% percent UCL/max EPCs of whole body tissue to 50 for the mean EPCs of fillet tissue. For the whole body tissue, 95% percent UCL/max EPC scenario, the PCB HQ is approximately 26 times higher than any other HQ. The toxicity endpoint for PCBs is immunological and skin. The immunological and skin specific HIs for tribal adult consumption are the highest endpoint specific HIs, and exceed the next highest HI by a factor of 10. Additional endpoints that exceed an HI of 1 for the tribal adult 95% percent UCL/max consumption scenario are reproduction, central nervous system (CNS), and blood.

The multi species diet evaluated in this BHHRA included resident fish as well as salmon, sturgeon, and lamprey. Because salmon, sturgeon, and lamprey spend time outside the Study Area, the risks from ingestion of salmon, sturgeon, and lamprey cannot be conclusively associated with sources within the Study Area. However, resident fish accounted for approximately 95 percent of the cumulative risk in the whole body diet. Of the four resident fish species included in the multi species diet, risks from ingestion of smallmouth bass and common carp were the primary contributors to the cumulative risk.

5.12.5.1.2 Tribal Child, Fish Consumption

The risks ranged from a cumulative cancer risk of 3 x 10^{-3} for the 95% percent UCL/max EPCs of whole body tissue to a cumulative cancer risk of 4 x 10^{-4} for the mean EPCs of fillet tissue. For all scenarios, risks are above a 1 x 10^{-4} cumulative cancer risk and are primarily due to PCBs and dioxins/furans.

The cumulative HIs ranged from 800 for the 95% percent UCL/max EPCs of whole body tissue to 100 for the mean EPCs of fillet tissue. The PCB HQ for the whole body tissue diet is approximately 26 times higher than any other HQ. The immunological and skin specific HIs for tribal child consumption are the maximum endpoint-specific HIs, and exceed the next highest HI by a factor of 10. Additional health endpoints that exceed an HI of one for the tribal child 95% percent UCL/max consumption scenario are reproduction, CNS, liver, and blood.

The multi species diet evaluated in this BHHRA included resident fish as well as salmon, sturgeon, and lamprey. Because salmon, sturgeon, and lamprey spend time outside the Study Area, the calculated risks from ingestion of salmon, sturgeon, and lamprey cannot be conclusively associated with sources within the Study Area.

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However, resident fish accounted for approximately 95 percent of the cumulative risk associated with this scenario.

5.12.5.1.3 Combined Tribal Child and Adult, Fish Consumption

Cancer risks were calculated for the combined child and adult tribal fisher scenarios in order to incorporate early life exposures (EPA 2005, DEQ 2010). . Cumulative cancer risks from fish consumption for the combined child and adult tribal fisher ranged from 3 x x 10^{-3} (fillet tissue consumption, mean scenario) to 2 x x 10^{-2}, (whole body tissue consumption, 95% percent UCL/Max scenario) primarily due to ingestion of PCBs in tissue. . The results of the combined tribal child and adult cancer risks for consumption of fish tissue are presented in Tables 5-75 and 5-76.

5.12.5.1.4 Breastfeeding Infant of Tribal Adult Who Consumes Fish

Risks and hazards to an infant consuming human milk of a tribal adult who consumes fish were calculated for bioaccumulative compounds, consistent with EPA (2005) and DEQ (2010) guidelines. . These risks are presented in Tables 5-77 and 5-78. . Cancer risks range from 2 x x 10^{-3} to 2 x x 10^{-2}, and noncancer hazards range from 1,000 to 9,000.

5.12.5.1.5 Summary of Risks from Tribal Consumption of Fish

A summary of risks from tribal consumption of fish is provided in Table 5-79. . Both cancer risks and noncancer hazards exceed the target risk values of 1 x x 10^{-6} and 1, respectively, for all tribal receptors.

5.12.5.2 Non-tribal Fishers

Risks for the non-tribal fish consumption scenarios were estimated for both single- and multi-species diets consisting only of resident fish species (smallmouth bass, black crappie, brown bullhead, and common carp). . Risks were estimated separately for each exposure area (based on species home range) and for Study Area-wide exposure. . Consumption of smallmouth bass was evaluated on a river mile basis, and consumption of common carp, brown bullhead, and black crappie was evaluated on a fishing zone basis (fishing zones were designated from RM 3-6 and from RM 6-9 for black crappie and brown bullhead, and from RM 3-6, RM 6-9, RM 0-4, RM 4-8, and RM 8-12 for common carp). . In addition to evaluating risks using mean and 95% percent UCL/max tissue concentrations for both whole body and fillet tissue, each fish consumption scenario was evaluated using three different ingestion rates for adult and child consumers. . The results of the risk evaluation for fish consumption by an adult are presented in Tables 5-80 through 5-119. . The results of the risk evaluation for fish consumption by a child are presented in Tables 5-120 through 5-159. . The results of the risk evaluation for fish consumption by a combined child and adult receptor are presented in Tables 5-160 through 5-169. In addition, Maps 5-4-1 through 5-7-3 show exposure areas with risk exceedances from 95% percent UCL/max EPCs for single species diets, at the 17.5 g/day, 73 g/day, and 142 g/day ingestion rates for adults.

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5.12.5.2.1 Adult, Fish Consumption

Risks to adult fish consumers were evaluated for ingestion rates of 142 g/day, 73 g/day, and 17.5 g/day. . These rates correspond to approximately 19 meals per month, 10 meals per month, and two meals per month, based on an 8-ounce serving size, every month of the year exclusively of resident fish caught within the Study Area.

The highest risk for all adult consumer scenarios was equal to a cumulative cancer risk of 6 x x 10^{-2}. . This was for the scenario based on the 95% percent UCL/max EPC, 142 g/day ingestion rate, and a fish diet comprised solely of whole body common carp. . The lowest risk was equal to a cumulative cancer risk of 7 x x 10^{-6} for the 95% percent UCL/max and mean EPCs, 17.5 g/day ingestion rate, and a fish diet comprised solely of black crappie fillet tissue. . For all tissue consumption scenarios, PCBs are the primary contributor to cumulative cancer risks. . The highest cumulative HI from fish tissue ranged from 3,000 for the 95% percent UCL/max EPC, 142 g/day ingestion rate, common carp fillet tissue scenario to 0.5 for the mean EPC, 17.5 g/day ingestion rate, black crappie fillet tissue only scenario. . For the 95% percent UCL/max EPC, multi species, whole body tissue scenario, the PCB HQ is approximately 30 times higher than the HQ for any other chemical. . . In general, the immunological specific HIs for adult consumption scenarios are the highest of all endpoint specific HIs, and exceed the next highest HIs by a factor of 10 to 100. . Additional health endpoints that exceed an HI of 1 for the 95% percent UCL/max EPCs at the 17.5 g/day ingestion rate are reproduction, CNS, liver, skin, and blood.

Figures 5 10 through 5 17 show a summary of risk results for adult consumption of tissue for single species diets. . These figures illustrate the relative contribution of individual COPCs to total risk for both whole body and fillet tissue consumption, per river mile, per fishing area, and per species. .

In general, risks from consuming whole body tissue were greater than risks from consuming fillet tissue; however, fillet tissue was not analyzed for PCB or dioxin/furan congeners in black crappie or brown bullhead, and therefore PCB TEQ and dioxin/furan TEQ risks could be not evaluated in fillet tissue for those species. . Smallmouth bass and common carp diet scenarios generally resulted in higher risks than the other diets evaluated. . Black crappie diet scenarios generally resulted in the lowest risks of the diets evaluated. .

5.12.5.2.2 Child, Fish Consumption

Risks to child consumers were evaluated for 60 g/day, 31 g/day, and 7 g/day ingestion rates. . The risks for all child consumer scenarios ranged from a cumulative cancer risk of 2 x x 10^{-2} for the 95% percent UCL/max EPC, 60 g/day ingestion rate, common carp whole body tissue only scenario to a cumulative cancer risk of 3 x x 10^{-6} for the mean EPC, 7 g/day ingestion rate, black crappie fillet tissue only scenario. . For all tissue consumption scenarios, PCBs are the primary contributor to cumulative cancer risks. .

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The highest endpoint-specific HIs ranged from 5,000 for the 95% percent UCL/max EPC, 60 g/day ingestion rate, common carp whole body tissue-only scenario to 0.9 for the mean EPC, 7 g/day ingestion rate scenario for black crappie fillet tissue-only scenario. . For the 95% percent UCL/max EPC, multi-species, whole body tissue diet scenario, the PCB HQ is approximately 30 times higher than the HQ for any other chemical. . In general, the immunological-specific HIs for child consumption scenarios exceed the next highest HIs by a factor of approximately 10. . Additional health endpoints that exceed an HI of 1 for the child 95% percent UCL/max consumption scenarios at the 31 g/day ingestion rate are reproduction, CNS, liver, skin, and blood.

In general, risks from whole body tissue were greater than risks from fillet tissue. . Smallmouth bass and common carp diet scenarios generally resulted in higher risks than the other diets evaluated. . Black crappie diet scenarios generally resulted in the lowest risks of the diets evaluated. .

5.12.5.2.3 Combined Child and Adult, Fish Consumption

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Cancer risks were calculated for a combined child and adult consumer of fish, to account for early life exposures, for all fish consumption scenarios evaluated in this BHHRA. . Results for the evaluation of combined child and adult cancer risks from fish consumption are presented in Tables 5-160 through 5-169. . Cancer risks for the combined child and adult consumer of fish are generally the same order of magnitude as adult-only risks. . The highest cumulative cancer risk for the combined child and adult consumer is 7 x 10^{-2}, which occurs at the child ingestion rate of 60 g/day and the adult ingestion rate of 142 g/day, due to consumption of whole body carp from the fishing zone covering RM 4 through RM 8.

5.12.5.2.4 Breastfeeding Infant of Adult Who Consumes Fish

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Risk and hazards to infants consuming human milk from adults consuming fish collected from the Study Area were assessed for bioaccumulative compounds for all adult fish consumption scenarios, in accordance with EPA (2005) and DEQ (2010) guidance. . Cancer risks to infants were calculated by applying an IRAF to the combined child and adult cancer risk from fish consumption. . Noncancer hazards were calculated by applying an IRAF to the adult HQ for each fish consumption scenario. . Results of the risk and hazard calculations for breastfeeding infants of adult consumers of fish are provided in Tables 5-170 through 5-179. . The highest cancer risk to a breastfeeding infant of an adult consumer of fish is 7 x 10^{-2}, due primarily to PCBs in breastmilk. . The highest noncancer hazard is 60,000, also due primarily to PCBs in breastmilk.

5.2.5.3 Consideration of Regional Tissue Concentrations

PCBs and dioxins/furans have been detected in fish tissue collected in the Willamette and Columbia Rivers, outside of the Study Area. . In the Columbia River Basin Fish Contaminant Survey, the basin-wide average concentrations of total PCBs in resident fish ranged from 0.032 to 0.173 parts per million (ppm) for whole body samples and

from 0.033 to 0.190 ppm for fillet with skin samples (EPA 2002c). In the Middle Willamette River (RM 26.5 to 72), the average concentrations of total PCBs in resident fish ranged from 0.086 to 0.146 ppm for whole body samples and from 0.026 to 0.071 ppm for fillet with skin samples (EVS 2000). . These concentrations are lower than the concentrations detected in the Study Area where average concentrations ranged from 0.16 to 2.8 ppm in whole body samples and from 0.17 to 2.5 ppm in fillet with skin samples (for PCBs as total congeners). . The fish species included in the studies were different than those collected within the Study Area, so the concentrations may not be directly comparable. Sources contributing to the PCBs and dioxins/furans detected in fish collected outside of the Study Area are unknown and may not be relevant to the Study Area. .

In addition, the LWG collected upstream fish tissue samples at RM 20 and 28 during Round 1. . The data for the upstream fish tissue samples are described in further detail in Section 5.5 of the RI Report. . While there are a limited number of samples and species in the upstream fish tissue dataset, the results from the upstream fish tissue are consistent with the results from the Columbia and mid-Willamette River studies.

The EPA established a target fish tissue concentration of 0.0015 ppm for PCBs to allow a monthly fish consumption rate of more than 16 meals per month (EPA 2000c). The highest fish ingestion rates used in this BHHRA, 142 g/day for adult fishers and 175 g/day for adult tribal fishers, equate to over 19 and 23 meals per month, respectively, assuming an eight-ounce meal size.

The target fish tissue concentration established by EPA is based on a target cancer risk level of 1 x 10^{-6}. . The regional PCB concentrations detected in resident fish from the Willamette and Columbia Rivers are approximately 20 to 100 times higher than the EPA target fish tissue concentration. These concentrations from outside of the Study Area are equivalent to cancer risks ranging from 2 x 10^{-5} to 1 x 10^{-4} relative to the EPA target fish tissue concentration, indicating that regional concentrations of PCBs exceed the lowest target cancer risk level of 1 x 10^{-6} for fish consumption rates higher than 16 meals per month. For noncancer endpoints, the EPA established a target tissue concentration is 0.0059 ppm. . Concentrations detected in resident fish from the Willamette and Columbia Rivers are up to 30 times higher than this target tissue concentration. Regional efforts are underway to reduce concentrations in fish tissue.

5.2.5.4 Summary of Fish Consumption Risk Characterization

Consumption of individual species by the fisher resulted in cumulative cancer risks ranging from 7 x 10^{-6} to 6 x 10^{-2} for the adult consumer and from 3 x 10^{-6} to 2 x 10^{-2} for the child consumer. . The maximum endpoint-specific hazard index (HI) for both adult and child fish consumption scenarios was for the immunological endpoint, primarily due to consumption of PCBs in tissue. . The highest HI for the immunological endpoint occurs from child consumption of whole body common carp

tissue from river miles (RM) 4-8. . The range of HIs for the immunological endpoint across all single-species exposure scenarios evaluated for non-tribal consumers is from 0.9 to 3,000 for the adult fish consumer and from 0.7 to 5,000 for the child fish consumer.

Fish consumption risks were also evaluated for adult and child tribal fishers based on the 95th percentile ingestion rate from the CRITFC Consumption Study (1994). The tribal fish consumption risks assumed a multi-species diet consisting of resident fish species (common carp, black crappie, brown bullhead, and smallmouth bass) as well as sturgeon, lamprey, and salmon. . Risks from the tribal fish diet were based on consumption of either whole body or fillet with skin tissue. . It was assumed that all fish consumed were caught within the Study Area. . Consumption of fish by the tribal fisher resulted in cumulative cancer risks ranging from 2 x _x 10^{-3} to 2 x _x 10^{-2} for the tribal adult fisher and from 4 x _x 10^{-4} to 3 x _x 10^{-3} for the tribal child consumer. . The maximum endpoint-specific HIs for both the tribal adult and tribal child fishers were for the immunological endpoint, primarily due to consumption of PCBs in fish tissue. . The range of immunological HIs for all tribal fisher fish consumption scenarios was from 50 to 400 for the tribal adult and from 100 to 800 for the tribal child.

Twenty-four contaminants resulted in a cancer risk greater than 1 x _x 10^{-6} or hazard quotient greater than 1 for at least one of the fish consumption scenarios evaluated in the draft BHHRA. The contaminants identified as posing potentially unacceptable risks were: PCBs, dioxins, six metals (antimony, arsenic, lead, mercury, selenium, and zinc), bis 2-ethylhexyl phthalate (BEHP), PAHs, hexachlorobenzene, and eleven pesticides (aldrin, dieldrin, heptachlor epoxide, total chlordane, total DDD, total DDE, total DDT, alpha-, beta, and gamma-hexachlorocyclohexane, and heptachlor). . Of these, PCBs resulted in the highest cancer risks and hazard quotients.

A summary of risks from fish consumption is provided in Tables 5-180 and 5-181.

5.12.6 Shellfish Consumption Risk Characterization Results

5.12.6.1 Adult, Shellfish Consumption

Potential risks from shellfish consumption were estimated for the adult fisher scenarios. . Risks to adult shellfish consumers were evaluated for clam and crayfish diets. . For crayfish, risks were evaluated for each sample station and for Study Area-wide exposure. . For clam, risks were evaluated on a river-mile basis and for Study Area-wide exposure separately for depurated and undepurated tissue, as agreed upon with EPA. . Risks were estimated for an 18 g/day ingestion rate, which equates to approximately two and a half 8-ounce meals per month, and for a 3.3 g/day ingestion rate, which is just less than an 8-ounce meal every 2 months. . Risks were calculated using both the 95% percent UCL/max and mean tissue concentrations of shellfish tissue. . The results of the risk evaluation for shellfish consumption are presented in

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Tables 5-182 to 5-193. . Cumulative risk exceedances for shellfish scenarios are summarized by exposure point in Maps 5-8-1 through 5-8-4. .

Estimated risks from shellfish consumption within the Study Area ranged from a high cumulative cancer risk of 7 x x 10^{-4}, which was for the 95% percent UCL/max EPCs, 18 g/day ingestion rate undepurated clam tissue scenario, to a cumulative cancer risk of 9 x x 10^{-7}, which was for the mean EPC, 3.3 g/day ingestion rate crayfish tissue scenario. . Estimated risks from shellfish consumption in areas assessed outside of the Study Area ranged from 2 x x 10^{-6} to 8 x x 10^{-5}. Clam samples were not all analyzed for the same chemicals, and the uncertainties associated with the resulting risks are discussed in Section 6. . Study Area-wide risks from ingestion of undepurated clam tissue are two to three times higher than Study Area-wide risks from ingestion of depurated clam tissue, as shown in Table 5-182 and Table 5-183. Depurated clam tissue samples were collected from five locations at the northern and southern edges of the Study Area, while undepurated clam tissue samples were collected from 22 locations throughout the Study Area. . For all high ingestion rate scenarios, risks are above a 1 x x 10^{-6} cumulative cancer risk and are primarily due to PCBs.

Figures 5-18 through 5-21 show the relative contribution of individual COPCs to total risks from clam and crayfish consumption, as well as a summary of total risks per exposure point for the different ingestion rates.

The cumulative HIs from shellfish consumption ranged from 40 for the 95% percent UCL/max EPCs, 18 g/day ingestion rate, undepurated clam tissue scenario to 0.06 for the mean EPCs, 3.3 g/day ingestion rate, crayfish tissue scenario. . Noncancer hazards above an HI of 1 are primarily due to PCBs. Study Area-wide HIs from ingestion of undepurated clam tissue are one to two times higher than Study Area-wide risks from ingestion of depurated clam tissue. . These results are shown in Table 5-182 and Table 5-183.

5.12.6.2 Breastfeeding Infant of Adult Who Consumes Shellfish

Risk and hazards to infants consuming human milk from adults consuming shellfish were assessed for bioaccumulative compounds for all adult shellfish consumption scenarios, in accordance with EPA (2005) and DEQ (2010) guidance. . Cancer risks and noncancer hazards to infants were calculated by applying an IRAF to the adult cancer risk and noncancer results from shellfish consumption, as shown in Tables 5-194 through 5-197. . The highest cancer risk to a breastfeeding infant of an adult consumer of shellfish is 7 x x 10^{-4}, from human milk consumption of an adult who consumed undepurated clam tissue at the 18 g/day ingestion rate. . The risk is primarily from PCBs in breastmilk. . The highest cumulative hazard quotient from bioaccumulative chemicals is 800 due primarily to PCBs in breastmilk.

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6.1.1.1 Summary of Risks from Consumption of Shellfish

A summary of risks from consumption of Shellfish is provided in Table 5-198 by receptor and analyte. . Cancer risks and noncancer hazards exceed the targets of 1 x 10^{-6} and 1, respectively, for all scenarios evaluated.

5.12.7 Evaluation of Cumulative and Overlapping Scenarios

As shown in the conceptual site model (Figure 3-1), multiple exposure scenarios may exist for a given population. . For example, recreational beach users are potentially exposed to both beach sediment and surface water. . The risks for each of the exposure scenarios that are considered potentially complete and significant for a given population were summed to estimate the cumulative risks for that population. . The cumulative risks are presented in Table 5-199 for 95% percent UCL/max exposures, and in Table 5-200 for mean exposures. . Additionally, cumulative risks for divers exposed to both in-water sediment and surface water are presented on a ½-river mile basis, per side of river, in Table 5-201 for RME exposures and Table 5-202 for CT exposures.

As discussed in Section 3, certain individuals may be exposed to COPCs within the Study Area through multiple exposure scenarios; for example, a recreational beach user might also be a fisher. . This BHHRA quantitatively estimated risks for the individual exposure scenarios. . Due to multiple exposure locations over different scales for both RME and CT scenarios, as well as ranges of ingestion rates and multiple diets for fish consumption, there are numerous potential combinations of overlapping scenarios. . As a result, this BHHRA did not quantitatively evaluate all possible overlapping scenarios. . However, risks from fish consumption are generally at least an order of magnitude higher than risks from other exposure scenarios, so if an individual consumes fish, the contribution from other exposure scenarios is not likely to contribute significantly to the overall risks for that individual. .

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5.12.8 Risk Characterization of Lead

A great deal of information on the health effects of lead has been obtained through decades of medical observation and scientific research. . By comparison to most other environmental toxicants, the degree of uncertainty about the health effects of lead is quite low. . The adverse health outcomes, which include neurotoxic and developmental effects, may occur at exposures so low that they may be considered to have no threshold. . EPA views it to be inappropriate to develop noncarcinogenic "safe" exposure levels (RfDs) for lead. . Because age, health, nutritional state, body burden, and exposure duration influence the absorption, release, and excretion of lead, EPA has not established standard toxicity endpoints values for lead based on an external dose. . Instead, the concentration of lead in the blood is used as an index of the total dose of lead, regardless of the route of exposure (EPA 1994). . As a result, blood lead levels, rather than intakes, are used to evaluate potential risks associated with exposure to lead. . The Centers for Disease Control (CDC) has identified a

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blood lead level of 10 micrograms per deciliter (µg/dl) as the level of concern above which significant health risks may occur (CDC 1991). . An acceptable risk for lead exposure to lead typically equates to a predicted probability of no more than 5 percent greater than the 10 µg/dl level (EPA 1998b). .

Lead was identified as a COPC for in-water sediment, fish and shellfish. . The following discusses the evaluation of risks from lead for each of those media.

5.12.8.1 In-Water sediment

Lead was identified as a COPC for in-water sediment because the maximum detected concentration exceeds the RSL for industrial soil of 800 mg/kg. . The RSL was developed to be protective of the fetus of a pregnant woman exposed to lead. . The only receptors for in-water sediment exposures are adults. . Therefore, the fetus of a pregnant in-water worker or fisher is the most sensitive scenario for exposure to lead in in-water sediment, and the RSL is protective of that scenario. . While maximum detected concentrations were used in identifying COPCs, EPCs were used to calculate risks. . The maximum EPC for one of the in-water sediment exposure areas (2,200 mg/kg) is greater than the RSL. The adult lead model (ALM, Version 5/19/05, EPA 2003c) was used to estimate the probability of exceeding a target blood level for lead of 10 µg/dl from exposure to in-water sediment. Exposure parameters from Table 3-27 were used to develop site-specific ALM input parameters. . For scenarios modeling exposure to in-water sediment, the exposure factors from Table 3-27 were adjusted with the assumption of a 25% percent sediment contact frequency. . For ALM parameters without site-specific values, the model defaults for the West Region from Phases 1 and 2 of the National Health and Nutrition Evaluation Survey (NHANES III) (EPA 2002e) were used. . The site-specific ALM blood lead concentration estimates for receptors potentially exposed to in-water sediment within the Study Area are presented in Tables F5-1 and F5-2 of Attachment F5.

Using the maximum EPC of 2,200 mg/kg, the maximum estimated probability of exceeding a fetal blood lead level of 10 µg/dL for any in-water sediment exposure scenario is one percent, which is for the RME in-water worker and RME high-frequency fisher scenarios. . Because the maximum EPC for lead results in a probability of exceeding protective blood lead levels in the fetus of a pregnant woman that is less than 5 percent, lead is not considered a chemical potentially posing unacceptable risks for in-water sediment. . All other EPCs for lead were below the RSL. . The uncertainty associated with the evaluation of lead is discussed further in Section 6.

5.12.8.2 Fish

Lead was identified as a COPC for fish consumption because it was detected in fish tissue. . The Columbia River Basin Fish Contaminant Survey (EPA 2002c) determined fish tissue concentrations for lead that are unlikely to result in blood lead levels exceeding 10 µg/dl for the fetus of a pregnant adult, and for children. . These

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~~concentrations were developed using the ALM (EPA 2003c) and the Integrated Exposure Uptake Biokinetic Model for Lead in Children (IEUBK, EPA 2007d), in combination with the fish ingestion rates from the CRITFC Fish Consumption Survey (CRITFC 1994). . The concentrations of concern were developed using health protective exposure assumptions and were considered unlikely to underestimate risks from fish consumption.~~

~~*Adults*~~
~~The following equations from the ALM were used in the Columbia River Basin Fish Contaminant Survey (EPA 2002c) to develop tissue concentrations to be protective of fetuses of tribal adults:~~
~~$PbB_a = PbB_o + BKSF * (PbF * IR_F * AF_F * EF_F)/AT$~~
~~$PbBf = PbB_a * 0.9$~~

~~Probability that fetal blood lead is less than 10 µg/dl using the z-value where:~~
~~$p' = \Phi z [(\ln(PbBf) - \ln(10)) / \ln(GSD)]$~~

~~Where:~~
~~PbB_a = Central tendency of adult blood lead level~~
~~PbB_o = Adult baseline blood lead level~~
~~PbBf = Fetal blood lead level~~
~~GSD = Geometric standard deviation~~
~~BKSF = Biokinetic slope factor~~
~~PbF = Lead fish tissue concentration~~
~~IR_F = Fish tissue ingestion rate~~
~~AF_F = Absolute gastrointestinal ingestion factor for ingested lead in tissue~~
~~EF_F = Exposure frequency of fish ingestion~~
~~AT = Averaging time~~

~~The EPA (2003c) ALM approach was used to determine protective fish tissue concentrations for the fetuses of both adult fishers and adult tribal fishers in the Study Area, using updated default ALM assumptions for the West Region, which are based on current EPA guidance (EPA 2003c). . Differences in default parameter values from the EPA (2003c) application of the ALM to the ALM application for this BHHRA include a change in PbB_o from 2.2 µg/dl to 1.4 µg/dl, and a change in AF_F from 0.1 to 0.12.~~

~~The evaluation of risks from lead is based on geometric mean levels and associated probabilities, so median values are generally used as inputs to the equations. . The mean estimate of national per capita fish consumption of 7.5 g/day was used as the consumption rate for adults (EPA 2000b). . The median fish ingestion rate for tribal fishers is 39.2 g/day, as stated in the CRITFC Fish Consumption Survey (CRITFC 1994) and used by the EPA (2002c) in calculations of protective lead tissue concentrations. . The ALM inputs and~~

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results for estimating protective lead tissue concentrations for fetuses of adult fishers and adult tribal fishers consuming fish in the Study Area are provided in Table F5-

3 of Attachment F5.

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Using the above equations, the ALM predicts that fetal blood lead levels will exceed 10 µg/dl less than 5 percent of the time for adult fishers at a lead fish tissue concentration of 5.25 mg/kg. . The maximum fish tissue EPC for lead in the Study Area is 1,100 mg/kg, detected in a smallmouth bass whole body tissue sample. . This is above the protective concentration of 5.25 mg/kg. . However, this maximum EPC is orders of magnitude greater than all other resident fish EPCs and may be attributable to lead in the gut of the fish due to the ingestion of a metallic object (e.g., sinkers) (Integral 2008). . There are no other resident fish tissue EPCs which exceed a protective lead concentration of 5.25 mg/kg. . Therefore, while lead is considered a preliminary chemical potentially posing unacceptable risks for fish ingestion by an adult fisher, the uncertainties associated with the maximum detected concentration and evaluations of lead are discussed further in Section 6. .

The protective lead tissue concentration for fetuses of tribal adults, using the above methods, is 1.01 mg/kg. . The maximum fish tissue lead EPC for an adult tribal fisher is 23 mg/kg. . However, the tribal fisher tissue ingestion scenario is for a multi-species diet consisting of both resident and anadromous species. . There are no detected concentrations in anadromous species exceeding 1.01 mg/kg. . Over 99% percent of the lead in the maximum lead EPC for tribal fishers is attributable to the Study Area-wide EPC for lead in smallmouth bass, which is influenced by the maximum EPC mentioned above for adult fishers. . Therefore, while lead is considered a preliminary chemical potentially posing unacceptable risks for fish ingestion by an adult tribal fisher, the uncertainties associated with the maximum detected concentration and evaluations of lead are discussed further in Section 6. .

Children

The EPA (2002c) used the IEUBK model in the Columbia River Basin Fish Contaminant Survey to determine risks from ingestion of lead in tissue in tribal children. . The same IEUBK methodology was applied to assess risks to children from ingestion of lead in fish tissue for this BHHRA.

To assess risks to children from ingestion of lead in fish tissue, a protective tissue concentration of lead in fish tissue was calculated using the IEUBK model with all exposure parameters set to default levels and with the addition of a fish ingestion rate based on the child consumption scenario for this BHHRA. . The default exposure parameters for the IEUBK model, provided as Table F5-4, are the same model parameters used by the EPA (2002c) because site-specific values for soil lead concentration, house dust lead concentration, lead concentration in air and drinking water are not readily available. The ratio of child to adult consumption rates of 0.42, described in Section 3.5.1.5, was applied to the consumption rate for adults of 7.5

g/day to obtain a consumption rate for children of 3.15 g/day. . In accordance with the methodology used by the EPA (2002c), fish ingestion was specified in the IEUBK model as the percentage of meat in diet consisting of locally caught fish and the lead concentrations in the fish. . The protective fish tissue concentration for a child consumer, using the above method, is 2.6 mg/kg lead in fish tissue. . The protective fish tissue concentration of 2.6 mg/kg is the fish tissue concentration resulting in predicted geometric blood lead level of 4.6 µg/dl and the probability of achieving a blood lead level greater than 10 µg/dl is no more than 5 percent. .

The Columbia River Basin Fish Contaminant Survey (EPA 2002c) determined that 0.5 mg/kg is a protective tissue concentration for tribal children consuming tissue at a rate of 16.2 g/day, which is the 65th percentile consumption rate from their survey. . Within the Portland Harbor Study Area, the maximum lead tissue EPC for the tribal child consumption scenario is 23 mg/kg, which is greater than the estimated protective concentration. . Over 99% percent of this concentration is attributable to the contribution from the Study Area-wide smallmouth bass EPC. . There are no anadromous species with detected lead concentrations exceeding 0.5 mg/kg. . Therefore, while lead is considered a preliminary chemical potentially posing unacceptable risks for fish tissue for a tribal child consumer, the uncertainties associated with the maximum detected concentration and evaluations of lead are discussed further in Section 6. .

5.12.8.3 Shellfish

Lead was identified as a COPC for shellfish consumption because it was detected in shellfish tissue. . Shellfish consumption was only evaluated for adult scenarios. . Therefore, the tissue concentration of concern for fetuses is the only tissue concentration relevant for shellfish consumption. . The CRITFC approach to assessing risks from lead using the ALM was applied to the shellfish ingestion scenario for the site. . Using the ALM equations applied to adult fishers in the previous section, the mean shellfish ingestion rate of 3.3 g/day, and the maximum shellfish exposure point concentration of 1,320 µg/kg, the ALM predicts that fetal blood lead levels will exceed 10 µg/dl less than 5 percent of the time. . Therefore, lead is not considered a chemical potentially posing unacceptable risks for shellfish consumption. The ALM parameter values and results used to assess risk from adult exposure to lead via ingestion of shellfish are shown in Attachment F5.

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5.135.3 CUMULATIVE RISK ESTIMATESSUMMARY OF RISK CHARACTERIZATION

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Cancer risk and noncancer hazard from site-related contamination was characterized based on current and potential future uses at Portland Harbor, and a large number of different exposures scenarios were evaluated. Exposure to bioaccumulative contaminants (PCBs, dioxins/furans, and organochlorine pesticides, primarily DDE/DDD/DDT) via consumption of resident fish consistently poses the greatest

potential for human exposure to in-water contamination. The ranges of estimated potential risks resulting from the different exposure scenarios evaluated in this BHHRA are summarized in Table 5-203. . The ranges included in Table 5-203 for different scenarios reflect differences in CT vs. RME scenarios, differences in tissue EPCs (mean vs. 95% percent UCL/max), level of fish consumption (17.5 g/day [EPA 2002b], 73 g/day [Adolfson 1996], and 142 g/day [EPA 2002b]), location of sediment (for beach scenarios), tissue type (whole body vs. fillet or depurated vs. undepurated), and species of fish consumed. . There were multiple uncertainties associated with the different scenarios such as the spatial scale of EPCs, sediment and surface water exposure parameters, tissue consumption rates, tissue type and fish and shellfish species consumed, fish and shellfish cooking and preparation methods, and contributions from background. .

In general, the risks from fish consumption are higher than any of the other exposure scenarios evaluated in this BHHRA. . These risks can be summarized as follows:

- The range of cumulative risks from all fish consumption scenarios is 3 x x 10^{-6} to 7 x x 10^{-2}, and the cumulative HIs range from 0.5 to 5,000. . The highest HI for a breastfeeding infant of a fish consumer is 60,000. .

- Cumulative cancer risks from consumption of shellfish range from 9 x x 10^{-7} to 7 x x 10^{-4}, and the cumulative HIs range from 0.06 to 40. . The highest HI for a breastfeeding infant of a shellfish consumer is 800. .

- For beach sediment, cumulative cancer risks range from 8 x x 10^{-9} to 9 x x 10^{-5}, and the cumulative HIs range from 5 x x 10^{-4} to 1.

- For in-water sediment, cumulative cancer risks range from 3 x x 10^{-9} to 3 x x 10^{-4}, and the cumulative HIs range from 6 x x 10^{-5} to 3. . The highest HI for a breastfeeding infant of an in-water sediment receptor is 5 (for the tribal fisher).

- For direct contact to surface water, cumulative cancer risks range from 8 x x 10^{-10} to 9 x x 10^{-4}, and the cumulative HIs range from 1 x x 10^{-5} to 2. .

- For groundwater seeps, cumulative cancer risks range from 4 x x 10^{-10} to 3 x x 10^{-9}, and the cumulative HIs range from 1 x x 10^{-3} to 6 x x 10^{-3}. .

Chemicals that resulted in a cancer risk greater than 1 x x 10^{-6} or an HQ greater than 1 under any of the exposure scenarios for any of the exposure point concentrations evaluated in this BHHRA are presented in Table 5-204. Cumulative risk and hazard estimates were calculated for those populations where concurrent exposure to more than one media was assumed to occurbe plausible. Recreational/subsistence and tribal fishers were further evaluated on the basis of whether they were assumed to fish predominately from the shore or from a boat. MediaPopulations for which concurrent exposure to more than one media was considered for each populated are as follows:

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- Transients: Beach sediment, in-water sediment, surface water
- Divers: In-water sediment, surface water
- Recreational beach users: Beach sediment, surface water
- Recreational fishers (beach): Beach sediment, fish tissue (fillet or whole body)
- Recreational fishers (boat): In-water sediment, fish tissue (fillet or whole body)
- Subsistence fishers (beach): Beach sediment, fish tissue (fillet or whole body), shellfish tissue
- Subsistence fishers (boat): In-water sediment, fish tissue (fillet or whole body), shellfish tissue
- Tribal fishers (beach): Beach sediment, fish tissue (fillet and whole body)
- Tribal fishers (boat): In-water sediment, fish tissue (fillet and whole body)

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Cumulative risk estimates are generally presented for each one-half river mile per side of the river, and the risk estimates for specific media appropriate to each one-half mile segment were used to calculate the total risk or hazard. For example, cumulative risks for subsistence fishers who fish from a boat and consume smallmouth bass would include the risks associated with exposure to in-water sediment at the specific half-mile, shellfish collected within same half-mile and side-of-river specific segment, and smallmouth bass from the larger river mile assessment. The results of the cumulative risk estimates are presented in Table 5-xxx through 5-xxx. Chemicals that resulted in a cancer risk greater than 1 x 10^{-6} or an HQ greater than 1 under any of the exposure scenarios for any of the exposure point concentrations evaluated in this BHHRA are presented in Table 5-204xxx.~~Risk estimates for each media were summed f~~

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~~SUMMARY OF RISK CHARACTERIZATION~~

~~Cancer risk and noncancer hazard from site-related contamination was characterized based on current and potential future uses at Portland Harbor, and a large number of different exposures scenarios were evaluated. Exposure to bioaccumulative contaminants (PCBs, dioxins/furans, and organochlorine pesticides, primarily DDE/DDD/DDT) via consumption of resident fish consistently poses the greatest potential for human exposure to in-water contamination. In general, the risks associated with consumption of resident fish are greater by an order of magnitude or more than risks associated with exposure to sediment or surface water. The greatest non-cancer hazard estimates are associated with bioaccumulation through the food~~

~~chain and exposure to infants via breastfeeding. Because the smallest scale over which fish consumption was evaluated was per river mile, the resolution of cumulative risks on a smaller scale is not informative. The highest relative cumulative risk or hazard estimates are at RM 2, RM 4, RM 7, Swan Island Lagoon, and RM 11. However, assuming exposure to sediment alone, areas posing the greatest risk are RM 6W, RM 7W, RM 8.5W, and RM 11E, shellfish consumption alone poses the greatest risks at RM 4E, RM 5W, RM 6W, and RM 6E.~~

~~Chemicals that resulted in a cancer risk greater than 1 x 10^{-6} or an HQ greater than 1 under any of the exposure scenarios for any of the exposure point concentrations evaluated in this BHHRA are presented in Table 5-204.~~

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5.4 SUMMARY OF RISK CHARACTERIZATION

Cancer risk and noncancer hazard from site-related contamination was characterized based on current and potential future uses at Portland Harbor, and a large number of different exposures scenarios were evaluated. Exposure to bioaccumulative contaminants (PCBs, dioxins/furans, and organochlorine pesticides, primarily ~~DDE/DDD/DDT~~)DDx compounds, via consumption of resident fish consistently poses the greatest potential for human exposure to in-water contamination. In general, the risks associated with consumption of resident fish are greater by an order of magnitude or more than risks associated with exposure to sediment or surface water. The greatest non-cancer hazard estimates are associated with bioaccumulation through the food chain and exposure to infants via breastfeeding. Because the smallest scale over which fish consumption was evaluated was per river mile, the resolution of cumulative risks on a smaller scale is not informative. The highest relative cumulative risk or hazard estimates are at RM 2, RM 4, RM 7, Swan Island Lagoon, and RM 11. However, assuming exposure to sediment alone, areas posing the greatest risk are RM 6W, RM 7W, RM 8.5W, and RM 11E, shellfish consumption alone poses the greatest risks at RM 4E, RM 5W, RM 6W, and RM 6E.

The results of the BHHRA will be used to derive risk-based PRGs and AOPCs for the FS, as well as to develop risk management recommendations for the Site. In addition, the BHHRA may be consulted by risk managers as they deliberate practical risk management objectives during the course of the FS.

~~7.0~~6.0 UNCERTAINTY ANALYSIS

The presence of uncertainty is inherent in the risk assessment process~~Uncertainty is associated with every step of a risk assessment~~, from the sampling and analysis of chemicals in environmental media to the assessment of exposure and toxicity, and ~~the~~ risk characterization~~.~~. EPA policy calls for numerical risk estimates to always be accompanied by descriptive information regarding the uncertainties of each step in the risk assessment to ensure an objective and balanced characterization of the true risks and hazards~~.~~.~~—~~ ~~In general, the approach and methodologies used in a risk assessment are designed to err on the side of conservatism, i.e., protection of health. In a deterministic risk assessment, conservative assumptions can compound to result in an estimate of risk that is at the upper end of the probable risk range.~~

The te~~rm RM~~rm~~-~~ "uncertainty" is often used in risk assessment to describe what are, in reality, two conceptually different terms:~~–~~ uncertainty and variability~~.~~~~—~~. Uncertainty can be described as the lack of a precise knowledge resulting in a fundamental data gap~~.~~~~–~~. Variability describes the natural heterogeneity of a population~~.~~~~–~~. Uncertainty can sometimes be reduced or eliminated through further measurements or study~~.~~~~–~~. By contrast, variability is inherent in what is being observed~~.~~~~–~~. Although variability can be better understood, it cannot be reduced through further measurement or study, although it may be more precisely defined~~.~~~~–~~. However, ~~at some point there are diminishing returns associated with the collection of additional data, and~~ the additional cost of further data collection may become disproportional to the reduction in uncertainty~~.~~~~–~~. ~~Uncertainty can have two components: 1) variability in data or information, and 2) lack of knowledge. An uncertainty analysis conducted as part of a risk assessment focuses on issues of variability and knowledge uncertainty associated with each of the inputs and models used to derive the risk estimates.~~

~~Variability arises from true heterogeneity in exposure variables or responses, such as dose-response differences within a population or differences in contaminant levels in the environment. The values of some variables used in an assessment change with time and space, or across the population whose exposure is being estimated. Although variability can be better understood, it cannot be reduced through further study. Use of RME and CT scenarios provide an estimate of high-end and average exposures that may reasonably occur. The difference between the RME and CT risk estimates provides an initial evaluation of the degree of variability in exposure between individuals.~~

~~The second factor that generates uncertainty is a lack of knowledge about factors such as adverse effects or chemical concentrations. Uncertainty may be reduced by increasing knowledge about a factor through additional study, although it is impossible to gather enough data to eliminate uncertainty. In addition, at some point, there are diminishing returns associated with the collection of additional data; the cost of data collection is substantial and disproportional to the reduction in uncertainty. A~~

~~substantial amount of uncertainty is often inherent in environmental sampling as well as in the scientific models used in risk assessment.~~

The risks and hazards presented are consistent with EPA's stated risk management goal of being protective of 90 to 95 percent of the potentially exposed population~~.~~. However, these estimates are based on numerous and often conservative assumptions and, in the absence of definitive information, ~~.~~assumptions are used to ensure that actual sites risks are not underestimated~~.~~. The cumulative effect of these assumptions can result in an analysis having an overall conservativeness greater than the individual components~~.~~. Accordingly, it is important to note that the risks presented here are based on numerous conservative assumptions in order to be protective of human health and to ensure that the risks presented here are more likely to be overestimated rather than underestimated

~~6.0 This section includes a detailed analysis of uncertainties associated with each step of the BHHRA. However, a deterministic risk assessment alone cannot quantify the degree of conservatism in risk estimates, and this BHHRA does not include a probabilistic risk assessment, per agreement with EPA. This uncertainty analysis addresses variability and/or uncertainty in the inputs to the risk estimates, focusing on those inputs likely to have the greatest effects on the results of the risk analyses. A summary of uncertainties associated with this BHHRA and discussed in this section are provided in Table 6-1.~~

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6.1 DATA EVALUATION

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As discussed in Section 2, sediment, surface water, groundwater seep, and biota data were ~~data~~ collected during the RI~~.~~, D~~ as well as d~~ata of confirmed quality that meet the DQOs for risk assessment~~,~~ were used in this BHHRA to estimate ~~risks~~exposures~~.~~. Although uncertainty is inherent in environmental sampling, ~~Sediment, surface water, groundwater seep, and biota data were collected t~~The ~~for use in this BHHRA.~~ u~~U~~se of the EPA's DQO planning process (EPA 2000e) minimized the uncertainty associated with the data collected during the RI~~; however, some amount of uncertainty is inherent in environmental sampling.~~ . ~~The following~~A discussion of key data evaluation uncertainties ~~have been identified~~is presented in the following sections.

6.1.1 Use of Target Species to Represent All Types of Biota Consumed

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Because it is not practical to collect samples of every resident fish and shellfish species consumed by humans within the Study Area, as recommended by EPA guidance (2000a), target resident species were selected to represent the diet of all ~~biota~~ types likely consumed by humans~~, as recommended by EPA guidance (2000a).~~ . Four target species were collected to represent ~~resident fish tissue~~a diet consisting of resident fish: ~~(~~smallmouth bass, black crappie, common carp, and brown bullhead. ~~),~~ Crayfish and clam tissue samples~~and two species~~ were collected to represent a diet

containing locally-harvested shellfish ~~diet (crayfish and clam). .~~ Factors considered in selecting the target species included~~:~~ likely consumption by humans, home range, the potential for bioaccumulation of COPCs, the trophic level of species, and their abundance.

~~The range of contaminant concentrations detected in the target species generally coincides with the range of concentrations detected in other species that were collected. Furthermore, the concentrations of~~ PCBs~~,~~ generally ~~which is the chemical group with~~ represent~~ing~~ the greatest ~~contribution~~ contributors to the estimated risks, ~~are~~ and detected concentrations are ~~generally~~ highest in smallmouth bass and common carp~~, both of which were included in this BHHRA. .~~ Therefore, the use of target resident species ~~to represent~~as representative of all biota consumed ~~should not~~is unlikely to ~~impact the conclusions of this BHHRA~~underestimate potential risks.~~, and may in fact overestimate risks, especially i~~If~~ non-resident species are consumed, the risks may be less, commensurate with the amount of non-resident species present in the diet~~. .~~

6.1.2 Source of Chemicals for Anadromous and Wide-Ranging Fish Species

~~N~~For ~~non-resident fish S~~species, salmon, lamprey, and sturgeon have traditionally ~~were chosen as target non-resident fish species to~~ represented a substantial portion of the ~~tribal~~ fish ~~tissue~~ diet of tribal members~~. .~~ T~~Due to the life cycles of these species, t~~hese ~~fish~~ species likely spend ~~some~~ a substantial portion of their lives outside of the Study Area~~. The time spent outside the Study Area may be significant for bioaccumulation of chemicals due to the growth, development, and feeding that occurs, as well as the relative amount of time spent within the Study Area versus outside of the Study Area~~, and thus contaminant concentrations in these species may bear little relationship to sediment concentrations in the Study Area~~. .~~

The Washington Department of Ecology analyzed returning fall Chinook salmon, as fillet tissue with skin, collected from three coastal rivers~~-~~ (the Queets, Quinault, and Chehalis Rivers) in 2004 (Ecology 2007).~~ .~~ PCBs as Aroclors were detected at concentrations ranging from 5.0 µg/kg to 6.3 µg/kg in the Ecology study, relative to the maximum detected concentration of 20 µg/kg for salmon fillet tissue with skin collected from the Lower Willamette. The dioxin TEQ concentrations ranged from 0.09 picograms per gram (pg/g) to 0.23 pg/g in the Washington coastal rivers relative to the maximum detected concentration of 2 pg/g for salmon fillet tissue with skin collected from the Lower Willamette~~. .~~ A comparison of the tissue concentrations from the Ecology study and the Lower Willamette indicates that the concentration of PCBs measured as Aroclors and congeners are noticeably greater in salmon collected from the Clackamas fish hatchery relative to concentrations detected in the Ecology study~~. .~~ The reported concentrations of total DDT and dioxins as TEQs are generally consistent between the Ecology study and results from Portland Harbor~~. .~~ These results are ~~presented~~ summarized in Table 6-2~~. .~~ While the Chehalis River passes

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through some developed areas and therefore may have localized sources, both the Queets and Quinault Rivers are located almost entirely within Olympic National Forest and wilderness areas, so the potential for contribution from localized sources should be minimal~~.~~ . ~~These results indicate that sources of chemicals outside of the Study Area may contribute to bioaccumulation tissue concentrations of certain chemicals in anadromous fish species.~~

~~T~~here is a high degree of uncertainty as to the source of chemicals detected in non-resident fish species and whether ~~t~~he degree to which ~~those chemicals~~contaminant concentrations in anadromous fish are ~~actually~~ due to exposures that occur within the Study Area is unknown~~.~~ . However, approximately 95 percent of the cumulative ~~risk from~~tribal fish consumption risk is due to ~~chemical concentrations~~ contaminants detected in resident ~~fish~~species, even though ~~resident fish~~ they only account for 50 percent of the estimated ~~mass of fish consumed~~diet~~.~~ . ~~Therefore, using the results of the BHHRA to focus on~~addressing ~~potential sources of chemicals contaminants potentially posing unacceptable risks in resident fish species should address sources of chemicals potentially posing unacceptable risks within the Study Area that contribute to concentrations in non-resident fish species as well.~~ As a result, the uncertainty associated with the source of chemicals to non-resident fish species should not ~~impact~~ affect the conclusions of this BHHRA~~.~~ .

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6.1.3 Use of Either Whole Body or Fillet Samples to Represent ~~All~~ Fish Consumption

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~~Chemicals bioaccumulate differently and are~~Different contaminants are preferentially accumulated in different parts of an organism~~.~~ . Organic compounds tend to accumulate ~~more~~ to a greater degree in ~~the fatty~~ tissues with a higher fat content, ~~and~~ while heavy metals accumulate more in muscle tissues~~.~~ . Thus, diets consisting of different parts of the fish would result in varying levels of exposure to the consumer~~.~~ . The ~~chemicals~~ COPCs with the greatest contribution to the cumulative ~~cancer~~ risk and ~~with the highest noncancer HQ~~ hazard are persistent ~~PCBs~~chlorinated organic compounds (PCBs, DDx, and various PCDD/PCDF congeners)~~, which are organic compounds~~ that preferentially accumulate ~~preferentially~~ in fatty tissue~~.~~ . ~~Diets consisting of different fish parts result in varying levels of risk to the consumer. Using~~Assuming a diet ~~only~~ of ~~whole body or fillet tissue with skin to evaluate risk from all types of fish tissue diets is a~~represents a ~~conservative representation of actual consumption of fish~~assumption. ~~As~~ As discussed in Attachment F6, the difference in measured concentrations between fillet and whole body can be as great as a factor of 10 or more~~, d~~Depending ~~on the species and chemical, the difference in measured concentrations between fillet and whole body tissue can be minimal~~ negligible ~~or more~~ greater ~~than a factor of 10, as discussed in Attachment F6.~~ . ~~Since PCBs contribute to the vast majority of risks from tissue consumption on a Study Area-wide scale and on a localized scale for most exposure areas, this uncertainty could have a significant impact on the conclusions of this BHHRA. Alternatively, chemicals such as methyl mercury preferentially accumulate in muscle tissue, which means~~

~~concentrations of mercury in fillet tissue would likely be higher than concentrations of mercury in whole body tissue.~~

Based on information presented in the Columbia Slough consumption survey (Adolfson 1996), the majority of fishers surveyed ~~are most likely to~~ consume only the fillet ~~portion of the fish~~, which may not include skin~~.~~. ~~Based~~ According to ~~on~~ the CRITFC ~~Fish Consumption~~ Survey (CRITFC 1994), tribal fish consumers are also most likely to consume ~~only~~ the fillet ~~portion of the fish, which may not include skin.~~. However, ~~because~~ some individuals or groups ~~may~~ consume other portions of the fish~~, and the~~assuming a ~~whole body diet~~ that includes ~~is the most conservative estimate of potential cumulative risk from~~ due to consumption of tissue ~~fish~~consumption, ~~as organic chemicals have the greatest contribution to risk.~~. ~~.~~. ~~For an individual who consumes primarily fillet tissue, it would be appropriate to focus on risk results from fillet tissue consumption, recognizing that the risks are based on fillet with skin tissue and that risks associated with fillet without skin would likely be even lower for organic chemicals.~~

~~While it is not known to what extent consumption of non-fillet portions of fish occurs, this the BHHRA evaluated risks associated with consumption of only both fillet only and tissue or only whole body tissue.~~ Assuming a diet of whole body or fillet tissue with skin represents a conservative assumption and~~This approach~~ provides ~~the potential~~a range of risks associated with ~~the~~ different ~~diets~~dietary habits~~, and the risks from consumption of fillet tissue without skin would likely be even lower than those presented in this BHHRA.~~ ~~.~~ I~~Thr0 estimated risks for if an individuals~~ who consumes mostly ~~primarily~~ fillets, but ~~also occasionally other portions of the fish, the risks to that individual should~~ would fall within the range of ~~risks estimated~~ estimates presented in this BHHRA. ~~.~~ Because it is unlikely that a diet consists entirely of whole body tissue, the evaluation of risks associated with consumption of only whole body tissue provides a health protective approach.

6.1.4 Use of Undepurated Tissue to Represent Clam Consumption

~~Clam O~~~~The majority of~~ nly a limited number clam~~-~~ tissue samples (five of 22) collected ~~throughout~~ in ~~most of~~ the Study Area ~~was~~ were not depurated ~~analyzed~~ prior to analysis~~;as undepurated samples, and only a limited number of clams samples were depurated before analysis.~~ ~~.~~. Depuration ~~A~~ is a common practice in the preparation of clams ~~tissue~~ for human consumption ~~includes depuration~~, although ~~undepurated clam~~they may also be consumed undepurated~~.~~. ~~.~~ ~~The amount of COPC-containing~~COPCs ~~may be adhered to sediment particles within the gut of bivalves can vary widely; however, studies have demonstrated that the sediment content in the gut of bivalves could represent up to 39% percent of the total body load of metals (Wallner-Kersanach et al. 1994).~~ With the exception of ~~a few~~ certain metals, average chemical concentrations detected in clam tissue in the Study Area were higher in undepurated ~~clam tissue collected at the Study Area~~ than in depurated ~~clam tissue collected at the Study Area~~samples~~.~~ ~~.~~ However, depurated clam tissue ~~accounted for~~

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~~only five of the 22 clam~~ samples were collected ~~for the BHHRA dataset, and these depurated samples were collected~~ from edges of the site ~~(~~at the northern and southern stretches~~). –~~ , and the ~~Therefore, there are uncertainties associated with comparing depurated and undepurated tissue in the BHHRA dataset. These~~ concentrations are shown in ~~the EPC tables in Section 3 (~~Tables 3-24 and 3-25~~). –~~ . Using the ~~analytical~~ concentrations ~~of~~ from undepurated ~~tissue to represent tissue consumption throughout most of the Study Area~~samples provides a health-protective approach to assessing risk from consumption of clams ~~tissue consumption~~.

6.1.5 Use of Different Tissue ~~Types~~ Sample Preparation to Assess the Same Chemical

Samples ~~R~~of r~~For r~~esident fish tissue ~~samples~~ from ~~the~~ Round 1 were analyzed for ~~sampling event,~~ mercury ~~was analyzed~~ in fillet ~~tissu~~tissue ~~e~~ without skin~~. For resident tissue samples from the~~, while during Round 3, smallmouth bass and common carp ~~sampling event, mercury~~it ~~was~~samples were analyzed in fillet tissue with skin ~~i. n The BHHRA resident species included in the Round 3 tissue sampling were smallmouth bass and common carp. –~~ . ~~These fillet~~The Round 1 and Round 3 datasets were combined for Study Area analysis~~. –~~ . For the reasons presented in Section 6.1.3, the comparability of analytical data from fillet tissue with skin and fillet tissue without skin creates uncertainty in the BHHRA~~. –~~ . Because mercury preferentially accumulates in muscle tissue, ~~one would expect mercury~~ concentrations would ~~to~~ be ~~slightly~~ expected to be higher in the fillet tissue samples without skin~~. –~~ . However, for ~~the~~ smallmouth bass, mercury concentrations were generally higher in fillet tissue with skin, ~~and~~ while in common carp~~,~~ mercury concentrations were generally higher in fillet tissue without skin~~. –~~ . A comparison of mercury tissue concentrations is provided in Table 6-3. The uncertainty associated with the use of different tissue types to assess risks from mercury should not ~~impact~~ affect the conclusions of this BHHRA~~. –~~ .

6.1.6 Exclusion of Results Where Detection Limits ~~That Are Above~~Exceeded Analytical Concentration Goals ~~(ACGs)~~

~~Uncertainty exists in the evaluation of chemicals that were not detected for which the method detection limits (DLs) exceed the ACGs.~~ Although s~~S~~ite-specific Analytical Concentration Goals (ACGs) were established for each media, ~~the .~~ ~~However,~~ ACGs for some chemicals ~~are exceptionally very low, and in some instances~~were ~~,~~ not attainable some instances with present laboratory methods~~. –~~ . DLs for chemicals that were analyzed but never detected were compared to the appropriate ACG for each media~~. –~~ , and the results of that analysis are presented in Tables 6-5 through 6-7~~. –~~ . ~~For In sediment, the maximum DLs exceed both ACGs and method reporting limits (MRLs) for *four* analytes (see Table 6-4).~~

~~In tissue~~T~~, he maximum DLs in tissue samples exceed ACGs and MRLs for eight analytes (see Table 6-5). Five chemicals were never detected in tissue, but their DLs~~

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~~were below ACGs. It should be noted that DLs for PAHs were above the ACGs for PAHs, and PAHswhich were not detected in fish tissue samples collected in Round 1 fish tissue. However, because fish metabolize and excrete PAHs, 000and thus there is less likelihood for PAHsthey are less likely to bioaccumulate in fish. PAHs were detected in fish tissue samples collected in Round 3B fish tissue, as well as in Round 1, 2, and 3B shellfish tissue collected in Round 1, 2, and 3B. Thus, indicating thatthe data were sufficient to estimate risks from PAHs in both fish and shellfish tissue.~~

~~As discussed in Attachment F2, when a non-detected result was greater than the maximum detected concentration for a given exposure area, that result was removed from the dataset prior to calculation of an EPC. When a non-detected result was less than the maximum detected concentration, it was included in the dataset for calculation of EPCs according to the rules presented in Attachment F2. These data rules also apply to non-detected PAHs in Round 1 fish tissue. I~~

~~n addition, DLs for PCB congeners were elevated for some smallmouth bass tissue samples, which may add uncertainty to PCB TEQ estimates. However, the risks from total PCBs (due to detected congeners) were higher than the risks from the PCB TEQ for those exposure areas with elevated detection limits. Because the PCB congeners were detected in other smallmouth bass tissue samples, the elevated DLs were incorporated in the PCB TEQ estimates at one half the DL. Therefore, while the elevated detection limits contribute to uncertainty, using the elevated detection limits in this BHHRA should not significantly affect the risk results.~~

~~In the groundwater seep sample, The maximum DLs exceed were greater than both ACGs and MRLs for one two analytes in the groundwater seep sample (see Table 6-6). In surface water samples, the DL for five six analytes plus (including PCBs as Aroclors)PCB Aroclors exceed were greater than ACGs; the DL for two three analytes plus (including PCB Aroclors) was greater than the exceed MRLs (see Table 6-7). However, for surface water, PCB congener data were used instead of Aroclor data, as discussed in Attachment F2.~~

Chemicals that were not detected were not quantitatively evaluated ~~further~~ in ~~this~~ the BHHRA~~.~~. If chemicals were present at concentrations above the ACGs but below the DLs, those chemicals ~~could contribute to unacceptable risks~~would contribute to the estimated risk and hazard.~~.~~ However, given the number of chemicals that were detected at concentrations above their respective ACGs and the magnitude of difference between detected concentrations and ACGs, it is unlikely that exclusion of chemicals that were not detected would ~~impact~~ affect the conclusions of this BHHRA.

6.1.7 Removal of Non-Detected Results Greater Than the Maximum Detected Concentration for a Given Exposure Area

As discussed in ~~Attachment F2~~Section 3.4, if the DL for ~~a given~~ non-detected result was greater than the maximum detected concentration for an ~~exposure scenario and~~ exposure area, that result ~~was removed from the dataset prior~~00 ~~to~~not included when calculati~~ng on of~~the EPC~~s. .~~ These results are ~~discussed in Attachment F2 and~~ presented in tables F2-7 through F2-13~~, .~~ Inclusion of non-detected data greater than the maximum detected concentrations would likely have resulted in higher risk estimates in the risk characterization of the BHHRA.

6.1.8 Using N-Qualified Data

As discussed in Section 2.2.3 of the RI ~~report~~, ~~some~~ data were qualified using the "N" qualifier, ~~which indicates that~~when the identity of the analyte is not definitive~~. The use of the N qualifier is~~ , generally a result of the presence of an analytical interference in the sample~~.~~. Examples include samples analyzed for ~~the~~chlorinated ~~of an analytical interference such as hydrocarbons or, in the case of pesticides, PCBs. P~~pesticide ~~data and SVOCs analyzed~~ by EPA Method 8081A, which were most commonly N-qualified as a result of analytical interference due to the ~~presence~~presence of PCBs in the samples~~.~~. These N-qualified data were used in the BHHRA for calculating EPCs in fish and/or clam tissue~~.~~. The following COPCs were included based solely using N-qualified data, and had e~~E~~stimated cancer risks greater than 1 x 10^{-6} or HQs greater than 1 ~~following analytes :were identified as tissue EPCs (for hexachlorobenzene and several other pesticides) that resulted in cancer risk estimates exceeding 1 x~~ x 10^{-6} ~~or HIs exceeding 1.~~

- ~~Alpha~~alpha-~~hexachlorocyclohexane~~Hexachlorocyclohexane (fish tissue)~~,~~
- beta-hexachlorocyclohexane~~,~~ (fish tissue) ~~and~~
- gamma-hexachlorocyclohexane (fish tissue)
- Heptachlor epoxide (clam tissue)

~~were identified as contaminants potentially posing unacceptable risks greater than 1 x 10^{-6} in fish tissue based on EPCs in fish tissue that were calculated using only N-qualified data only. Heptachlor epoxide was identified as a contaminant potentially posing unacceptable a risks risk greater than 1 x 10^{-6} in clam tissue based only on N-qualified data only. B~~While these contaminants were identified as contaminants potentially posing unacceptable risks based on the results of the BHHRA, it is important to note that there is uncertainty in both the identity and concentration of these contaminants in fish/clam tissue is uncertain~~. These contaminants~~, and they were not detected in abiotic media at levels posing risk to human health~~. . Attach~~A discussion of ~~ment F6 discusses~~ how EPCs and risk estimates would change for adult consumption of whole body fish tissue and shellfish tissue if N-qualified data were not included in the BHHRA dataset is presented in Attachment F6.~~.~~

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6.1.9 Using One-Half The Detection Limit for Non-Detect Results in Summed Analytes

WAs described in Attachment F1, when concentrationsdata are presented as summed values (e.g., total PCB congeners), one-half the detection limit When was used as a surrogate concentration when calculating the summed value for those individualsspecific analytes reported as non-detect when calculating the summed value.. an individual analyte that is part of a summed analyte (i.e. total PCB congeners, total endosulfans, etc.) was determined to be present in a given medium according to the rules for non-detects discussed in Section 2, but was not detected for a specific sample, one-half of the detection limit was used to calculate the summed analyte result, as described in Attachment F1. This value is assumed to represent a conservative estimate for the concentrations below the detection limitUse of one-half the detection limit assumes that there is equal probability that the actual concentration in the sample may be greater or less than the surrogate value, and introduces uncertainty into the summed analyte calculations. . In general, the detection limits for non-detect results were low relative to detected concentrations. . In addition, by only including those contaminants that were determined to be present in a given medium, the uncertainty associated with the use of non-detect results was minimized. . However, in cases where the detection limits were above analytical concentration goals and the chemical was detected infrequently, use of one-half the detection limit could impact the risk results.

6.1.10 Contaminants That Were Not Analyzed in Certain Samples

Per Consistent with the sampling and analysis plan that wasas approved by EPA,N certain not all fish tissue samples were analyzed for a subset of thethe same suite of analytes. . For example, samples collected in Round 1 fillet tissue samples were not analyzed for PCB as Aroclors, but no analysis was done for , dioxins , orand furans congenerswere not measured.. . Fillet samples of s, while s Smallmouth bass and common carp fillet samples In collected in Round Round 3B, smallmouth bass and common carp fillet tissue samples were analyzed for specific PCB, dioxin, and furan congeners. . In samples where congeners were analyzed, the risks from the total dioxin TEQ, which is not included through other analytesotherwise measured (i.e., risks from total PCBs are included through as PCBs as Aroclors) comprise approximately 1 to 70 percent of the cumulative risks. . Therefore, the risks from consumption of black crappie and brown bullhead fillet tissue, which were only analyzed in Round 1, likely underestimate the actual risks particularly in those areas where PCBs and dioxin/furans are the predominant contaminants. . However, because a range of risks was calculated for fish consumption scenarios, which includeingd samples that were analyzed for congeners, so the lack of analysis of contaminants in certain samples should not impact affect the overall conclusions of this the BHHRA.

In addition, not all clam samples were analyzed for the same number of contaminants, due to lack of availablelimited tissue mass for of some composites collected during

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~~the~~ Round 2 ~~sampling efforts.~~ . Table 6-8 presents a listing of analyses not completed for ~~Missing analytes and associated sample identifications for clam tissue collected in Round 2 are shown in~~specific samples ~~Table 6-8.~~ . Additional samples were collected i~~I~~n Round 3B~~,~~ ~~additional clam samples were collected~~ and analyzed for ~~additional~~ a greater number of specific contaminants~~.~~ . The Round 2 and Round 3B clam tissue data were combined and evaluated on a river-mile basis in the BHHRA~~.~~ . Therefore, EPCs were available for almost all COPCs in each exposure area. ~~Lack of analytical values for COPCs in all samples within an exposure area may over or underestimate the risk for that exposure area. However, a range of risks was calculated for shellfish consumption scenarios, which included samples where all COPCs were analyzed, so the lack of analysis of contaminants in certain samples should not impact the conclusions of this BHHRA.~~

6.1.11 Chemicals That Were Not Included as Analytes

~~It~~ As it is not ~~possible~~ practical to analyze for every chemical, ~~and thus~~specific chemicals and chemical groups were chosen for analysis based on an investigation of known or probable sources at in the LWR. ~~and pollutants~~~~contaminants~~. ~~Because~~ However, the chemicals expected to have the potential for significant contributions to risk are included in the risk assessment~~, chemicals not included as analytes introduce a low level of uncertainty to overall risk.~~ . The list of chemicals for analysis was determined in collaboration with EPA and its partners and ~~was included~~ presented in the approved sampling and analysis plan ~~that was approved by EPA.~~ . Since ~~then~~Subsequently, there has been interest in two additional groups of chemicals ~~that were not included as analytes in this BHHRA~~: polybrominated diphenyl ethers (PBDEs) and volatile organic compounds (VOCs) in tissue~~.~~ . Risks have subsequently been assessed for exposures to PBDEs in in-water sediment and resident fish tissue, as presented in Attachment F3~~.~~ .

VOCs were not analyzed in tissue or surface water~~the BHHRA tissue or surface water datasets~~ samples.~~.~~ Because of their nature, ~~of~~ VOCs~~, they~~ are not expected to accumulate in tissue to ~~a~~a sufficient degree ~~high enough~~ to pose significant risk via ~~tissue~~ consumption~~, especially given~~ relative to the other chemicals detected in tissue ~~that are clearly primary contributors to the calculated risk (e.g., PCBs).~~ .~~.~~ Given the magnitude of concentrations and toxicities of other chemicals that were ~~analyzed for and~~ detected in surface water and tissue, VOCs are unlikely to contribute significantly to the overall risks. Therefore, the lack of analysis for VOCs ~~should not~~is unlikely to ~~impact~~ alter the conclusions of ~~this~~ the BHHRA.

~~As mentioned earlier in this section, it is impossible to analyze for every chemical, and there are a number of constituents~~ analytes ~~that have not been historically considered as contaminants but are recently gaining attention as research provides documentation that they are ubiquitous in the environment. These chemicals are generally referred to as "emerging contaminants," and are not considered in this BHHRA, with the exception of PBDEs, which are discussed in Attachment F3. In~~

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~~accordance with EPA guidance on risk assessment for superfund sites, this BHHRA assessed risks associated with CERCLA releases, and did not include studies focused on non-CERCLA releases, which include some recent studies on regional emerging contaminants. From a human health perspective, unregulated chemicals such as emerging contaminants may exist at the Site, but lack of knowledge and data regarding many of these chemicals precludes a human health risk assessment. Because emerging contaminants are not related to CERCLA releases for the Study Area, the lack of analysis for these chemicals should not impact the conclusions of this BHHRA.~~

6.1.12 Chemicals That Were Analyzed But Not Included in BHHRA

Not all detected chemicals ~~analyzed for~~ were included in the BHHRA~~. Specifically, not all conventional analytes or nutrient metals were analyzed for potential risk. Many conventional analytes are essential nutrients, and are not evaluated under the CERCLA program. The two conventionals that were included in this BHHRA are cyanide and perchlorate. ~~.~~. The following a~~The conventional a~~nalytes ~~and metals that~~ were excluded from assessment are either because there are no suspected sources, or the analyte typically only present adverse health risks at high concentrations ~~listed here~~:

- Ammonia
- Calcium
- Calcium carbonate
- Carbon dioxide
- Chloride
- Ethane
- Ethylene
- Magnesium
- Methane
- Nitrate
- Nitrite
- Oxygen
- Phosphate
- Phosphorus
- Potassium
- Silica
- Sodium
- Sulfate
- Sulfide

~~7.0 Because of the lack of toxicity and/or essential nature of these analytes, exclusion of these chemicals from the BHHRA should not impact the conclusions of this BHHRA.~~

~~7.1.1~~6.1.13 Data Not Included in BHHRA due to Collection Date

Data collected after June 2008 were not included in ~~this~~ the BHHRA due to the completion schedule of ~~collection date of the data relative to~~ the RI/FS ~~completion schedule.~~ ~~–~~. These data sets are discussed in the Portland Harbor RI Report, and include a number of in-water sediment samples~~.~~ ~~–~~. ~~Because these data were not included in the BHHRA, there is uncertainty in the in-water sediment exposure scenarios.~~ However, due to the large spatial coverage of the existing in-water sediment BHHRA dataset, this uncertainty is not expected to ~~impact~~ affect the overall conclusions of ~~this~~ the BHHRA.

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~~7.1.2~~6.1.14 Compositing Methods for Biota and Beach Sediment Sampling

~~Compositing methods for biota and beach sediment sampling were designed to provide a conservative estimate of risk.~~ Compositing schemes ~~need to be~~were developed to be representative of the medium sampled ~~(grid pattern, stratified random, etc.)~~ and to be representative of ~~an~~ each exposure unit~~.~~.

Fish were composited based on an estimate of the average home range for each species (ODFW 2005)~~.~~. The home ranges for common carp and brown bullhead may be as large ~~as~~ or larger than the Study Area ~~and possibly even larger~~, ~~and~~ the home range for bass may be larger or smaller than the one mile assumed in the BHHRA~~.~~. For example, bass may only reside on one side of a river mile reach instead of throughout the one mile reach on both sides of the river ~~as assumed for the HHRA.~~. Smallmouth bass were composited on a river mile basis, while black crappie, brown bullhead, and carp were composited on a fishing zone basis. Fishing zones for brown bullhead and black crappie were from ~~RM~~ RM 3-6 and ~~RM~~ RM 6-9; fishing zones for common carp were from ~~RM~~ RM 0-4, ~~RM~~ RM 4-8 and ~~RM~~ RM 8-12 ~~as well.~~. ~~Uncertainty exists in this~~However, the compositing scheme ~~because the delineation of home range boundaries for the purposes of the risk evaluation are~~ represents only an approximation of the home ranges of the fish ~~samples actually~~ collected~~. However, composite samples,~~ and typically consisted of five individual fish~~.~~. ~~r~~Replicate composite samples were collected, and risks were evaluated using both ~~for individual sample locations~~the composite samples as well as on a Study Area-wide basis~~.~~. ~~Therefore, the compositing method for biota is not expected~~Where contaminants are evaluated on a harbor-wide basis and/or specific species are wide-ranging, this process is not likely to have an appreciable ~~to impact~~ effect on the conclusions of th~~e~~~~is~~ BHHRA~~.~~. However, where samples are composited over an area larger than the actual home range of specific fish species, the result may either over- or underestimate risks, depending on the distribution of contaminant concentrations in the area over which samples are composited~~.~~. For example, the highest DDx concentrations are located on the west side of the river at RM- 7.5, while the EPC for smallmouth bass at that river mile combined data collected from both sides of the river.

Beach sediment was composited on a beach by beach basis, resulting in ~~one~~ a single sample result for each exposure area~~.~~. Uncertainty ~~exists in~~stems from this compositing scheme because the results of the risk evaluation are dependent on a single sample~~.~~. Composite samples are generally assumed to represent the area from which the individual samples of the composite were taken, but an unrepresentative individual sample (e.g., one representing extremely localized or ephemeral contamination) used in the composite could significantly bias the composite results~~.~~. The compositing scheme for beaches results in risk evaluation based on a single sample at a single point in time~~.~~. If a beach was found to pose an unacceptable risk, additional samples at that beach might be warranted~~.~~. However, all of the beach

sediment exposure scenarios ranged from 8 ~~x~~ x 10^{-9} to 9 ~~x~~ x 10^{-5}, which are below or within the target risk range of 1 x 10^{-4} to 1 x 10^{-6}.

~~7.1.3~~6.1.15 Mislabeling of Smallmouth Bass Fish Sample

One smallmouth bass sample collected from the west side of ~~RM~~ RM 11 (LW3-SB11W-11) during the Round 3 sampling event was incorrectly recorded as LW3-SB11E-01 (~~RM~~ RM 11 east) at the field lab~~.~~ . This fish became part of the final LW3-SB11E-C00B and LW3-SB11E-C00F composite samples, which are the body and fillet composites from ~~RM~~ RM 11 east~~.~~ . Fish SB11E-01 (actually from SB11W) accounted for 15~~%~~ percent of both sample types on a mass basis~~.~~ . ~~This results in uncertainty in the concentration of the smallmouth bass sample from the east side of RM 11, since a fish from outside RM 11E was included in the composite.~~ However, since smallmouth bass exposure areas ~~are~~ were assessed on a river mile basis, the data from ~~RM~~ RM 11E and ~~RM~~ RM 11W were included in the same EPC calculations, and the effects of this uncertainty are not expected to ~~impact~~ affect the conclusions of this BHHRA~~.~~ .

~~### 7.1.4 Use of DEQ Risk-Based Concentrations for Screening Values~~

~~4.0 EPA RSLs were used to screen chemicals detected in in-water sediment for the identification of COPCs. RSLs are not available for petroleum hydrocarbons, so DEQ risk-based concentrations (RBCs) for occupational surface soil exposure DEQ 2003) were used. DEQ does not have specific RBCs for lube oil, motor oil, or residual range hydrocarbons, so the screening value for generic oil was used as a surrogate. There is uncertainty associated with applying the screening value for generic oil to heavier oils, as lighter range petroleum hydrocarbons tend to be more toxic than heavier range petroleum hydrocarbons. However, the maximum detected concentrations of these three oils in in-water sediment also does not exceed the screening value for the lighter range hydrocarbons detected within the Study Area (diesel, gasoline), so the uncertainty associated with the COPC screening values for heavier oils are not expected to impact the conclusions of this BHHRA.~~

~~### 7.1.5 Selection of Tissue COPCs Based On Detection of An Analyte~~

~~5.0 The selection of fish and shellfish tissue COPCs was based on whether an analyte was detected in each species/tissue type, and not based on a comparison with health-protective screening levels. There is uncertainty associated with identification of tissue COPCs based on detections alone, and this could potentially impact the conclusions of this BHHRA.~~

~~7.2~~6.2 EXPOSURE ASSESSMENT

Uncertainties that arise during the exposure assessment can typically have some of the greatest ~~impacts~~ effect on ~~the~~ risk estimates~~.~~ . The following subsections address

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uncertainties associated with exposure models, exposure scenarios, exposure factors, and EPCs used in the risk estimates.

~~7.2.1 Model Applicability~~

~~6.0 The standard exposure models used to estimate risks may result in uncertainty. The exposure models rely on identification of exposure scenarios and selection of appropriate exposure factors for those scenarios. Uncertainty in the applicability of the exposure scenarios will result in uncertainty in the risk estimates. Site-specific exposure scenarios were developed to provide a conservative estimate of risk within the Study Area, using conservative exposure factors to represent both reasonable maximum and central tendency exposures that could hypothetically occur within the Study Area. While uncertainties associated with the exposure models could impact the conclusions of this BHHRA, the models used are consistent with applicable risk assessment guidance and are a source of uncertainty in all risk assessments.~~

~~7.2.2~~6.2.1 Subsurface Sediment Exposure

A complete exposure pathway ~~needs to include~~requires the presence of a retention or ~~a~~ transport medium, an exposure point, and an exposure route~~.~~. Subsurface sediment was not considered an exposure medium ~~for this~~in the BHHRA because it was assumed that ~~any~~ potential human contact with river sediment below 30 cm in depth was unlikely, ~~and~~ or that if it does occur, the frequency and extent would be minimal~~.~~. Situations ~~in~~ which may result in human exposure to subsurface ~~might occur~~ include: potential scouring, natural hydraulic events that are not well understood, future development of near-shore and upland properties, maintenance of the ~~federal~~ navigation channel, ports, and docks, placement and maintenance of cable and pipe crossings, pilings and dolphins, anchoring and spudding of vessels, and exposure to propeller wash from vessels~~.~~. ~~All of these situations could provide minimal impact to subsurface in-water sediment as well as to surface sediment, and thus the assessment of risk from exposure to surface sediment would be adequately protective of potential exposure to subsurface sediment. However, the uncertainty associated with not directly assessing subsurface sediment exposure could underestimate risks from multiple exposure pathways for the Study Area.~~ Due to the low ~~levels~~ potential of ~~possible~~ exposure to subsurface sediment, ~~this uncertainty is not expected to impact the conclusions of this~~the estimates presented in the BHHRA are considered sufficiently representative of baseline exposures.

~~7.2.3~~6.2.2 Potential Exposure Scenarios

Some of the ~~exposure scenarios evaluated in this BHHRA have limited documentation regarding the actual extent of exposure to receptors in the Portland Harbor. These scenarios were included in this BHHRA at the direction of EPA Region 10. The~~ uncertainties associated with the~~se~~ exposure scenarios~~-~~ evaluated in the BHHRA are ~~are~~ discussed in the following subsections~~.~~.

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~~**7.2.3.1 Human Milk Consumption**~~

~~**7.0** The BHHRA evaluated risks to an infant consuming human breastmilk for receptors exposed to bioaccumulative compounds selected as COPCs. The evaluation of this pathway was performed consistent with DEQ guidance (2010), but there are a number of uncertainties associated with modeling infant exposure to contaminants through breastmilk based on exposure to the mother, which could potentially affect the outcomes of this BHHRA.~~

~~**8.0** Risks to an infant consuming breastmilk from the adult receptors evaluated in this BHHRA resulted in risks above the EPA points of departure for cancer and noncancer endpoints. However, breastfeeding is still the healthiest way to feed a baby, even if the milk contains contaminants. Even though infants may receive a dose of contaminants from their mothers' milk, human milk also contains hundreds of healthy nutrients, vitamins, minerals, and immune system boosters. These natural, healthy substances more than compensate for any health risks from contaminants and may even help repair damage caused by contaminants before the baby was born. Breastfeeding has been shown to boost immunity and IQ and prevent many diseases. Calculated risk to infants from breastfeeding presented in this report should not discourage any mother from breastfeeding her infant (adapted from DEQ, 2010).~~

~~**7.2.3.2**~~**6.2.2.1 Shellfish Consumption**

~~This BHHRA evaluated risks from shellfish consumption based on crayfish and clam tissue data. However, the harvest or possession of Asian clams, which is the species assessed in this BHHRA, is illegal.~~

A commercial crayfish fishery ~~exists has existed~~exists in the LWR, and c~~. C~~rayfish landings must be reported to ODFW by water body and county~~.~~. Per ODFW, the crayfish fishery in the LWR is not considered a large fishery (Grooms 2008), and ~~. Based on ODFW's data for 2005 to 2007,~~ no commercial crayfish landings were reported for the Willamette River in Multnomah County from 2005 to 2007~~.~~. DHS had previously received information from ODFW indicating that an average of 4,300 pounds of crayfish were harvested commercially from the portion of the Willamette River within Multnomah County each of the five years from 1997-2001. In addition to this historical commercial crayfish harvesting, DHS occasionally receives calls from citizens who are interested in harvesting crayfish from local waters who are interested in fish advisory information. According to a member of the Oregon Bass and Panfish club, crayfish traps are placed in the Portland Harbor Superfund Site boundaries and collected for bait and possibly consumption (ATSDR 2006)~~.~~. It is not known to what extent non-commercial harvesting of crayfish occurs within the Study Area, if at all, or whether those crayfish are consumed and/or used for bait.

Evidence of current consumption of freshwater clams from Portland Harbor is ~~largely anecdotal~~limited~~.~~. ~~The only reported clam consumption was from~~According to a project conducted by the Linnton Community Center (Wagner 2004), transients reportedly consume clams from the river on a limited and infrequent basis~~.~~. As part

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of the project, conversations were conducted with transients about their consumption of fish or shellfish from the Willamette River~~.~~. These conversations were not conducted by a trained individual ~~nor~~ and were ~~the conversations~~not documented~~.~~. T~~he t~~ransients ~~that were contacted~~ reported consuming various fish species, as well as crayfish and clams, and . ~~M~~many ~~of the individuals~~ indicated that they were in the area temporarily, move from location to location frequently, or have variable diets based on what is easily available~~.~~. Assuming that clam consumption occurs, the Linnton Community Center project suggests that it does not occur on an ongoing basis within the Study Area~~.~~. DEQ and EPA staff have occasionally received calls from individuals who claim to have harvested clams and are inquiring whether consumption is safe, and individuals of apparent southeast Asian descent have been observed harvesting clams from the shore in Portland~~.~~. However, the actual extent to which freshwater clams or other shellfish are currently harvested and consumed is not known.

~~The evaluation of risks from shellfish consumption in this BHHRA is a health protective approach.~~

~~7.2.3.3~~6.2.2.2 Wet Suit Divers

Commercial diving companies in the Portland area were contacted to develop a better understanding of potential diver exposures within the Study Area~~.~~. All of the diving companies that were contacted indicated that the standard of practice for commercial divers is the use of dry suits and helmets when diving in the LWR (Hutton 2008, Johns 2008, and Burch 2008)~~.~~. EPA Region 10 reported observing divers in wet suits and with regulators that are held with the diver's teeth within the Study Area~~, so a wet suit diver and associated ingestion for the "in the mouth" regulator exposure scenarios were included at the direction of EPA.~~ . ~~Evaluation~~ An evaluation was also performed of helmet diving with use of a neck dam, which allows can allow ~~polluted~~ water ~~leakage~~ to leak into the diving helmet~~.~~. Commercial divers as recently as 2009 have been observed using techniques to don a diving helmet which increase exposure (Sheldrake personal communication with RSS, 2009, DEQ, 2008). The observed wet suit divers were performing environmental investigation and remedial activities, which are not activities evaluated as part of a commercial diver scenario~~.~~. Also, it is not known whether the individuals who were observed diving in wet suits on specific occasions are diving within the Study Area on a regular basis, as they do not work for the commercial diving companies in the Portland area~~.~~. Recreational diving also takes place in Portland Harbor (Oregon Public Broadcasting Think Out Loud, "Are you going to swim in that?" August 22, 2008). Therefore, including a wet suit diver scenario with associated ingestion from use of a recreational type regulator, rather than a full face mask or diving helmet, and full body dermal exposure in this BHHRA (in addition to a dry suit diver scenario) is a conservative approach.

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~~7.2.3.4~~6.2.2.3 Domestic Water Use~~rs~~

The ~~domestic water user risks~~evaluation of surface water as a domestic water source ~~are~~ is based on the ~~hypothetical use of~~assumption that ~~untreated~~ surface water is drawn from the Study Area ~~as a domestic water source.~~. Within t~~Surface water in t~~he Study Area, the LWR ~~within the Study Area~~ is not currently used as a domestic water source~~.~~. According to the City of Portland, the primary domestic water source for Portland is the Bull Run watershed, which is supplemented by a groundwater supply from the Columbia South Shore Well Field (City of Portland 2008)~~.~~. In addition, the Willamette River was determined not to be a viable water source for future water demands through 2030 (City of Portland 2008)~~.~~.

~~Under OAR 340-041-0340 Table 340A, domestic water supply is a designated beneficial use of the Willamette River, but only with adequate pretreatment and natural quality that meets drinking water standards. The use of the Willamette River as a domestic water source would only occur after adequate pretreatment to meet Safe Drinking Water Act standards and Oregon rules. As a result, the term hypothetical was used to describe the scenario, which was based on the use of untreated surface water.~~

Therefore, the evaluation of ~~untreated~~ surface water as a domestic water source~~, even under hypothetical future conditions,~~ is a conservative approach and is not based on current knowledge of future planned uses of the Willamette River within the Study Area as a domestic water ~~source or based on Oregon rules that require adequate pretreatment~~.

~~7.2.4~~6.2.3 Potentially Complete and Insignificant Exposure Pathways

Exposure pathways that have been determined to be potentially complete and insignificant were not evaluated further in this BHHRA~~.~~. As described in Section 3.2, these exposure pathways have a "source or release from a source, an exposure point where contact can occur, and an exposure route by which contact can occur; however, the pathway is considered a negligible contributor to the overall risk."~~.~~ The exposure pathways identified as potentially complete and insignificant were related to Willamette River surface water exposures to populations evaluated in this BHHRA~~.~~. ~~The~~ Ingestion and dermal absorption of chemicals from surface water were quantitatively evaluated for the populations that are expected to have the most frequent contact with surface water ~~(transients, recreational beach users, and hypothetical future residents) as well as the EPA directed evaluation of surface water exposure to divers were quantitatively evaluated in this BHHRA for ingestion and dermal absorption of chemicals from surface water.~~. ~~The populations for which s~~Surface water exposures were not evaluated were for dockside workers, in-water workers, tribal fishers, and fishers~~.~~. ~~For several other populations, only the inhalation exposure pathway was determined to be insignificant. These populations were transients, divers, recreational beach users, and hypothetical future residents.~~

The~~is~~ BHHRA identified and evaluated the exposure pathways that were expected to result in the most significant exposure to COPCs in the Study Area~~.~~. The magnitude

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of exposures experienced by populations for these exposure pathways are typically expected to be much greater than that expected for the exposure pathways identified as "insignificant."
Thus, the assessment of risk to populations from exposure pathways that were quantitatively evaluated in this BHHRA would be adequately protective of exposed populations in the Study Area. However, the uncertainty associated with not directly evaluating "insignificant" exposure pathways considered insignificant could underestimate risks for the Study Area. Due to the low levels of possiblepotential of exposure for these "insignificant" exposure pathways, this uncertainty is not expected to impact the conclusions of this BHHRA.

7.2.56.2.4 Exposure Factors

Assumptions about exposure factors typically result in uncertainty in any risk assessment. As discussed previously, the scenarios evaluated are representative of exposures that could occur in the Study Area under either current or future conditions. RME and CT values were used for some of the exposure scenarios to evaluate help assess the overall impact effect that variability in each of the exposure assumptions has on the risk estimates. As discussed previously, most of the RME scenarios represent the reasonable maximum exposures that could occur in the Study Area under current and future conditions. In the case of the scenarios assessing the use of untreated surface water as a domestic water source, both the RME and CT scenarios represent hypothetical exposures. The other CT exposure scenarios represent the expected average or mean exposure for exposures that could occur in the Study Area in the present and future. The range of risk estimates between these two exposure scenarios provides a measure of the uncertainty surrounding these estimates.

For fish consumptionA, a range of ingestion rates for fish consumption were used to evaluate variability on the risk estimates (see discussion of exposure parameters for tissue ingestion scenarios below). As recommended by EPA guidance, these ingestion rates were used with EPCs calculating using both the mean and 95% percent UCL on the mean (or maximum concentrations for EPCs when sample size was less than 5), and thus the resulting risks in this BHHRA represent a range of possible human health risksoutcomes, including estimates that might may be representative of the upper range of plausible exposuresfall into the high end of those possible. .

In addition to the variability, there is also uncertainty associated with the exposure factors that were used in this BHHRA.

The following exposure factor uncertainties have been identified and analyzed further to determine the potential effects on the risk estimates:

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~~7.2.5.1~~6.2.4.1 Exposure Parameters for Sediment Exposure Scenarios

The parameters used in the BHHRA to evaluate beach and in-water sediment exposure ~~parameters~~ used ~~in this BHHRA~~ were intended to provide conservative estimates ~~of~~ based on potential uses ~~for~~ in the Study Area.

Beach areas that are accessible to the general public were identified as potential human use areas, even though it is not known whether recreational beach use actually occurs at these locations~~. Even if beach use occurs,~~, and the extent to which the beach ~~is~~ may be used and the nature of the contact with sediments~~/beach~~ is unknown~~.~~. Future changes in land use may make some beach areas ~~more~~ more- or ~~less~~ less-accessible to the general public~~for humans~~, which increases uncertainty about future exposure~~.~~. ~~For~~ When evaluating in-water sediment, ~~every~~ each ~~½~~ on-half mile river mile segment on each side of the navigation channel was considered a potential exposure area for all in-water sediment exposure scenarios, regardless of the feasibility or practicality of use of the area~~.~~. Information from this approach can be used to info~~rm RM~~rm ~~the~~ public about relative risks throughout the river and can help focus the feasibility study~~, but likely over-estimates risk estimates for in-water sediment~~.

There are uncertainties ~~The~~ associated in the selection of the exposure duration, frequency, and intake parameters ~~for~~ used to evaluate both beach and in-water sediment ~~also have associated~~exposures ~~uncertainties.~~. These scenarios assume ~~exposure to the~~long-te~~rm RM~~rm repeated use of the same beach or ~~½~~ one-half mile river mile segment, which may not accurately reflect actual use practices ~~for an entire childhood, or 25 to 70 year exposure duration for adults, depending on the receptor.~~. The exposure ~~Frequency~~ frequencies evaluated ~~of exposure~~ range~~s~~ from ~~94~~ 94 days/year up to 250 days/year~~.~~. Default intake parameters for soil exposure were generally used; however, to account for an assumed greater moisture content of beach sediments, the dermal adherence factor ~~(dermal contact with sediment) for~~ used to evaluate child recreational beach ~~user~~ exposure was ~~more than 10 times~~10-fold greater than the default for soil~~.~~.

~~Another uncertainty associated with exposure parameters for sediment is the dermal absorption factor, which does not exist for all COPCs. Per~~Consistent with EPA guidance (2004), only those compounds or classes of compounds for which dermal absorption factors ~~exist~~ are available were quantitatively evaluated ~~quantitatively for~~via ~~the~~ dermal contact exposure ~~pathway.~~. ~~For compounds~~COPCs for which ~~without~~ dermal absorption factors were not available were not quantitatively evaluated, as dermal absorption was essentially assumed to be zero~~.~~. However, as the majority of COPCs were quantitatively evaluated,~~ which for the sediment COPCs are certain metals and perchlorate, dermal intake was assumed to be zero. However, dermal absorption factors exist for the chemicals and chemical groups that are likely to pose the greatest concern for risk from dermal contact. So although the lack of dermal absorption factors for all COPCs may underestimate risk from dermal contact~~

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~~with sediment for certain metals and perchlorate,~~ this uncertainty ~~would~~ does not substantially change the conclusions of this BHHRA~~.~~.

Most of the uncertainties associated with the sediment exposure parameters are likely to overestimate the risks associated with direct exposure to sediment~~.~~. ~~However, all of the beach sediment exposure scenarios were below or within the target risk range of 1 x x 10^{-4} to 1 x x 10^{-6}, and with the exception of two segments specifically for the tribal fisher RME scenario, all of the in-water sediment exposure scenarios were also below or within the target risk range of 1 x x 10^{-4} to 1 x x 10^{-6}. For the tribal fisher RME scenario, the exposure parameters are especially conservative as it is unlikely that an individual would fish the same ½ river mile river segment for five days every week of every year for 70 years.~~

~~7.2.5.2~~6.2.4.2 Exposure Parameters for Surface Water and Groundwater Seep Exposure Scenarios

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~~Transients were assumed to be exposed to surface water through ingestion and dermal contact. Tap water ingestion rates were used to represent exposure to surface water via ingestion for transients. However, tap water ingestion rates are an estimate of ingestion of a drinking water source, and the use of untreated water from the Lower Willamette as a source of drinking water by transients on an ongoing basis for two years is assumed to be health protective. The tap water ingestion rate used in the risk evaluation was 2 L/day for the transient and assumes surface water will be ingested every day for two years. In addition, it was assumed that transients bathe directly in the Lower Willamette two days per week throughout the entire year for two years.~~

~~For the recreational beach users, exposure to surface water was assumed to occur through incidental ingestion and dermal contact while swimming in the Lower Willamette. The incidental ingestion rate of 50 milliliters per day (ml/day) used in this BHHRA is that recommended by EPA for a swimming scenario. The exposure scenario assumes that adults frequent the same quiescent water area 26 times per year for 30 years, and that children frequent the same area 94 times per year for six years.~~

~~In addition to the direct contact scenarios mentioned above, risks were assessed from exposure to surface water as a hypothetical future domestic water source. This scenario assumes untreated surface water is used as a domestic water source 350 days a year for 30 years (adult resident) or six years (child resident). The LWR within the Study Area is not currently used as a domestic water source, but could be used as such in the future.~~

~~Another exposure parameter resulting in uncertainty for the surface water and groundwater exposure parameters is the absorbed dose per event. This parameter was derived per EPA guidance (2004) using chemical-specific factors, but the factors for some of the COPCs fall outside of the predictive domain. Specifically,~~Although dermal absorption of PAHs from water was quantitatively evaluated in the BHHRA,

the dermal permeability coefficient (K_p) falls outside of the effective predictive domain (EPD) for a number of the PAHs, including the following ~~COPCs~~:

- Benzo(a)anthracene
- Benzo(a)pyrene
- Benzo(b)fluoranthene
- Indeno(1,2,3-cd)pyrene
- Dibenzo(a,h)anthracene

EPA dermal assessment guidance (EPA 2004) states that "~~Although~~ although the methodology [for predicting the absorbed dose per event] can be used to predict dermal exposures and risk to contaminants in water outside the EPD, there appears to be greater uncertainty for these contaminants."~~–~~ The range of uncertainty associated with the Kp value can be several orders of magnitude~~.—~~. For instance, the predicted Kp value recommended by EPA (2004) for benzo(a)pyrene is 0.7 centimeters per hour (cm/hr), while the range of predicted Kp values presented by EPA (2004) is 0.024 cm/hr (95~~%~~ percent lower confidence level) to 20 cm/hr (95~~%~~ percent upper confidence level)~~.—~~. This uncertainty could result in over-estimation or under-estimation of risk from exposure to surface water~~.—~~. With the exception of arsenic, the only exceedances of 1×10^{-6} risk from surface water scenarios are the result of dermal exposure to PAHs in surface water~~.—~~. However, all of the surface water exposure scenarios were below or within the target risk range of 1×10^{-4} to 1×10^{-6}.

~~7.2.5.3~~6.2.4.3 Exposure Parameters for ~~Tissue Ingestion~~Fish/Shellfish Consumption Scenarios

Site-specific information regarding fish consumption is not available for Portland Harbor~~.—~~. In the absence of specific data, fish consumption data representative from several sources was considered and selected as being representative of the general population of the greater Portland area, as well as that portion of the population that actively fishes the Lower Willamette and utilizes fish from the river as a partial source of food~~.—~~. ~~The exposure parameters used for to evaluate tissue ingestionfish consumption were designed to provide a conservative estimates of exposurerisk. Fish tissue ingestion rates were developed using fish consumption data from a national study of fish consumption (CSFII, USDA), from a creel survey of Columbia Slough fishers north of the Study Area, and from the CRITFC Columbia River Fish Consumption Survey (CRITFC) study. The CRITFC Fish Consumption Survey provides fish consumption data for the Columbia River Basin for four of the six tribes who are parties to the Consent Decree for the Portland Harbor site. In addition, although the Columbia Slough Study was not done in Portland Harbor , the Columbia Slough is within one-half mile of the northern part of the Portland Harbor site, so fishers in the Portland Harbor site may have similar fishing practices and fish consumption rates as those fishing in the Slough.~~

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~~Site-specific information regarding fish consumption information is not available for the fisher scenarios~~Portland Harbor. ~~As a result~~In the absence of specific data, ~~nationwide fish consumption data~~ representative from several sources ~~was~~ were used ~~to calculate target fish tissue levels~~considered and selected as being representative of the general population of the greater Portland area, as well as that portion of the population that actively fishes the Lower Willamette and utilizes fish from the river as a partial source of food. ~~A consumption study conducted for the Columbia Slough was also used. The 99th percentile rate from the nationwide Continuing Survey of Food by Individuals,~~ However, the rates presented in the CSFII ~~(United States Department of Agriculture [USDA] 1998) of 142 g/day (as calculated in USEPA Estimated Per Capita Fish Consumption in the United States, freshwater and estuarine fish and shellfish) was used as one ingestion rate for adult fishers in the BHHRA. The 90th percentile rate of 17.5 g/day from the same study was used also used as one of the ingestion rates for adult fishers in the BHHRA. Concerns have been expressed regarding the methodology used by EPA in this study to establish the fish consumption rates, which are also recommended as default AWQC subsistence fish consumption rates in EPA's WQC Human Health Methodology guidance (EPA 2000d). Criticisms of these rates have been raised because they are based on~~study represent per capita consumption rates ~~from the general population – that is, "fish consumption" rates that are estimated based on the combined consumption information from fish consumers and fish non-consumers alike. For~~rather than true long-te~~rm RM-~~rm averaged consumption rates.~~ ~~–~~. Further, the large range between the percentile values ~~are~~is indicative of substantial variability in the underlying data~~.~~ ~~–~~. For example, consumption rates consumers ~~the~~ are 200 g/day at the 90th ~~-~~percentile ~~rate for fish consumers is 200 g/day, while~~ and 506 g/day at the ~~90th-~~99th percentile~~,~~ ~~–~~. ~~rate including data regarding fish~~ The consumption rate for consumers and non-consumers is ~~about~~ approximately 18 g/day at the 90th percentile and 142 g/day~~.~~ ~~Similarly,~~ at the 99th percentile ~~value for fish consumers is about 506 g/day, while the 99th percentile is approximately 142 g/day.~~ ~~–~~. ~~when data including the lack of fish in the diet of non-consumers are added. As previously discussed~~There is a large ~~difference in the percentiles of the dataset when information from people who do not consume fish are included. The consumer-only ingestion rates likely overestimate actual ingestion rates because people who do consume fish but did not on the 2 days of the study (e.g., many infrequent consumers) are not included in consumers only rate. At the same time, EPA guidance (1989) recommends using the 95th percentile, or even the 90th percentile, for RME~~upper bound values for ~~contact values~~rates ~~when evaluating RME. However, the data are indicative that considerable variability exists in fish consumption rates. In addition~~As discussed in Section 3.5.9.6, the RME consumption rate selected for recreational fishers ~~The the 95th UCL rate~~of 73 g/day is based on data from the Columbia Slough study ~~was used in the BHHRA as the RME consumption 73 g/day rate for adult recreational fishers~~consumers in the ~~BHHRA. –~~. ~~The Columbia Slough Study~~That study was a creel survey~~.~~ ~~–~~, and the representativeness of the~~is~~ rate is dependent on several factors. ~~As a result, the consumption rates used in the BHHRA may overestimate or underestimate actual fish~~

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~~consumption rates in the Study Area. This is due to many reasons,~~ including but not limited to:

- Willingness of anglers to participate
- Communication. If a substantial number of anglers consist of 1st or 2nd generation ethnic minorities, then language may be a barrier.
- Discrepancy between individuals who catch fish and those who prepare meals~~.~~ . Men generally fish but women generally prepare seafood and are much more familiar with the mass of seafood consumed.
- Difficulty in translating from the items inspected in an angler's basket to portion sizes and amounts consumed, since this requires assumptions about edible portions and cleaning factors.
- Lack of a random or representative sample~~. –~~ . Interviewers can only speak with who they encounter.
- Timing and seasonality of interviews.
- Weather conditions may bias the results of any day's interviews.

In addition ~~to the uncertainties behind~~ to the ~~rates of fish~~ consumption~~,~~ rates, ~~it was assumed that the frequency of consumption occurred at the same ingestion rate for 30 years for the adult fisher scenarios. Furthermore~~uncertainty also exists with respect to the relative percentage of the diet of obtained from the Study Area versus other nearby sources of fish, and the degree to which different methods of preparation and cooking may reduce concentrations of persistent lipophilic contaminants~~, 100% percent of the fish consumed was assumed to be caught within a 1 mile stretch on both sides of the river for bass and within a 3 mile stretch on both sides of the river for crappie, carp and bullhead trout over 30 years for localized exposures.. No reduction in concentrations of contaminants during food preparation and cooking was assumed, although reductions can occur depending on cooking and methods of preparation. .~~

~~For the tribal fish consumption scenario, the 95th percentile rate from the CRITFC Fish Consumption Survey (CRITFC 1994) was used. The CRITFC Fish Consumption Survey was performed by interviewing four of the six tribes who are natural resource trustees for the Site. It is not clear how this would impact the fish consumption rate for tribal populations used in the BHHRA, which was based up on the CRITFC Fish Consumption Survey.~~Uncertainties associated with tribal consumption rates largely relate to limitations inherent in the CRTFIC consumption survey on which the consumption rates used in the BHHRA are based~~. –~~ . ~~Also, some published articles have suggested that the fish consumption rates in the CRITFC Fish Consumption Survey~~These consumption rates may ~~ab~~re biased low for tribal members because:

- Tribal members who have a traditional lifestyle (and likely a higher consumption rate) would have been unlikely to travel to the tribal offices that were used for administering the CRITFC fish consumption interviews.

- The fish consumption rates for some tribal members that were perceived as being outliers (consumption rates were too high) were dropped from the CRITFC data before the consumption rates were calculated.
- Current fish consumption rates may be suppressed and, therefore, do not reflect the potential of the higher consumption rates if fishery resources improved or if~~–~~ contaminant concentrations in the water body decrease.

~~While the tribal fish consumption rates may or may not be biased low, there were additional conservative assumptions incorporated in the tribal fish consumption scenario. For example, fish consumption by an adult tribal fisher was assumed to occur at the same rate every day of every year for 70 years. As with the fisher scenarios, it was assumed that 100% percent of the fish consumed was caught at the same location for 70 years, and no reduction in concentration of contaminants occurred during food preparation or cooking.~~Conversely, conservative assumptions were used with respect to exposure frequency and duration, as well as the relative contribution of fish from the Lower Willamette to the overall tribal diet.~~ The~~ According to the CRITFC s~~C Fish Consumption S~~urvey, ~~that was used as the basis for the tribal fish ingestion rate also indicated that~~ none of the respondents fished the Willamette River for resident fish and at most, approximately 4~~%~~ percent fished the Willamette ~~River~~ for anadromous fish~~.–~~. However, future use of the site by tribal members may change i~~. Tribal members who have a traditional lifestyle and were unlikely to travel to tribal offices for the CRITFC Fish Consumption Survey also may be unlikely to travel to Portland Harbor to fish. It is unknown to what extent future tribal fishing habits may change i~~f fishery resources improved ~~or if COC concentrations in the water body decrease.–. ODEQ is proceeding with development of state water quality limits based on a tribal ingestion rate of 175 g/day.~~

I~~The i~~nformation ~~suggesting~~ regarding consumption of ~~that~~ shellfish ~~consumption may occur at~~from the Study Area ~~comes from a~~relies in part from information obtained from a community project sponsored by the Linnton Community Center, as discussed in Section 3.3.6~~.–~~. However, it is not known to what extent shellfish consumption actually occurs~~.–~~. Because site-specific shellfish ~~ingestion~~ consumption rates are not available, nationwide CSFII (USDA 1998) shellfish consumption data were used ~~to calculate target tissue levels for clams and crayfish.~~ . ~~The 95th percentile rate for shellfish consumption for freshwater and estuarine habitats combined from the nationwide survey was the source of the18 g/day ingestion rate, and the mean rate from the nationwide survey was the source of the 3.3 g/day ingestion rate.~~ As with the rates for fish ~~ingestion~~ consumption~~rates for adult consumers~~, these ~~shellfish ingestion rates~~ are based on per capita consumption rates from the general population. ~~– that is, consumption rates that include shellfish consumers and non-consumers alike. Consumer-only rates were not calculated in the EPA document for shellfish alone, but it is likely that they are higher for consumers-only compared to the rate based on both consumers and non-consumers.~~ In the nationwide survey, shrimp , ~~which is not found within the Study Area,~~ accounted for more than 80~~%~~ percent of the shellfish consumed~~.–~~, ~~– Crayfish~~ crayfish accounted for less than ~~1%~~one percent

of ~~the shellfish consumed~~diet, and freshwater clams were not included in the nationwide survey~~.~~. It is not known to what extent fishers substitute alternative local types of shellfish~~.~~. However, ~~for freshwater habitat only, which is the same as the Study Area,~~ the mean nationwide shellfish consumption rate from freshwater sources is 0.01 g/day; upper percentiles for freshwater shellfish consumption rates are not available (EPA 2002b).

~~Daily shellfish consumption rates used in this BHHRA represent mathematical artifacts to account for annual consumption rates. The daily consumption rates for shellfish represent approximately two and a half 8-ounce meals per month (18 g/day ingestion rate), and just less than one 8-ounce meal every two months (3.3 g/day ingestion rate). As with fish, 100 percent of the shellfish was assumed to be caught from the same one-mile stretch of river, on the same side of the river, for the 30 years, and no losses in chemical concentration were assumed from food preparation or cooking. It is unlikely that the Study Area supports *Corbicula* populations large enough to supply the quantity of tissue needed to satisfy the ingestion rates used in the BHHRA. During the Round 2 sampling event, the maximum mass of clam tissue data collected at a given sampling location was only 217.57 grams. At 18 g/day, this location would be depleted of clam tissue within 13 days. However, following EPA direction, bivalve consumption is treated as a potential future exposure pathway at the rates used in the BHHRA.~~

~~Most of the uncertainties associated with the fish and shellfish exposure parameters provide a conservative estimate of the risks associated with fish and shellfish consumption. Because noncancer hazards and cancer risks associated with consumption of fish and shellfish exceeded the NCP target noncancer hazard quotient of one and the cancer risk range of 1 x _x 10^{-4} to 1 x _x 10^{-6} as well as the point of departure of 1 x _x 10^{-6}, the uncertainties associated with fish and shellfish consumption could affect the decisions made in the FS.~~ The upper and lower bounds ~~magnitude~~ of uncertainty ~~associated with exposure parameters for~~ relating to ~~tissue~~ fish the shellfish consumption ~~ingestion scenarios was estimated for the BHHRA based on the data presented above, and~~ is discussed in Attachment F6.

~~7.2.5.4~~6.2.4.4 Assumptions about a Multi-Species Diet

Uncertainties exist in the assumptions about the relative composition of a multi-species diet ~~composition.~~ . The non-tribal multi-species diet assumes equal proportions of all four resident fish species~~. The~~, the tribal multi-species diet ~~consists~~ assumed ~~of~~ equal proportions of the four resident fish species, as well as dietary percentages of salmon, lamprey, and sturgeon ~~that come~~derived from the CRITFC ~~Fish Consumption s~~Survey ~~(CRITFC 1994).~~ . Variations of these dietary assumptions ~~from these compositions~~ would result in different risk estimates~~.~~. Because the risks from consumption of the individual species that make up the multi-species diet were evaluated separately, the range of risks from fish consumption scenarios encompasses the potential variations in the multi-species diet~~.~~. The range of the magnitude of these risks ~~was between 1 and 8~~generally less than an order of

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magnitude, and is discussed further ~~. The derivation of these risk ranges is further discussed~~ in Attachment F6~~.~~. ~~The~~ magnitude in the difference of risk estimates based on diet composition shows that this uncertainty could result in over or under-estimation of actual risks from a multi-species diet.

~~7.2.6~~6.2.5 Exposure Point Concentrations

~~The EPC is supposed to represent the arithmetic average of the concentration of a contaminant that will be contacted over the exposure duration; however, as a protective approach, a UCL on the arithmetic average is recommended for use as the EPC (EPA 1989). Given the uncertainties and variability associated with environmental data, a high amount of uncertainty is associated with calculating a representative EPC.~~ The following ~~EPC~~ uncertainties ~~have been identified~~related to calculation of ~~–~~ EPCs ~~and~~ for this risk assessment were analyzed further ~~in the BHHRA~~ to determine the potential effects on the risk estimates.

~~7.2.6.1~~6.2.5.1 Using 5-10 Samples to Calculate the 95~~%~~ percent UCL on the Mean

Data sets with fewer than 10 samples per exposure area generally provide poor estimates of the mean concentration, defined as a large difference between the sample mean and the 95 percent UCL~~.~~. In general, the UCL approaches the true mean as more samples are included in the calculation~~Using less than ten sample results to calculate a 95% percent UCL on the mean increases the uncertainty associated with the 95% percent UCL for certain calculation methods. EPCs for a number of exposure areas throughout the Study Area were based upon the 95% percent UCL on the mean concentration calculated using less than 10 samples. These EPCs are discussed and listed in Attachment F2 text and tables. They include EPCs for in-water sediment, surface water, and tissue. Calculating the 95% percent UCL on the mean using less than 10 samples could overestimate or underestimate actual exposures.~~ The Study Area-wide fish tissue EPCs that were calculated as 95~~%~~ percent UCL on the mean ~~concentrations,~~ using less than 10 samples, included ~~the Study Area-wide~~ EPCs for whole body brown bullhead and fillet common carp~~.~~. The ~~maximum~~ EPCs for the individual exposure points for whole body brown bullhead and fillet common carp were up to two times higher than the Study Area-wide EPCs, as discussed in Attachment F6.

~~9.0 If maximum detected concentrations had been used as EPCs in place of 95% percent UCL on the mean concentrations for exposure areas with less than 10 samples, exposures would have likely resulted in an overestimate of actual risks.~~

~~7.2.6.2~~6.2.5.2 Nondetects Greater than Maximum Detected Concentrations

Consistent with EPA guidance, ~~Individual non-detected~~ analytical results reported as non-detect for which the detection limit was greater than the maximum detected

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concentration in a given exposure area were removed from the dataset prior to calculation of the 95% percent UCL ~~calculations.~~ . These sample identifications, detection limits, and associated maximum concentrations are ~~discussed and~~ listed by media and exposure area in ~~in~~ the tables in Attachment F2 ~~text and tables~~. ~~A nondetect concentration means the actual concentration of the chemical could be as high as the detection limit, or it could be not present. However, if a detection limit exceeds the maximum detected concentration in a given exposure area, it is unknown whether the actual concentration is closer to zero or closer to the detection limit. Removal of these data prior to 95% percent UCL calculations decreases the need for assumptions about what the actual concentration may be, but it also decreases overall sample size for a given chemical and exposure area.~~

~~As discussed in Section 5.2.5, PCBs are the primary contributor to the cumulative risks for all of the fish tissue consumption scenarios, and dioxins are the secondary contributor. There were no cases for which nondetect concentrations exceeded the maximum detected concentration of PCBs and dioxins in fish tissue. It follows that the cases where nondetect concentrations exceeded the maximum detected concentrations did not impact the cumulative risk estimates. PCBs and dioxins were also the primary contributor to cumulative risk for shellfish tissue consumption and there were no cases where nondetect concentrations exceeded the maximum detected concentration of PCBs and dioxins in shellfish tissue. For surface water and in-water sediment the ratio of the nondetect concentrations exceeding the maximum detected concentrations were within two orders of magnitude.~~ If the actual concentrations were closer to the detection limit for surface water and in-water sediment, the risk estimates would still be less than $1 \text{ ~~x~~ } \times 10^{-6}$.

~~7.2.6.3~~6.2.5.3 Using the Maximum Concentration to Represent Exposure

The maximum concentration was used ~~For cases~~in instances ~~with~~ where there were either less than five detected ~~samples~~ results or fives samples for a given analyte and exposure area~~, the sample size was not sufficient to calculate a 95% percent UCL on the mean concentration for an EPC, and the maximum concentration was used. This,~~ including ~~es~~ EPCs calculated to represent Study Area-wide exposure~~.~~ . ~~Using maximum detected concentrations of infrequently detected contaminants to represent individual exposure areas, and especially Study Area-wide exposure, results in an extremely conservative estimate of risk for the Study Area. In general, use of 95% percent UCL on the mean concentrations or maximum concentrations provided a protective approach and likely resulted in overestimates of the actual risks, especially for ongoing, repeated, long-term exposures.~~ Use of the maximum concentration to represent exposure occurred for all media, and occurred most frequently for the fish and shellfish consumption scenarios~~.~~ . Contaminants and exposure points for which the maximum detected concentration was used instead of a 95% percent UCL on the mean are presented in the exposure point concentration tables in Section 3~~.~~ . In some cases, the maximum concentration for a contaminant was anomalously high, and may not be representative of tissue concentrations resulting from exposure to CERCLA-related contamination within the Study Area.

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Generally, the ratios between the maximum and minimum detected concentrations are less than 3.~~—~~. For in-water sediments, the ratios are less than 4.~~—~~. When comparisons are made within an exposure area for biota, the majority of the ratios of the 95~~%~~ percent UCL/maximum EPCs to the mean are equal to or less than 2, and the remaining ratios are less than 4.~~—~~. A more in-depth analysis of scenarios for which using the maximum concentration to represent exposure significantly affected the result of the risk estimate, and consequently which chemicals were designated as contaminants potentially posing unacceptable risks for a scenario, is provided in Attachment F6.

EPA's UCL guidance (EPA 2002) notes that that defaulting to the maximum observed concentration may not be protective when sample sizes are very small because the observed maximum may be smaller than the population mean~~The conservatism of using the maximum detected concentration as the EPC for exposure areas with less than 5 detected results impacts the conclusions of this BHHRA~~.

~~7.2.6.4~~6.2.5.4 Possible Effects of Preparation and Cooking Methods

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Cooking and preparation methods of fish tissue can ~~modify the amount of contaminant ingested by fish consumers~~change the concentration of lipophilic contaminants in fish tissues;~~.~~ ~~The~~ EPA (1997b) states that "cleaning and cooking techniques may reduce the levels of some chemical pollutants in the fish.~~"—~~ PCBs~~, which were found to have the greatest contribution to the cumulative cancer risks and the highest noncancer HQs,~~ tend to concentrate in fatty tissues.~~—~~. T~~herefore, t~~rimming away fatty tissues, including the skin, may reduce the exposure to PCBs.~~—~~. Removing the skin can reduce ~~The~~ PCB concentrations ~~of PCBs~~ in raw fillet ~~tissue have been shown to decrease~~ by ~~approximately~~ 50~~%~~ percent by ~~removing the skin~~ (EPA 2000c)~~.~~ . Cooking can also reduce the concentrations ~~of PCBs up to~~as much as 87~~%~~ percent, depending on the method (Wilson et al. 1998).~~—~~. However, one study showed a net gain in PCB concentrations after cooking (EPA 2000c).~~—~~. The potential for reduction in PCB concentrations due to cooking is subject to a substantial degree of variability, and some consumption practices make use of whole fish, reductions in PCB concentrations were not considered quantitatively in the risk assessment

~~As per EPA directive, dose modifications to account for cooking or tissue preparation were not used in determining EPCs for fish ingestion. If included, the risk estimates may have been reduced by up to approximately 90% percent for some contaminants. Since PCBs contribute to the majority of risks from fish consumption, this uncertainty could significantly impact the results of this BHHRA. For other contaminants, particularly mercury, which accumulates in the muscle tissue of fish, cooking is not known to reduce the concentrations in tissue; however, mercury does not contribute to the cumulative cancer risks.~~ .

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~~7.2.6.5~~6.2.5.5 Assumptions about Arsenic Speciation

The ~~EPA~~ toxicity ~~data represent inorganic~~of arsenic is dependent on the chemical species, inorganic arsenic~~.~~ Is generally more toxic than organic forms~~.~~. ~~\and~~ T~~t~~issue concentrations of ~~Arsenic~~ arsenic ~~in tissue was analyzed~~are~~were~~ reported ~~only~~ as total arsenic, which is consistent with EPA toxicity criteria, which are based on total arsenic~~.~~. A study conducted on the middle ~~Toxicity data are only available for inorganic arsenic.~~ Willamette River (EVS 2000) measured composites of resident fish (largescale sucker, carp, smallmouth bass, and northern pikeminnow) from a 45-mile section of the iver extending from the Willamette (River Mile 26.5) to Wheatland Ferry (River Mile 72). Total arsenic and inorganic arsenic concentrations were determined in composites of whole body, fillet with skin, and composites of that portion of the fish remaining after removing fillets~~.~~. Percent inorganic arsenic ranged from 2 percent (carp) to 13.3 percent (sucker)~~.~~. The average percent of inorganic arsenic was 4.2 percent for the carp and 3.8 percent for the smallmouth bass. ~~The Columbia River Basin Fish Contaminant Survey (EPA 2002e) determined that a "value of 10% percent is expected to result in a health protective estimate of the potential health effects from arsenic in fish". Therefore,~~Consistent with the recommendation in the Columbia River Basin Fish Contaminant Survey (EPA 2002e), the EPC for inorganic arsenic was estimated as 10~~%~~ percent of the total arsenic detected in tissue~~.~~. ~~In previous fish tissue studies in the lower Columbia and Willamette Rivers, the percent of inorganic arsenic relative to total arsenic ranged from 0.1% percent to 26.6% percent with an average percent inorganic arsenic of 5.3% percent in the resident fish samples from the Willamette River (Tetra Tech 1995, EVS 2000).~~

~~In clams~~I~~,~~ inorganic arsenic in clams was found to range as high as 50~~%~~ percent of total arsenic in ~~tissue~~ data collected in the Lower Duwamish River~~.~~. However, ~~the~~ the Lower Duwamish ~~River~~ is an estuarine system, ~~ry~~ while the Lower Willamette in Portland Harbor is ~~a~~ freshwater ~~river, .~~. ~~so the species of clams in the Duwamish River are different from those in Portland Harbor.~~ Since the actual percent of arsenic that is inorganic in clam tissue from the Study Area is unknown, this results in uncertainty in the estimate of inorganic arsenic EPCs ~~for~~ in shellfish~~clam~~. The clam tissue data collected from the Study Area ~~in Rounds 1 through 3~~ was evaluated to determine whether a higher percentage of inorganic arsenic might have a significant effect on overall risk from the consumption of clam tissue~~:. The analysis found:~~

- All of the arsenic concentrations in clam tissue are within a factor of 2~~.~~. ~~of each other (i.e., the maximum concentration is approximately 2 times higher than the minimum concentration).~~ In addition, the arsenic concentrations in clams are normally distributed~~.~~. ~~Both of these facts support the conclusion that the arsenic in clams is due to ubiquitous concentrations, not localized sources.~~
- Due to the narrow range of arsenic concentrations, the risks from consumption of clams are within a factor of 2 throughout the Study Area.

- If inorganic arsenic is assumed to be 50% percent of the total arsenic rather than the assumption of 10% percent used in the BHHRA, the cumulative risks from consumption of clams only increase by a factor of 1.1 to 1.3.—. Arsenic is not the because there are other contaminants that are primary contributors to risks from consumption of clams.

Given all of the other uncertainties associated with risks from clam consumption, the inorganic arsenic assumption is a minor uncertainty with minimal effect on the overall risk estimates.

Although arsenic resulted in risks greater than 1 x. x 10^{-6} for some of the fish consumption scenarios, the contribution of arsenic to the cumulative risk was insignificant relativesubstantially less than to that from PCBs.—. Therefore, the assumptions about inorganic arsenic are not likely to impact affect the overall the conclusions of this the BHHRA.—.

7.2.6.66.2.5.6 Polychlorinated Biphenyls

PCBs were analyzed as Aroclors in some media and as individual PCB congeners in others.—. This introduces some uncertainty when comparing cumulative risk across media. Congener analysis may provide a more accurate measure of PCBs in environmental samples than does the Aroclor analysis.—. Although most PCBs may have originally entered the environment as technical Aroclor mixtures, environmental processes, such as weathering and bioaccumulation, may have led to changes in the congener distributions in environmental media such that they no longer closely match the technical Aroclor mixtures used as standards in the laboratory analysis, leading to inaccuracies in quantitation.—.

The results for PCBs in whole body tissue samples analyzed for both PCBs as Aroclors and as individual PCB congeners were qualitatively compared to evaluate correlations associated with the use of Aroclor data. - Windward (2005) analyzed fish tissue from the Lower Duwamish Waterway as PCB Aroclors and as individual PCB congeners.—. The PCB Aroclor data and PCB congener data were significantly correlated for both fillet and whole body tissue.—. It should be noted that the Lower Duwamish Waterway is not freshwater, and different species were assessed in the Lower Duwamish study compared to Portland Harbor.—. Therse is less uncertainty associated with using PCB congener data to calculate EPCs; however, these correlations suggest that PCB Aroclor data may be used in the place of congener data if congener data are not available.

When available, PCB congener data were included in cumulative risk sums for tissue because differences in bioaccumulation , in addition to weathering, results in even greater uncertainty in the PCB Aroclor analysis for tissue.—. However, for fillet tissue collected in, Round 1 samples werewas analyzed for PCB Aroclors only, and Round 3 smallmouth bass and common carp samples, which were collected for smallmouth bass and common carp, were were analyzed for PCB congeners only.—. Because PCB

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congener data are available for smallmouth bass and common carp fillet tissue, cumulative risks for exposure to fillet tissue from ingestion include only the most recent tissue data for these two species. This introduces uncertainty to the cumulative risk estimates for exposure to fillet tissue when comparing risks across all four resident species.

PCB Aroclor data were included in cumulative risk sums for sediment because the PCB Aroclor dataset is larger than the congener dataset~~.~~ .

PCB congener data were included in the risk evaluation for surface water because the PCB Aroclor data was derived from the results of the congener analysis for the samples used in the risk characterization of this BHHRA~~.~~ . Total PCB congeners did not screen in as COPCs for any surface water scenarios~~.~~ . If PCB Aroclor data from the surface water dataset were used in the COPC screening, PCBs would still not be considered a COPC for any surface water scenarios.

When PCB congener data were used, the total PCB concentration was adjusted by subtracting the concentrations of coplanar PCBs from the total PCB concentration~~.~~ . This was done for purposes of estimating cancer risks because the coplanar PCBs were evaluated separately for the cancer endpoint~~.~~ .

~~7.2.6.7~~6.2.5.7 Bioavailability of Chemicals

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The toxicity values used in the risk assessment are ~~generally~~ often based on laboratory studies in which the chemical is administered in a controlled setting via food or water~~.~~ . A~~The actual a~~bsorption from environmental media may be lower than that observed in the laboratory~~.~~ . Studies have shown that conditions in environmental media (e.g., pH, organic carbon content) can affect the bioavailability of a chemical (Ruby et al. 1999, Pu et al. 2003, Saghir et al. 2007)~~.~~ . If the bioavailability of a chemical in a given environmental medium is less than that in the laboratory study used to derive the toxicity value, the risk assessment will overestimate the ~~risks associated with~~ exposure to that chemical in that medium~~.~~ . T~~A committee of t~~he National Research Council has recommended that consideration of bioavailability be incorporated in decision-making at sites (National Academy of Sciences 2003)~~.~~ . While site-specific information on the bioavailability of chemicals in sediment is not available, it is important to recognize that there is uncertainty associated with not incorporating bioavailability into the risk estimates, especially related to sediment-associated chemicals.

~~7.2.6.8~~6.2.5.8 Exposure Areas for Consumption of Smallmouth Bass ~~Exposure Areas~~

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Exposure via consumption of ~~Smallmouth~~ smallmouth bass ~~exposure areas were~~was evaluated on a river mile basis~~.~~ . Uncertainties associated with the home range of smallmouth bass are discussed in Section 6.1.13~~.~~ . In Round 1, samples were composited on a per river mile basis ~~(e.g., RM 2, RM 3). In~~ , Round 3, samples were

composited on a per river mile basis~~, per~~ for each side of river ~~(e.g., RM 2E, RM 2W).~~ . The Round 1 and Round 3 results were combined, and ~~included in~~ the EPC ~~calculations for each~~thus represents an ~~-~~exposure area of one river mile ~~exposure area. . Although studies have shown that smallmouth bass migrate from one side of the river to another in the lower~~ A study by ODFW (ODFW 2005) that included tracking the movement of smallmouth bass in the Lower Willamette indicated that their home range is typically between 0.1 and 1.2 km, and they are most frequently found in near-shore areas~~. . (ODFW 2005), it is possible that some smallmouth bass may have a home range that is limited to a single side of the river.~~

Figure 6-1 displays the ratios of concentrations of DDT, DDE, DDD, cPAH, dioxin/furan TEQ, and PCB congeners detected in composite smallmouth bass samples collected at the east side of the river mile compared to concentrations for those detected in composite samples collected at the west side of the river mile~~. .~~ . At ~~RM~~ RM 8, 9, and 10, the ratios are all less than 1, indicating concentrations on the east side of the river are generally less than concentrations on the west side of the river~~. .~~ . For the remaining river miles, some ratios exceed one~~. .~~ . East to west side concentration ratios for PCBs at river mile 11 are highest of any river mile evaluated~~. . A~~ ~~It should be noted, a~~s previously discussed in Section 6.1.14, that a fish from ~~RM~~ RM 11W was included in the composite for ~~RM~~ RM 11E due to a mislabeling of the sample~~. .~~ . Due to the low number of samples for each exposure area, the maximum detected concentration from either side of the river was typically ~~is almost always~~ used as the ~~95% percent UCL/max~~RME EPC for the river mile exposure areas ~~anyway, which eliminates the possibility of underestimating risk for a given river mile based on whether or not smallmouth bass migrate across the river. . Furthermore, the river mile exposure area was determined based on the smallmouth bass home range.~~ In addition, the area over which fishing occurs should also be considered~~. .~~ . Given ~~the~~ an exposure duration of 30 to 70 years, it is ~~likely~~ possible that fish would be collected over an area greater than a single river mile ~~for localized exposures~~. Therefore, ~~the characterization of risk for~~use of an exposure area consisting of a single river mile for evaluating consumption of smallmouth bass ~~in this risk assessment~~ is generally ~~a~~ health protective ~~estimate that is~~and unlikely to underestimate risks.

~~7.2.6.9~~6.2.5.9 EPCs in Surface Water ~~EPCs~~ for Recreational Beach Users

Only data collected from the low water sampling event was used to assess~~For~~ recreational exposures to surface water, ~~data from only the low water sampling event was used,~~ in order to represent surface water conditions during the time of year when most frequent recreational use occurs ~~(i.e. summer months). .~~ . There is some uncertainty in the representativeness of this dataset for surface water conditions for recreational users.

Because ~~Transient~~ exposure to surface water by transients can occur throughout the year, ~~so~~ data from sampling events during three seasons of the year were used for this

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scenario and can be used to assess the representativeness of the single low water sampling event~~.~~ . Arsenic was the only surface water COPC detected in recreational exposure areas~~.~~ . The Study Area-wide average total arsenic concentration for transient exposure to surface water, using year-round data, is 0.48 µg/l~~.~~ . The Study Area-wide average total arsenic concentration for recreational beach user exposure to surface water, using low flow data, is 0.51 µg/l~~.~~ . Given the similarity of these results, the uncertainty associated with the recreational beach user surface water dataset should not affect ~~impact~~ the conclusions of this BHHRA.

~~7.3~~6.3 TOXICITY ASSESSMENT

The results of animal studies are often used to predict the potential human health effects of a chemical~~.~~ . Extrapolation of toxicological data from animal studies to humans is one of the largest sources of uncertainty in evaluating toxicity ~~factors.~~ . Much of the toxicity information used in this BHHRA comes from EPA's Integrated Risk Information System (IRIS), which states the following on its website:

> In general IRIS values cannot be validly used to accurately predict the incidence of human disease or the type of effects that chemical exposures have on humans~~.~~ . This is due to the numerous uncertainties involved in risk assessment, including those associated with extrapolations from animal data to humans and from high experimental doses to lower environmental exposures~~.~~ . The organs affected and the type of adverse effect resulting from chemical exposure may differ between study animals and humans~~.~~ . In addition, many factors besides exposure to a chemical influence the occurrence and extent of human disease (EPA 2010b, http://www.epa.gov/iris/limits.htm).

EPA typically applies uncertainty factors, typically a factor 10, when deriving reference doses, to account for limitations in the data~~.~~ . ~~Because of these uncertainties, toxicological data parameters are usually conservative to be more protective of human health due to safety factors EPA uses when estimating toxicity values. The safety factors used by EPA typically range from two to three orders of magnitude (100 to 1,000 times), depending on various aspects of the animal study.~~ These limitations include variation in susceptibility among the members of the human population, uncertainty in extrapolating animal data to humans, uncertainty in extrapolating from data obtained in a study with less-than-lifetime exposure, uncertainty in extrapolating from a LOAEL rather than from a NOAEL, and uncertainty associated with extrapolation when the database is incomplete~~.~~ . As a result, actual risks within the Study Area ~~could~~ are likely to be lower than the ~~potential risk~~ estimates calculated in this BHHRA~~.~~ .

~~In~~ In addition ~~to the uncertainty already included in the toxicity values~~, the following specific uncertainties ~~the following toxicity value uncertainties~~ have been identified.

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~~7.3.1~~6.3.1 Early Life Exposure to Carcinogens

~~In 2005, EPA finalized the~~ As discussed in Section 3.5.6, early-in-life susceptibility to carcinogens has long been recognized as a public health concern~~.~~. EPA's Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens (EPA 2005b) ~~Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens (EPA 2005b). The guidance~~ provides a process to evaluate risks from early-life exposure to carcinogens ~~with~~ known to act via a mutagenic mode of action~~.~~. The only exposure scenarios ~~with~~ for which early-life exposures ~~(i.e., child populations)~~ are considered are recreational beach use~~rs, and~~ fish consumption, and household use of surface water~~.~~. ~~Of these, the only scenario with potential exposure to chemicals with a mutagenic mode of action is the recreational beach user scenario for exposure to PAHs.~~Of the COPCs identified in the risk assessment, only cPAHs have been identified as mutagenic~~.~~.

~~This~~The BHHRA did not ~~evaluate risks using the new EPA guidance as the exposure factors~~specifically address early-life exposures ~~for the specific age classes~~ in the separate child and adult scenarios~~.~~. However, ~~the guidance~~increased early-life susceptibility was used to assess risks associated with exposure to PAHs in the combined adult/child scenarios. Therefore, the combined adult/child scenario accounts for the additional potency associated with early life exposures.

~~7.3.2~~6.3.2 Lack of Toxicity Values for Delta-hexachlorocyclohexane, Thallium, and Titanium

Delta-HCH was detected in tissue and in-water sediment~~.~~. An SF or RfD toxicity value could not be identified for delta-HCH according to the hierarchy of sources of toxicity values recommended for use at Superfund sites (EPA 2003b)~~.~~. Also, an STSC review concluded that the other hexachlorocyclohexane isomers could not be used as surrogates for delta-HCH due to differences in toxicity (EPA 2002d)~~.~~. Potential risk from delta-HCH was not quantitatively evaluated because of the lack of availability of toxicity data ~~for the chemical~~.

Thallium was detected in in-water sediment and surface water, and titanium was detected in in-water sediment~~.~~. Thallium and titanium are naturally occurring elements, and although thallium may have a wide spectrum of effects on humans and animals (EPA 2009a), titanium has been characterized as having extremely low toxicity (Friberg et al 1986)~~.~~. An SF or RfD toxicity value could not be identified for titanium according to the hierarchy of sources of toxicity values recommended for use at Superfund sites (EPA 2003b), and consultation with EPA indicated no surrogate toxicity value was available~~.~~. Therefore potential risk from exposure to titanium was not quantitatively evaluated in this BHHRA.

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~~7.3.3~~6.3.3 Use of Toxicity Values From Surrogate Chemicals for Some Chemicals that Lack Toxicity Values

For some chemicals, if a RfD or SF toxicity value was not available from the recommended hierarchy, a structurally similar chemical was identified as a surrogate~~.~~ . The RfD or SF for the surrogate was selected as the toxicity value and the surrogate chemical was indicated in Section 4~~.~~ . Uncertainty exists in using surrogate chemicals to represent the toxicity of chemicals for which toxicity values are not available~~.~~ . Using surrogate toxicity values could over- or under-estimate risk for a specific chemical.

Based on the results of the BHHRA, the chemicals that exceeded the minimum target cancer risks of 1~~x~~ x 10^{-6} or hazard quotient of 1 did not rely on surrogate toxicity values~~.~~ . Therefore, the use of surrogate toxicity values should not ~~impact~~ affect the conclusions of this BHHRA.

~~7.3.4~~6.3.4 Toxicity Values for Chromium

Chromium was analyzed as total chromium in all media~~.~~ . Although toxicity values exist for both trivalent and hexavalent chromium, hexavalent chromium exhibits greater toxicity that the trivalent form~~Toxicity values exist for trivalent and hexavalent chromium only.~~ . ~~A~~ The reference dose for hexavalent chromium is 0.003 mg/kg-day, versus 1.5 mg/kg-day for trivalent chromium~~, which is a factor of 500 times higher.~~ . ~~The toxicity values for trivalent chromium were used in the toxicity assessment for the Study Area because~~ Hh~~h~~exavalent chromium ~~reduces~~ can be reduced to trivalent chromium in an aqueous environmental medium if an appropriate reducing agent is available, and thus trivalent chromium is more prevalent in the environment (ATSDR 2008)~~.~~ . S~~Likewise, s~~creening values for trivalent chromium were used in the selection of total chromium as a COPC for in-water sediment, beach sediment, the groundwater seep, and surface water. This is an uncertainty because the trivalent chromium screening level is for insoluble salts.

The highest HQ for chromium ~~For~~ from fish consumption~~, the highest HQ from chromium~~ was 0.004. ~~,~~ E~~so e~~ven if a portion of the chromium were present as hexavalent chromium, the HQ would likely still be less than 1~~.~~ . ~~Therefore, use of toxicity values for trivalent chromium should not impact the conclusions of this BHHRA~~A~~.~~

~~A~~dditionally, ~~that~~ EPA currently considers the carcinogenic potential of hexavalent chromium via oral exposure as "cannot be determined."~~–~~ Toxicity criteria derived by the New Jersey Dept. of Environmental Protection ~~A~~ was used as a Tier 3 source ~~of toxicity criteria, the New Jersey Dept. of Environmental Protection, has derived quantitative dose-response criteria~~ for evaluating the cancer risks associated with oral exposures to hexavalent chromium~~, which is the value used in the BHHRA~~.

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~~7.3.5~~6.3.5 Toxicity Values for Polychlorinated Biphenyls and Applicability to Environmental Data

The toxicity values for PCBs were applied to both PCB congeners (not including coplanar congeners) and Aroclors~~.~~. The RfD for PCBs is based on an immunotoxicity endpoint for Aroclor 1254 (EPA 2010b)~~.~~. Several other Aroclors have been detected in media within the Study Area, indicating the mixture of PCBs differs from that used in the study to develop the RfD~~.~~. The cancer SF for PCBs was derived for PCB mixtures based on administered doses of Aroclors to rats~~.~~. The PCB mixtures used in the studies included the coplanar PCB congeners (~~i.e.,~~ dioxin-like PCBs), and ~~. These~~ coplanar PCBs may have contributed ~~significantly~~ to the carcinogenicity observed in the study~~.~~. ~~The~~ Because the cancer risk from coplanar PCB congeners was evaluated separately, ~~so~~ including both the total PCB and coplanar PCB congener risks in the cumulative cancer risk ~~results~~ may result in an overestimate of the cancer risks~~.~~. Although the potential double counting of PCB mass was corrected for ~~in~~ by using the PCB adjusted values ~~(mass of dioxin-like PCB was subtracted)~~, there was no correction for the potential double counting of toxicity of dioxin-like PCBs in the PCB TEQ cancer risk estimate ~~and as part of the PCB adjusted value cancer risk estimate~~.

~~Based on the dose-response data from studies in rats,~~ PCBs are classified as probable human carcinogens based on adequate dose-response data from studies in rats~~.~~. However, the human carcinogenicity data are inadequate ~~for classification of PCBs as human carcinogens~~. Several cohort studies have been conducted that analyzed cancer mortality in workers exposed to PCBs. These studies did not find a conclusive association between PCB exposure and cancer; however they were limited by small sample sizes, brief follow-up periods, and confounding exposures to other potential carcinogens~~.~~. Therefore, using a cancer SF based on the dose-response observed in rats adds further uncertainties to the cancer risk estimates from PCBs as a dose-response has not been observed in humans.

In addition to the uncertainties with toxicity values for total PCBs, there are uncertainties with the toxicity values for the PCB TEQ, which is evaluated using toxicity values for dioxin and dioxin-like compounds ~~(e.g., dioxin-like PCBs).~~ . In ~~their~~ its 2001 evaluation of the ~~EPA~~ dioxin reassessment, members of the EPA's Science Advisory Board (SAB) did not reach consensus on the classification of 2,3,7,8-TCDD as a carcinogen (EPA 2001d)~~.~~. The National Academy of Sciences (NAS 2006) discussed the primary uncertainties with the toxicity values for dioxin and dioxin-like compounds as follows:

- The estimation of risks at doses below the range of existing reliable data may result in an overestimate of risk~~.~~. An estimate of risk for typical human exposures to dioxin and dioxin like compounds would be lower in a sub-linear extrapolation model than in the linear model that was used to derive the 2,3,7,8-TCDD SF.

- The issue of appropriately assessing the toxicity of various mixtures of these compounds in the environment.~~–~~ . The relative concentrations may change over an exposure period, even though the potency of the individual congeners remains constant.~~–~~ . The estimated risk in a given sample depends on both potency and concentration.

The above uncertainties apply to risks from dioxins and furans, as well as risks from dioxin-like PCBs.

~~7.3.6~~6.3.6 Adjustment of Oral Toxicity Values for Dermal Absorption

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As discussed in Section 4.7, an adjustment was applied to the oral toxicity factor to account for the estimated absorbed dose ~~To evaluate~~when evaluating dermal exposures ~~in this BHHRA, an adjustment to the oral toxicity factor to account for the estimated absorbed dose was applied, as discussed in Section 4.7 of this BHHRA~~ .

~~As recommended by EPA guidance (EPA 2004), an adjustment to the oral toxicity factor to account for the estimated absorbed dose was applied in this BHHRA~~ when the following conditions ~~are~~ were met:

- The toxicity value derived from the critical study is based on an administered dose (e.g., through diet or by gavage)
- A scientifically defensible database demonstrates the GI absorption of the chemical is less than 50~~%~~ percent in a medium similar to the one used in the critical study.

~~If both conditions are not met, then a default oral absorption value of 100% percent is used so that no adjustment for GI absorption is made to evaluate toxicity from dermal exposures.~~

~~The~~ EPA (2004) recommends the adjustment of oral toxicity values to reflect dermal absorption ~~using a cutoff value of 50% percent GI absorption to reflect the intrinsic variability in the analysis of the absorption studies~~only when GI absorption was less than 50 percent, e~~. The cutoff value of 50% percent GI absorption obviates~~ liminating the need for small adjustments in the oral toxicity value that are not supported by the level of accuracy in the critical studies that are the source of the toxicity values.~~–~~ .

~~The EPA (2004) guidance states that scientific literature indicates that o~~Organic chemicals are generally well absorbed across the GI tract, absorption of . ~~For~~ inorganic chemicals , ~~the literature indicates a wide range of GI absorption values~~is dependent on a number of factors, but is generally less than for organic chemicals.~~–~~ . However, ~~if EPA (2004) guidance does not provide a GI absorption value for an inorganic COPC,~~in the absence of a specific value for GI absorption, ~~then the~~ a default ~~GI absorption value~~ of 100~~%~~ percent was used.~~–~~ . ~~The~~ EPA ~~(~~2004 ~~) guidance~~

states that ~~this assumption of~~assuming 100~~%~~ percent absorption may ~~contribute to~~ underestimat~~e~~ion ~~of~~ dermal risk for those ~~inorganics~~ chemicals that are poorly absorbed because it overestimates the dose at the site of action~~.~~. T~~.~~ ~~T~~he extent of ~~this~~ underestimation is proportional to the actual GI absorption~~, which would not exceed 50% percent~~. ~~.~~. I~~The i~~norganic COPCs for which the default value of 100~~%~~ percent GI absorption was used~~.~~ are~~includes the following metals :~~ aluminum, arsenic, boron, cobalt, copper, iron, molybdenum, selenium, thallium, and zinc~~.~~.

~~7.4~~6.4 RISK CHARACTERIZATION

Uncertainties arise during risk characterization due to the methods used in calculating, summing, and presenting risks~~.~~. The following subsections address uncertainties associated with the risk characterization of this BHHRA.

~~7.4.1~~6.4.1 Endpoint-specific Hazard Indices

In deriving endpoint-specific HIs, only one health endpoint is used for each chemical, even though ~~most~~ some chemicals may have a myriad of health effects as exposures increase~~.~~. As an example, a majority of the non-cancer ~~impacts~~ affect from the site are from PCBs and total TEQ. The endpoint used for deriving the RfD for PCBs is immunotoxicity, while the endpoint used for deriving the RfD for dioxin/furan TEQ and PCB TEQs is ~~reproduction~~reproductive effects~~.~~. If the reproductive endpoint for PCBs based upon the lowest observed adverse effects level (LOAEL) of 0.02 mg/kg/day is used with the same Uncertainty Factor as the immunological endpoint to derive an RfD for a reproduction endpoint for PCBs, the RfD for reproductive effects ~~will~~ would be ~~4 ti~~a factor of 4 greater ~~mes~~ than the RfD for immunological effects~~.~~. Using this ratio, the endpoint-specific HI for reproduction for this exposure scenario for PCBs would be 5,000/4 = 1,250. The total HI for reproduction effects, combining HIs for total TEQ (500) and non-dioxin-like PCBs (1,250), would increase from 500 to 1,750. For the chemicals that have the largest non-cancer contribution in the HHRA, there is a possibility of under-predicting non-cancer health effects by using only one endpoint per chemical.

~~7.4.2~~6.4.2 Risks from Cumulative or Overlapping Scenarios

Where multiple exposure scenarios exist for a given population ~~(i.e., recreational beach users are potentially exposed to both beach sediment and surface water)~~, the risks for each of the exposure scenarios that are considered potentially complete and significant for a given population were summed to estimate the cumulative risks for that population (see Tables 5-199 and 5-200)~~.~~. In calculating the cumulative risks, the maximum cancer risk for each RME scenario was used~~.~~. This provides a conservative approach, as the same individual may not ~~have~~ experience the maximum exposure under more than one exposure scenario~~.~~. However, due to the fact that risks from one scenario are usually orders of magnitude higher than any other scenario for a given receptor, risks from potential cumulative scenarios should not

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~~impact~~ affect the conclusions of this BHHRA~~.~~. However, the possible magnitude of uncertainty associated with risks from cumulative or overlapping scenarios is discussed further in Attachment F6.

In addition to cumulative exposure scenarios for a given population, an individual may be a member ~~part~~ of multiple exposure populations~~, (i.e., a dockside worker that is also a non-tribal fisher)~~ and thus ~~could have~~ overlapping exposure scenarios~~.~~. Because there are numerous possible combinations of overlapping scenarios due to variations in exposure points and exposure assumptions, a model was not developed to quantitatively evaluate overlapping scenarios in this BHHRA~~.~~. However, because the risk from ~~tissue ingestion~~fish and shellfish consumption is typically at least ~~10~~ 10-fold ~~times higher~~greater than other exposure pathways, if an individual consumes fish, the relative contribution from other exposure scenarios is not likely to contribute significantly to the overall risks for that individual~~.~~. This BHHRA presents the risks for all of the exposure scenarios, so the risks for a given overlapping scenario could be calculated simply by summing the risks for each of the exposure scenarios that make up the overlapping scenario.

This BHHRA assessed potential risks from exposure to media within the Study Area~~.~~. Upland sites were not included in this BHHRA~~.~~. If exposure to upland sites were incorporated with exposures to media within the study, the overall estimate of cumulative risk would likely be higher than the risk estimates in this BHHRA.

~~7.4.3~~6.4.3 Risks from Background

Metals are naturally occurring and may be present in tissue, water, or sediment may not be directly related to contamination~~.~~. Reported ~~Concentrations~~ concentrations of arsenic and mercury in samples collected within the Study Area ~~were found to~~ result in estimated risks greater than 1~~x~~ x 10^{-6} or an HQ of 1 for ~~at least~~ one or more of the exposure scenarios evaluated in ~~this~~ the BHHRA~~.~~. ~~However, metals are naturally occurring chemicals and may be present in tissue, water or sediment due to background concentrations. For~~Exposure concentrations of arsenic in beach sediment~~, the exposure point concentrations~~ ranged from 0.~~7~~ 7 mg/kg to 9.9 mg/kg, within the general range of ~~and are consistent with the default background soil concentration for arsenic of~~ 7 mg/kg used as a background concentration of arsenic by DEQ (~~DEQ~~ DEQ 2007)~~.~~. Risks from background concentrations of arsenic in beach sediment and surface water are discussed in Section 5 of ~~this~~ the BHHRA~~.~~. ~~In addition to naturally occurring metals, anthropogenic background may contribute to the overall risks.~~

Neither ~~natural~~ background nor anthropogenic ~~background~~ tissue concentrations of COPCs were established for the Study Area~~. Natural and anthropogenic sources of both metals and organic chemicals are known to contribute to COC concentrations in abiotic media and biota in the Study Area.~~ .

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~~Although background tissue concentrations for the Study Area were not established, in some cases, R~~regional tissue concentrations were ~~correspond to risk estimates above the target risk thresholds established by EPA (i.e. cancer risk of 10^{-6} to 10^{-4});~~[8] ~~For example,~~measured ~~in~~ as part of the Columbia River Basin Fish Contaminant Survey~~, HIs were greater than 100 and cancer risks were as high as 2 x 10^{-2} for the highest tribal fish consumption rate (389 g/day) (EPA 2002c). In this study, the fish species collected included~~ in five anadromous species (Pacific lamprey, smelt, coho salmon, fall and spring Chinook salmon, steelhead) and six resident species (largescale sucker, bridgelip sucker, mountain whitefish, rainbow trout, white sturgeon, walleye)~~.~~. All samples were composites; the size of the individual fish varied with species~~.~~. C~~However, c~~oncentrations of certain contaminants are higher in tissue collected within the Study Area than observed in the ~~regional tissue~~Columbia River study, and the sources of the regional tissue concentrations are unknown~~, and regional efforts are underway to reduce contaminant concentrations in tissue.~~. ~~.~~

~~While~~Consistent with EPA policy, ~~risks~~ risk estimates were presented in this BHHRA without accounting for contributions from background~~, .~~. However, it is important to recognize that background concentrations may result in unacceptable ~~risks~~ risk and hazard estimates. ~~based on the exposure assumptions used in this BHHRA. The proportion of the concentrations that are not due to releases from sources in the Study Area cannot be controlled by remedial actions in the Study Area. This could prevent remedial actions in the Study Area from achieving acceptable risk levels.~~

~~7.4.4~~6.4.4 Risks from Lead Exposure

T~~Because t~~he maximum EPC~~s~~ calculated for lead are ~~greater than the protective fish tissue concentrations~~ associated with ~~an acceptable~~a probability of exceeding protective blood lead levels in the fetus of a pregnant woman ~~ingesting tissue~~who consumes fish from the Study Area.~~, . lead is considered a chemical potentially posing unacceptable risk for fish tissue.~~ T~~However, t~~his ~~maximum~~ EPC ~~is orders of magnitude greater than all other fish EPCs and~~ may be attributable to lead in the gut of the fish rather than tissue concentrations~~. .~~

Protective lead ~~tissue~~ concentrations in tissue ~~were estimated using the EPA Adult Lead Methodology (ALM) (EPA 2003c), based on agreements with the EPA to follow the same methodology used in the CRITFC (1994) survey to assess tissue exposures from lead. The ALM as adapted for the Portland Harbor BHHRA focuses on potential ~~impacts~~ affects to the fetus ~~of a pregnant worker, and therefore, is only appropriate~~ when considering fish consumption by pregnant women~~. .~~ However, t~~T~~he ALM was developed ~~based on~~ for evaluating exposure to lead in soil and may not be appropriate to use for fish consumption~~. .~~ Furthermore, the ALM is ~~highly~~ sensitive to the bioavailability of ingested lead~~. .~~ For purposes of ~~developing~~ calculating ~~the~~

[8] ~~Regional tissue concentrations are discussed in the Risk Management Recommendations document for the Portland Harbor, provided by the LWG to EPA under separate cover.~~

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~~protective~~a tissue ~~concentrations~~concentration of lead that is expected to be without adverse effects, the default bioavailability of lead in soil was used~~. It~~, and it is not known whether this is an appropriate assumption for lead in tissue.

~~10.0 While lead was identified as a contaminant potentially posing unacceptable risk for fish tissue, there is considerable uncertainty associated with that decision. The identification of lead as a contaminant potentially posing unacceptable risk was based on the maximum EPC, which may not be due to CERCLA activities, and is not representative of Study Area-wide lead concentrations. Furthermore, the identification of lead as a contaminant potentially posing unacceptable risk was based on the ALM, which was not developed for fish consumption.~~

~~11.0 For in-water sediment, blood lead levels were also estimated using the ALM. As discussed above, the methodology focuses on potential impacts to the fetus of a pregnant worker, and therefore, is only appropriate when evaluating exposures by pregnant women. Because lead was not identified as a contaminant potentially posing unacceptable risk for in-water sediment, the use of the ALM to evaluate risks from lead exposure for in-water sediment is not likely to impact the conclusions of this BHHRA.~~

~~7.4.5~~6.4.5 Future Risks

This BHHRA estimated current and future risks for exposure within the Study Area, based on known and reasonably ~~foreseeable~~ anticipated future uses of the Study Area~~. . In addition, this BHHRA assessed hypothetical scenarios at EPA's request.~~ However, the LWR is a ~~highly~~ dynamic, industrialized water~~-~~way, and if the land uses in certain areas of the Study Area were to change in the future in a manner ~~that was not foreseen in~~with the uses considered in ~~this~~ the BHHRA, ~~the assumptions and scenarios used to evaluate risks for the Study Area may not be applicable to risks from new exposures~~risk and hazard estimates presented here may not be representative of conditions in the future~~. .~~ ~~Nevertheless, due to the conservative nature of the assumptions used in this BHHRA, the risk estimates in this BHHRA may still be protective of future uses of the Study Area that were not evaluated. The uncertainty related to future risks could result in either higher or lower risk estimates for the Study Area.~~

~~7.5~~6.5 OVERALL ASSESSMENT OF UNCERTAINTY

A summary of the uncertainties and a qualitative classification of their magnitude, their impact on the health protectiveness of the assessment, and their significance to risk management decisions are presented in Table 6-1~~.—~~. For each of the uncertainties identified and discussed in this section, Table 6-1 provides a qualitative assessment (using High, Medium, and Low as descriptors) for each of these properties~~.—~~. In addition, the table presents whether an uncertainty is more likely to over-estimate or under-estimate actual risks from the Study Area~~.—~~. While there are numerous

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uncertainties identified for this BHHRA, and the cumulative effect of these uncertainties could be significant to the conclusions of the BHHRA, some of these uncertainties would be expected to have more of a significant effect on risk management decisions than other uncertainties~~.~~. These are identified with a "High" descriptor under the "Significance to Risk Management" column in Table 6-1~~.~~.

Risk assessments typically include conservative assumptions to minimize the chances of underestimating exposure and/or risks of adverse effects to human health, and therefore potentially underestimating the need for remedial actions~~.~~. In this BHHRA, conservative assumptions were incorporated into the identification of exposure scenarios, the selection of exposure assumptions, the development of EPCs, and the use of toxicity values~~.~~. Only a portion of the uncertainties in this BHHRA are quantifiable~~.~~. Further analysis of the data and review of pertinent published literature provided a possible range of values for some of the uncertainties presented above~~.~~. The magnitude of these ranges are provided in Attachment F6 and discussed in this Section~~.~~.

While it is not probable that the maximum values of the uncertainties apply for every tissue consumption exposure scenario and contaminant , this magnitude of uncertainty indicates that risks may actually be less than 1~~x~~ x 10^{-4} or HI of 1 for certain scenarios.

While conservative, the results of the BHHRA are intended to show the relative risks associated with the exposure scenarios, and which contaminants are contributing the highest percentage of the calculated risks~~.~~.

~~8.0~~7.0 SUMMARY

The overall objective of this BHHRA ~~was to~~ is to provide an analysis of potential baseline risks to human health from site-related contaminants and help determine the need for remedial actions, provide a basis for determining contaminant concentrations that can remain onsite and still be protective of public health, and provide a basis for comparing the effectiveness of various remedial alternatives. ~~evaluate whether exposure to contaminants in sediment, surface water, groundwater seeps, or biota may result in unacceptable risks to human health. . The results of this BHHRA will be used in developing remedial action objectives and assist in risk management decisions for the Site. . The results of this BHHRA have been used in developing risk management recommendations for the Site, submitted to the EPA under separate cover.~~

The populations evaluated in ~~the risk characterization portion of~~ the BHHRA were identified based on human activities ~~that are~~currently known to occur within the Study Area ~~now and/~~or could ~~which could~~ occur in the future ~~within the Study Area~~, as described in the Programmatic Work Plan~~, or were directed by EPA for evaluation in this BHHRA. . P~~The following are the populations and associated exposure scenarios that were quantitatively evaluated in this BHHRA include:

- Dockside Workers – Direct exposure to beach sediment
- In-water Workers – Direct exposure to in-water sediment
- Recreational Beach Users – Direct exposure to beach sediment and surface water
- Transients – Direct exposure to beach sediment, surface water, and groundwater seep
- Divers – Direct exposure to in-water sediment and surface water
- ~~Recreational and Subsistence Tribal Fisher – Direct exposure to beach sediment or in-water sediment, and fish consumption~~
- Fishers – Direct exposure to beach ~~sediment~~ or in-water sediment, consumption fish ~~consumption,~~ and shellfish ~~consumption~~
- Tribal Fishers – Direct exposure to beach and in-water sediment, consumption of fish
- Domestic Water Use~~r~~ – D~~Hypothetical d~~irect exposure to ~~untreated~~ surface water used as a domestic water source

~~This draft document has been provided to EPA at EPA's request to facilitate EPA's comment process on the document in order for LWG to finalize the BHHRA. The comments or changes (including redlines) on this document may not reflect LWG positions or the final resolution of the EPA comments.~~

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- Infants - ~~Consumption of human milk~~Indirect exposure to bioaccumulative contaminants (PCBs, dioxin/furans, DDx, and PDBEs) in environmental media ~~was quantitatively assessed as a complete exposure pathway for all adult receptor populations exposed to bioaccumulative chemicals that were identified as COPCs for a given scenario~~via indirect exposures due to breastfeeding ~~(i.e., PCBs, dioxin/furans, and DDX)~~.

~~7.6~~7.1 SUMMARY OF RISKS

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~~Cancer risks and noncancer hazards were calculated for each of the exposure scenarios listed above for potential exposure to the contaminants selected as COPCs. . The following sections present a summary of the risks for each of the media quantitatively evaluated in this BHHRA, and a discussion of the relative magnitude of the risk estimates for each media.~~

~~7.6.1 Summary by Exposure Scenario~~

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~~This section summarizes the risks for each of the media evaluated for potential risks in this BHHRA (beach sediment, in-water sediment, surface water, groundwater seep, fish tissue, and shellfish tissue). . Table 5-196 presents a tabular summary of the risk estimates by exposure scenario. Figures 5-1 through 5-21 illustrate the contaminants contributing to risk for each exposure scenario by exposure point, and comparisons of risk across exposure points.~~

~~7.6.1.1 Fish Consumption~~

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~~Fish consumption risks were calculated for the adult and child non-tribal fish consumers, based on three different ingestion rates representing a range of potential consumption scenarios. . Fish consumption risks were also evaluated for both single species and multi-species diets (common carp, black crappie, brown bullhead, and smallmouth bass) based on consumption of either whole body or fillet with skin tissue. . Fish consumption was assumed to occur at the same ingestion rate for 30 years for an adult and for 6 years for a child. . It was assumed that all fish consumed were resident fish caught within the Study Area (from RM 2 to 11 for smallmouth bass, between RM 0 to 12 for carp, from RM 3 to 9 for brown bullhead and black crappie) or within a single exposure area (within a one mile area on both sides of the river for bass and within a 3 mile stretch of both sides of the river for crappie, carp and bullhead trout). .~~

~~Fish consumption risks were also evaluated for adult and child tribal fishers based on an upper-bound ingestion rate for a multi-species diet consisting of resident fish species (common carp, black crappie, brown bullhead, and smallmouth bass) as well as sturgeon, lamprey, and salmon. . Risks from the tribal fish diet were based on consumption of either whole body or fillet with skin tissue. . Fish consumption was assumed to occur at the same ingestion rate for 70 years for an adult and for 6 years~~

for a child. . It was assumed that all fish consumed were caught within the Study Area.

Consumption of individual species by the non-tribal fisher resulted in cumulative cancer risks ranging from 3 x x 10^{-6} to 7 x x 10^{-2} for the scenarios including adult fisher, child fisher, combined adult and child fisher, or breastfeeding infant of an adult fisher consuming fish. . The cumulative HIs range from 0.5 to 5,000 for the child and adult non-tribal fish consumers. . The highest HI was 60,000 for the breastfeeding infant of a non-tribal fish consumer. . Risks from fish consumption by non-tribal fishers are primarily from exposure to PCBs.

Consumption of fish by the tribal fisher resulted in cumulative cancer risks ranging from 4 x x 10^{-4} to 2 x x 10^{-2} for the tribal adult consumer, tribal child consumer, and breastfeeding infant of tribal adult consumer. The highest HI was 400 for the tribal adult fisher, 800 for the tribal child consumer, and 9,000 for a breastfeeding infant of a tribal adult consuming fish. . Risks from fish consumption by tribal fishers are primarily from exposure to PCBs.

There were multiple uncertainties associated with the fish consumption scenarios of which the following were of primary significance: lack of site-specific fish consumption information, the small area assumed for exclusive collection of fish or shellfish consumed, fish consumption rates, tissue type and fish species consumed, cooking and preparation methods, and contributions from background. . Round 1 fillet tissue samples were not analyzed for PCB, dioxin, or furan congeners. . Therefore, the risks from consumption of black crappie and bullhead fillet tissue, which were only analyzed in Round 1, likely underestimate the actual risks. . However, a range of risks was calculated for fish consumption scenarios, which included samples that were analyzed for congeners, so the lack of analysis of contaminants in certain samples should not impact the conclusions of this BHHRA.

7.6.1.2 Shellfish Consumption

Current and potential future shellfish consumption rates for the site are not known. . However, both crayfish and clams were evaluated for consumption risks. . Two different ingestion rates based on the nationwide survey for shellfish consumption for freshwater and estuarine habitats combined were used to calculate risks from shellfish consumption. . Shellfish consumption was assumed to occur at the same ingestion rate for 30 years. . It was assumed that all shellfish consumed were caught within the Study Area or within a single exposure area for spatial scales smaller than the Study Area. . Cumulative cancer risks from consumption of shellfish ranged from 9 x x 10^{-7} to 7 x x 10^{-4}. . The cumulative HIs range from 0.06 to 40 for shellfish consumption. . The highest HI was 800 for the breastfeeding infant of a shellfish consumer. .

In addition to the uncertainty of whether shellfish consumption actually occurs on an ongoing basis, there were other uncertainties associated with the shellfish

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consumption scenarios of which the following were of primary significance: spatial scale of EPCs, shellfish consumption rates, shellfish species consumed, cooking and preparation methods, and contributions from background. .

7.6.1.3 Direct Exposure to In-Water Sediment

Risks from in-water sediment exposure were estimated separately for each of the ½-mile river segment exposure areas on each side of the river, and for Study Area-wide exposure. .Each ½-river mile segment was considered a potential exposure area, regardless of the use of the area. .In-water sediment within the navigation channel was not included in the risk evaluation. .Risks from in-water sediment exposure were evaluated for exposures by in-water workers, tribal fishers, fishers, and divers. .

The cumulative cancer risks for all of the CT scenarios for direct exposure to in-water sediment were below 1 x 10^{-4}, and only the tribal fisher CT scenario had cancer risks above 1 x 10^{-6}. .For the RME scenarios, cumulative cancer risks were greater than 1 x 10^{-6} but were below 1 x 10^{-4}, with the exception of cancer risks above 1 x 10^{-4} for in-water sediment by a tribal fisher at exposure areas RM 6W (risk is 2 x 10^{-4} due primarily to PAHs) and RM 7W (risk is 3 x 10^{-4} due primarily to dioxins). .The highest HI is 3.

There were multiple uncertainties associated with the direct exposure to in-water sediment scenarios of which the following were of primary significance: degree of sediment contact that occurs during fishing scenarios, spatial scale of in-water sediment EPCs, exposure parameters, bioavailability of contaminants in sediment, and contributions from background. .The uncertainties associated with exposure parameters and contributions from background were not quantified in this BHHRA. .

7.6.1.4 Direct Exposure to Beach Sediment

Beaches were identified as potential human use areas associated with industrial upland sites (dockside workers), recreation (recreational users or fishers), and/or trespassing or transient use (transients). .Even if such beach use occurs, the extent to which the beach is used and the nature of the contact with sediments/beach is uncertain. .However, health protective assumptions were included in the risk analysis of this exposure pathway to provide an estimate of potential risks. .

The only CT scenarios for exposure to beach sediment resulting in risks above 1 x 10^{-6} were the dockside worker (6 x 10^{-6}) and tribal fisher and child recreational beach user scenarios (2 x 10^{-6}). .The cumulative cancer risks for all of the CT scenarios were below 1 x 10^{-4}. .The RME scenarios for exposure to beach sediment resulting in cumulative cancer risks above 1 x 10^{-6} include: dockside worker, adult and child recreational beach user, tribal fisher and fisher. .The maximum cancer risk from RME scenarios was 9 x 10^{-5} for the dockside worker exposure to beach sediment. None of the RME scenarios for exposure to beach sediment resulted in risks greater than 1 x 10^{-4}. None of the scenarios resulted in

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HIs exceeding 1. . Risks above 1 x x 10^{-6} resulting from exposures to beach sediment are due primarily to arsenic, which is likely present at naturally occurring background concentrations, and benzo(a)pyrene. .

There were multiple uncertainties associated with the direct exposure to beach sediment scenarios of which the following were of primary significance: spatial scale of beach sediment EPCs, exposure parameters, bioavailability of contaminants in sediment, and contributions from background. . The uncertainties associated with exposure parameters and contributions from background were not quantified in the BHHRA.

7.6.1.5 Direct Exposure to Surface Water

Risks were evaluated for direct surface water exposures by transients, divers and adult and child recreational beach users. . The scenarios resulting in cumulative cancer risks greater than 1 x x 10^{-6} were the diver in wet suit (1 x x 10^{-5}) and the diver in dry suit (2 x x 10^{-6}) at RM 6W due primarily to cPAHs. . None of the direct surface water exposure scenarios resulted in HIs exceeding 1. .

Surface water within the Study Area is not currently used as a domestic water source, nor are there plans to use surface water within the Study Area as a domestic water source in the future. . However, risks were also evaluated for hypothetical exposure to untreated surface water used as a domestic water source by future residents. . The maximum cumulative cancer risk for hypothetical exposure to untreated surface water was 9 x x 10^{-4}, due primarily to cPAHs, and benzo(a)pyrene specifically. . The child RME scenario for hypothetical exposure to surface water as a domestic water source was the only scenario with an exceedance of an HI of 1. . The exceedance occurred at RM 8.5, primarily from exposure to MCPP (HQ for MCPP was 2).

7.6.1.6 Direct Exposure to Groundwater Seeps

Risks from exposures to groundwater seeps were evaluated for exposure by a transient for only one exposure point. . The transient exposure scenario did not result in cumulative cancer risks greater than 1 x x 10^{-6} or HIs greater than 1.

7.6.2 Comparison of Risks Between Exposure Scenarios

A comparison of the estimated risk ranges across by exposure media can help focus risk management decisions by identifying the media contributing most to the overall human health risks to human health at the Study Area. . As discussed in Sections 5, the magnitude of risk varies greatly across the different scenarios. . Figures 7-1 and 7-2 display the ranges of total cumulative cancer risk and endpoint-specific HIs, respectively, for each media type, based on mean CT exposure assumptions for each media evaluated in the BHHRA. . Figures 7-3 and 7-4 display the ranges of total cumulative cancer risk and cumulative HIs, respectively, based on RME assumptions. The estimated As illustrated in Figures 7-1 and 7-2, the risks ranges for the scenarios

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~~assessing~~associated with consumption of fish and shellfish ~~tissue~~ are orders of magnitude higher than risks ~~for~~ from other~~s~~ scenarios, and exceed a cumulative cancer risk of 1~~-x-~~ x 10^{-4} and a HI of 1.~~—~~. ~~Figures 7-3 and 7-4 display the ranges of total cumulative cancer risk and cumulative HIs, respectively, based on RME assumptions, for each media type evaluated in the BHHRA. . As illustrated in Figures 7-3 and 7-4, the risk ranges for scenarios assessing consumption of fish and shellfish tissue are orders of magnitude higher than risks for other scenarios. . S~~The ~~only s~~cenarios ~~that exceed a~~for which the cumulative estimated cancer risk ~~of~~ is greater than 1~~-x-~~ x 10^{-4} or ~~a~~ the HI ~~of~~ is greater than 1 ~~are~~ are ~~the tissue consumption~~consumption of fish and shellfish scenarios and ~~and the scenario for~~ direct contact with in-water sediment by tribal and high frequency fishers.

~~7.6.3~~7.1.1 Contaminants Potentially Posing Unacceptable Risks

Contaminants were identified as potentially posing unacceptable risks if ~~they resulted in a~~the estimated cancer risk is greater than 1~~-x-~~ x 10^{-6} or ~~an~~ the HQ is greater than 1 ~~under~~ for any of the exposure scenarios ~~for any of the exposure point concentrations~~ evaluated in this BHHRA, regardless of the uncertainties associated with the estimates.~~—~~. Given the uncertainties in the analytical data discussed in Section 6, the preliminary COCs were assessed to select the final COCs for this BHHRA.~~—~~.

~~Four of the contaminants identified as potentially posing unacceptable risks~~ α~~(alpha~~-, β~~-beta~~, and γ~~gamma-hexachlorocyclohexane~~Hexachlorocyclohexane and heptachlor~~)~~ were ~~only~~ detected in fish tissue only as N-qualified data.~~—~~. Due to retention time issues in the analytical methods used for the Round 1 tissue samples, some of the pesticide tissue data were N-qualified, indicating that the identity of the chemical could not be confirmed.~~—~~. In the subsequent Rounds 2 and 3 sampling events, different analytical methods were used so that the identification of pesticides was not an issue in tissue ~~samples collected in Rounds 2 and 3.—~~. EPA guidance (1989) ~~does not~~ recommends ~~the~~ caution in the use of data where there are uncertainties in the identification of contaminants~~, as is the case in the N-qualified data.—~~. Therefore, if a chemical was identified as potentially posing unacceptable risks based only on the use of N-qualified data, that chemical is not recommended for further evaluation for potential risks to human health.~~—~~.

The contaminants potentially posing unacceptable risks to human health based on the results of this BHHRA that are recommended for further evaluation for potential risks to human health are presented in Table 7-1.~~—~~.

~~7.7~~7.2 PRIMARY CONTRIBUTORS TO RISK

~~In this BHHRA, there are certain exposure scenarios and contaminants that result in risks that are orders of magnitude higher than risks from other exposure scenarios and contaminants within the Study Area, and that exceed risk levels that generally warrant remedial action under CERCLA. . .~~ One role of the BHHRA is

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to identify those contaminants that pose the greatest risks to current and future receptors, along with the media and exposures routes associated with those risks~~.~~ . This information is used to info~~rm~~ ~~RM~~ rm response actions~~.~~ ~~—~~ . This section presents the primary contributors to human health risk at the Site~~.~~ ~~—~~ . The exposure scenarios and chemicals discussed here represent a subset of the scenarios and contaminants evaluated in this BHHRA~~.~~ ~~—~~ .

The focus on primary contributors to risk can assist with the development of the FS by focusing on those scenarios and contaminants associated with the greatest overall risk in the Study Area~~.~~ ~~—~~ . While these scenarios and contaminants may be the focus of the remedial analyses, other exposure scenarios and contaminants potentially posing unacceptable risks may still be considered in remedial decisions for the Site.

Only those exposure scenarios and contaminants that resulted in an estimated cancer risk greater than 1~~ x~~ x 10^{-6} or an HQ greater than 1 were considered in identifying the primary contributors to risk~~.~~ ~~—~~ . Additional considerations in the selection of contributors included:

- The relative percentage of each contaminant's contribution to the total human health risk consistent with assumptions on exposure areas.
- Uncertainties associated with the exposure scenarios, such as the likelihood of future ~~risk scenarios~~site use, number of assumptions made in estimating exposure, or level of uncertainty in estimates of exposure variables.
- Frequency of detection, both on a localized basis and Study Area-wide.
- Comparison of risks within the Study Area to risks based on measured regional contaminant concentrations for similar exposure scenarios, indicating background or other anthropogenic sources of chemicals in the region.
- Magnitude of risk ~~exceedance above~~greater than EPA's target range for managing cancer risk of 1 x 10^{-4} to 1 x 10^{-6} and noncancer hazard of ~~one~~1.

The chemicals potentially posing unacceptable risks and the primary contributors to risk based on the above criteria ~~for the exposure scenarios evaluated in this BHHRA~~ are discussed below.

~~7.7.1~~7.2.1 Fish Consumption Scenarios

Twenty six COCs (PCBs, dioxins, six metals, ~~Bis~~ Bis-2-ethylhexyl phthalate (BEHP), PAHs, hexachlorobenzene, and seven pesticides) ~~were~~ are identified as potentially posing unacceptable risks due to consumption of ~~for the~~ fish ~~consumption scenarios (i.e., both fisher and tribal fisher) based on exceedances of a cancer risk of 1 x~~ x 10^{-6} ~~or HQ of 1~~:

- PCBs:~~ Total~~ Both total PCBs ~~resulted in cancer risk estimates exceeding 1 x~~ x 10^{-4} ~~and/or HQs exceeding 1 for fish consumption.~~ ~~.~~ ~~Total~~and PCB TEQ ~~also resulted in cancer risk estimates exceeding 1 x~~ x 10^{-4} ~~and/or HQs~~

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exceeding 1 for fish consumption. . PCBs resulted in risk estimates that exceeded a cancer risk of 1 x x 10^{-4} and/or HQ of 1 for both localized and Study Area-wide exposures. PCBs are considered a primary contributor to risk for the fish consumption pathway becausebased on of the magnitude of the estimated risks greater than 1 x 10^{-4}, exceedances above the EPA target range for managing risk, the overall spatial scale of the risk exceedances, and the relative contribution to cumulative risk estimates.

- Dioxins/furans: Total dioxin/furan TEQ resulted in cancer risk estimates exceeding 1 x x 10^{-4} and/or HQs exceeding 1 for fish consumption. . Total dioxin TEQ resulted in risk estimates that exceeded a cancer risk of 1 x x 10^{-4} and/or HQ of 1 for associated with both localized and Study Area-wide exposures. Dioxins are considered a primary contributor to risk for the fish consumption pathway because of , the magnitude of the risk exceedancesestimates greater than 1 x 10^{-4}, the overall spatial scale of the risk exceedances, and the relative contribution to cumulative risk estimates.

- Metals: Antimony, arsenic, mercury, selenium, and zinc were associated with one or more fish consumption exposure scenarios that resulted in a risk estimate that exceeded a cancer risk of 1 x x 10^{-6} or HQ of 1.
  - The overall estimated risk estimates for Arsenic arsenic resulted in cancer risk estimates thatwereare greater exceeded thatn a cancer risk of 1 x x 10^{-4} for based on Study Area-wide exposures. .
  - The Antimony exceeded an HQ of associated with antimony wasis greater than 1 at RM RM 10 for based on consumption of whole body smallmouth bass tissue. However, this result is only due to a single smallmouth bass sample with the an anomalously high result, as discussed in Section 6.1.14. .
  - Lead, was identified as a contaminant potentially posing unacceptable risk based on a measured tissue concentration greater than the exceedance of protective tissue concentrations derived using blood lead models. The risk exceedances for lead from fish consumption areHowever, this wasis due to only due to only a single sample result of smallmouth bass whole body tissue collected at RM RM 10 with the anomalously high result, as discussed in Section 6.1.14
  - Mercury, resulted in risk estimates thatwas identified based on an exceeded a HQ of 1 for both localized and Study Area-wide exposures.
  - Selenium, exceeded was indentified based on an HQ of 1 at RM RM 11 only for consumption of smallmouth bass fillet tissue, due toin a single sample. . Due to a limited number of detected concentrations of antimony and selenium (i.e., 5 detects out of 32 samples and 1 detect out of 23 samples, respectively), antimony and selenium also resulted in HQs greater than 1 Study Area-wide.

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- Zinc-~~,slightly exceeded~~~~was identified~~ based on an HQ of ~~1 (HQ = 2)~~ ~~for fish consumption based on~~in a single sample of whole body common carp ~~tissue~~ collected from ~~RM~~ RM 4 to ~~RM~~ RM 8~~.~~ .

- BEHP~~: , was identified~~ , based on~~BEHP resulted in~~ cancer risk estimates greater than 1~~x~~ x 10^{-6} ~~for consumption of whole body smallmouth bass and brown bullhead, based~~ on both a localized and Study Area-wide basis~~, for all ingestion rates,~~. ~~BEHP resulted~~ and ~~and~~ RME ~~in~~ cancer risk estimates greater than 1~~x~~ x 10^{-4} and a HQ~~s~~ greater than 1 at ~~RM~~ RM 4 ~~for~~ based on consumption of smallmouth bass ~~at the 73 g/day and 142 g/day ingestion rates~~for recreational and subsistence fishers.

- PAHs:~~–~~ Benzo(a)anthracene, benzo(a)pyrene, dibenzo(a)anthracene, and total c~~arcinogenic~~ PAHs~~, were identified as a contaminant potentially posing unacceptable risk for fish tissue consumption~~ based on cancer risk estimates ~~exceeding~~ greater than 1~~x~~ x 10^{-6}. Cancer risk estimates for total carcinogenic PAH ~~exceeded~~ are greater than 1~~x~~ x 10^{-6} at five river mile segments and Study Area-wide based on consumption of smallmouth bass and for two fishing zones and Study Area-wide based on consumption of common carp. ~~for all ingestion rates for consumption of smallmouth bass and only the 73 g/day and 142 g/day ingestion rates for consumption of common carp. No cancer risk estimates exceeded 1 x x 10^{-4}. For consumption of smallmouth bass, cancer risk estimates for total carcinogenic PAHs exceeded 1 x x 10^{-6} for five rive mile segments and Study Area-wide. For consumption of common carp, cancer risk estimates for total carcinogenic PAHs exceeded 1 x x 10^{-6} for two fishing zones and Study Area-wide. . PAHs account for less than 1% percent of the cumulative cancer risks where they were detected. .~~

- Organochlorine Pesticides:~~–~~ Aldrin, dieldrin, heptachlor epoxide, total chlordane, total DDD, total DDE, and total DDT ~~were~~are identified ~~were associated with one or more fish consumption exposure scenarios that resulted in a risk estimate that exceeded a~~based on estimated cancer risk~~s~~ ~~of~~ greater than 1~~x~~ x 10^{-6} or an HQ of 1. ~~These pesticides did not result in cancer risks greater than 1 x x 10^{-4}.~~
  - Aldrin~~, was identified as a contaminant potentially posing unacceptable risk~~ based on cancer risk estimates ~~slightly~~ greater than ~~above~~ 1~~x~~ x 10^{-6}~~, at only the 142 g/day ingestion rate for consumption of common carp~~ for subsistence fishers at ~~(~~localized areas and Study Area-wide~~)~~. ~~Aldrin only contributes approximately 0.01% percent to the total Study Area-wide risk for the whole body common carp diet.~~
  - Dieldrin~~, was identified as a contaminant potentially posing unacceptable risk based on an exceedance of~~based on estimated cancer risks greater than 1~~x~~ x 10^{-6} for consumption of all fish species ~~(smallmouth bass, common carp, black crappie, and brown bullhead),~~

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~~all ingestion rates, and~~ on a localized and Study Area-wide basis. ~~For the multi-species whole body tissue diet, dieldrin contributes to less than 1% percent of the site-wide risk from tissue consumption.~~

- Heptachlor epoxide~~,~~ ~~was identified as a contaminant potentially posing unacceptable risk~~ based on estimated cancer risk estimates ~~slightly above~~greater than 1~~ x~~ x 10^{-6}~~, at only the 142 g/day ingestion rate for consumption of common carp~~ for single-species diet of common carp by subsistence fishers ~~, and for~~at ~~one fishing zone (RM~~ RM 0 to ~~RM~~ RM 4~~)~~. ~~For this fishing zone, heptachlor epoxide contributes to 0.1% percent of cumulative risk from consuming whole body common carp.~~
- Total chlordane~~,~~ ~~was identified as a contaminant potentially posing unacceptable risk based on an exceedance of~~based on estimated cancer risks greater than 1~~ x~~ x 10^{-6} for consumption of all fish species ~~(smallmouth bass, common carp, black crappie, and brown bullhead), all ingestion rates, and~~ on a localized and Study Area-wide basis.
- DDD~~,~~ ~~was identified as a contaminant potentially posing unacceptable risk~~ based on ~~an exceedance of~~estimated cancer risks greater than 1~~ x~~ x 10^{-6} for consumption of all fish species ~~(smallmouth bass, common carp, black crappie, and brown bullhead), all ingestion rates, and~~ on a localized and Study Area-wide basis.
- DDE~~,~~ ~~was identified~~ based on estimated cancer risks greater than 1 x 10^{-6} for consumption of all fish species on a localized and Study Area-wide basis, and ~~was identified as a contaminant potentially posing unacceptable risk based on an exceedance of 1 x~~ x 1~~,~~ $^{0-6}$ ~~for consumption of all fish species (smallmouth bass, common carp, black crappie, and brown bullhead), all ingestion rates, and on a localized and Study Area-wide basis. DDE also resulted in~~ an HQ ~~slightly~~ greater than 1 at ~~RM~~ RM 7~~,~~ ~~for assuming~~based on consumption of smallmouth bass.
- DDT~~,~~ ~~was identified as a contaminant potentially posing unacceptable risk~~ based on an ~~exceedance of~~estimated cancer risk greater than 1~~ x~~ x 10^{-6} ~~for~~ based on consumption of all fish species ~~(smallmouth bass, common carp, black crappie, and brown bullhead), all ingestion rates, and~~ on a localized and Study Area-wide basis.
- PDBEs, based on an HQ greater than 1 for consumption of smallmouth bass and carp on a localized basis.

Based on the magnitude ~~of risk,~~ and ~~the~~ relative contribution to the overall risk estimates ~~to risk~~, ~~and~~ as well as their frequency of detection, PCBs and dioxins/furans are considered the primary contributors to risk for fish consumption scenarios~~.~~. Estimated r~~The r~~isks ~~for~~ from PCBs and dioxins/furans ~~exceed a cancer risk of~~are greater than 1~~ x~~ x 10^{-4} or an HQ of 1 for both the ~~mean~~ CT and ~~maximum~~ RME ~~exposure scenarios~~evaluations ~~for~~ at both localized and Study Area-wide exposures~~.~~. ~~Figure~~ Figure 7~~.~~5 illustrates the relative contribution of individual contaminants to cumulative risk ~~percentages~~ estimates

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~~of cancer risks for individual contaminants contributing to total cumulative risk for~~based on the Study Area-wide multi-species ~~-~~fish consumption ~~of fish tissue~~ by ~~an~~ adult subsistence fisher~~sr, based on Study Area-wide EPCs for a multi-species diet. .. Separate charts are shown for diets based on whole body fish consumption and fillet tissue consumption. .~~As illustrated in the pie charts in Figure 7-5, PCBs are the primary contributor to the overall risk estimate, and taken together with ~~for fish consumption and~~ dioxins/furans expressed as a TEQ ~~are a secondary risk contributor for fish consumption of both whole body and fillet tissue diets~~account for the majority of the estimated risk~~. . A similar pattern is shown in Figure 7-6, which illustrates the relative percentage of cancer risk for consumption of fish tissue by an adult tribal fisher, based on Study Area-wide EPCs for a multi-species diet for both whole body and fillet tissue consumption. .For both the fisher and tribal fisher, and for both whole body and fillet tissue diets,~~Figure 7-6 shows the relative contributions to the overall risk estimate based on Tribal fish consumption. ~~PCBs contribute over 90% percent of the overall cancer risk and result in an HQ that is up to 57 times higher than any other HQ from whole body tissue consumption, and up to 153 times higher than any other HQ from fillet tissue consumption by adults. .~~

PCBs and dioxins/furans have been detected in fish tissue collected outside of the Study Area in both the Willamette and Columbia Rivers. In a risk assessment for the mid-Willamette (EVS 2000), PCB concentrations were found to result in a HQ greater than 1 assuming both a 142 g/day and a 17.5 g/day consumption rate, and an estimated cancer risk greater than 1 x 10^{-4} for the 142 g/day consumption rate. Dioxins and furans were also found to result in an estimated cancer risk greater than 1 x 10^{-4} using a 142 g/day consumption rate (non-cancer endpoints were not evaluated for dioxins and furans). In the Columbia River Basin Fish Contaminant Survey (EPA 2002c), the estimated cancer risks associated with PCBs and dioxins/furans were greater than 1 x 10^{-4} assuming a consumption rate of 142 g/day, and the estimated risk due to PCBs was greater than 1 x 10^{-4} assuming a consumption rate of 7.5 g/day. While ambient concentrations have not been established for fish tissue, as discussed in Section 6.4.2, regional tissue concentrations may be associated with unacceptable risks from fish consumption, especially at higher consumption rates. ~~The contributions of background concentrations to these risk estimates may exceed the risk levels that generally warrant remedial action under CERCLA. .While background concentrations have not been established for fish tissue, as discussed in Section 6.4.2, regional tissue concentrations may be associated with unacceptable risks from fish consumption, especially at higher ingestion rates. On a regional level, PCBs and dioxins/furans have been detected in fish tissue collected in the Willamette and Columbia Rivers, outside of the Study Area. .In a risk assessment for the mid-Willamette (EVS 2000), PCBs were found to result in an HQ greater than 1 for both the 142 g/day and 17.5 g/day ingestion rates, and a cancer risk greater than 1 x x 10^{-4} for the 142 g/day ingestion rate. .Dioxins and furans were also found to result in a cancer risk greater than 1 x x 10^{-4} for the 142 g/day ingestion rate~~

~~(non-cancer endpoints were not evaluated for dioxins and furans). .~~ ~~In the Columbia River Basin Fish Contaminant Survey (EPA 2002c), PCBs were found to result in cancer risks greater than 1 x~~ x 10^{-4} ~~and HQs greater than 1 for the 142 g/day and 7.5 g/day.~~[9] ~~ingestion rates for the general public consumption of resident fish. .~~ ~~Dioxins and furans were also found to result in a cancer risk greater than 1 x~~ x 10^{-4} ~~for the 142 g/day ingestion rate (non-cancer endpoints were not evaluated for dioxins and furans).~~ While the concentrations in the Study Area are higher than the regional tissue concentrations, the sources of PCBs and dioxins and furans in regional tissue data are unknown, and efforts are underway to reduce regional tissue concentrations~~, the regional tissue data indicate that CERCLA actions alone may not be adequate to achieve a target risk level of 1 x~~ x 10^{-6} ~~for~~ based on ~~some of the assumptions evaluated in this BHHRA~~.

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~~7.7.2~~7.2.2 Shellfish Consumption Scenarios

Seventeen contaminants (PCBs, dioxins, arsenic, PAHs, pentachlorophenol, and five pesticides) were identified as potentially posing unacceptable risks ~~for~~ due to consumption of shellfish ~~consumption~~, based on ~~exceedances of the cumulative~~estimated cancer risks ~~of~~ greater than 1~~x~~ x 10^{-6} or a HQ of 1~~,~~: ~~including PCBs, dioxins, arsenic, PAHs, pentachlorophenol, and five pesticides:~~

- PCBs:~~–~~ Total PCBs and PCB TEQs, ~~were identified~~ resulted in based on cancer risk estimates ~~exceeding~~ greater than 1~~x~~ x 10^{-4} and/or HQs ~~exceeding~~ greater than 1 for shellfish consumption~~. . Total PCB TEQ also resulted in cancer risk estimates exceeding 1 x~~ x 10^{-4} ~~and/or HQs exceeding 1 for shellfish consumption. . PCBs resulted in risk estimates that exceeded a cancer risk of 1 x~~ x 10^{-4} ~~and/or HQ of 1 for~~in ~~both~~ localized and Study Area-wide exposures. PCBs are considered a primary contributor to risk for the shellfish consumption pathway because of the magnitude ~~of the risk exceedances,~~ and spatial scale of the risk estimates greater than 1 x 10^{-4} ~~of the risk exceedances~~, their ~~the~~ relative contribution to cumulative risk estimates, and the frequency of detection.

- Dioxins/furans:~~–~~ Total dioxin/furan TEQs~~, resulted in~~were identified ~~based~~ on cancer risk estimates ~~exceeding~~ greater than 1~~x~~ x 10^{-4} and/or HQs ~~exceeding~~ greater than 1 for shellfish consumption~~. . Dioxins and furans resulted in risk estimates that exceeded a cancer risk of 1 x~~ x 10^{-4} ~~and/or HQ of 1 for~~ in ~~both~~ localized and Study Area-wide exposures. Dioxins are considered a primary contributor to risk for the shellfish consumption pathway because of the magnitude and spatial scale of the risk estimates greater than

[9] ~~The low ingestion rate used in the Columbia River Basin Fish Contaminant Survey is lower less than the lowest ingestion consumption rate used in this BHHRA, which was 17.5 g/day.~~

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1 x 10^{-4}, their relative contribution to cumulative risk estimates, and the frequency of detection~~magnitude of the risk exceedances, spatial scale of the risk exceedances, the relative contribution to cumulative risk, and the frequency of detection~~.

- Arsenic: ~~Arsenic was identified~~B ~~as a contaminant potentially posing unacceptable risk b~~ased on cancer risk estimates that ~~exceeded~~ greater than 1 ~~x~~ x 10^{-6} ~~for~~ from ~~both~~ clams and crayfish ~~,~~ at both ~~ingestion~~ consumption rates~~,~~ and on a localized and Study Area-wide scale. No cancer risk estimates exceeded 1~~ x~~ x 10^{-4}~~. .~~ Though arsenic ~~was~~ is identified as a contaminant potentially posing unacceptable risk on both a localized and Study Area-wide spatial scale, ~~the~~ concentrations in shellfish tissue ~~may~~ are likely ~~be~~ due in part to the contribution of ~~naturally occurring~~ background concentrations.

- cPAHs: B~~cPAHs were identified as a contaminant potentially posing unacceptable risk b~~ased on cancer risk estimates ~~that exceeded~~greater than 1~~ x~~ x 10^{-6} ~~for~~ from both clams and crayfish~~,~~ at both ingestion rates~~,~~ and on a localized and Study Area-wide scale. Cancer risk estimates greater than 1 x 10^{-4} ~~for total cPAHs across all exposure areas and exposure scenarios ranged from 2 x~~ x 10^{-8} ~~to 5 x~~ x 10^{-4}~~, and exceeded 1 x~~ x 10^{-4} ~~for the~~from clams collected at locations ~~RM~~ RM 5W and ~~RM~~ RM 6W and assuming a consumption rate of 18 g/day ~~ingestion rate for clams collected at locations RM 5W and RM 6W.~~ . cPAHs are considered a primary contributor to risk for the shellfish consumption pathway at those locations because of the magnitude of the risk ~~exceedances~~ estimates and their relative contribution to the cumulative risk.

- Pentachlorophenol: ~~–~~ Pentachlorophenol was detected only ~~detected~~ in a single crayfish composite sample collected near ~~RM~~ RM 8~~. –~~. It was not detected in the remaining ~~one out of 41~~ 40 shellfish samples~~, which was a crayfish composite sample collected near RM 8~~. This ~~one~~ single detection of pentachlorophenol resulted in a cancer risk estimate within the range of 1~~ x~~ x 10^{-6} to 1~~ x~~ x 10^{-4}~~. .~~

- Organochlorine p~~P~~esticides: Aldrin, dieldrin, total DDD, total DDE, and total DDT~~,~~ ~~were associated~~ identified based ~~with one or more shellfish consumption exposure scenarios that resulted in a risk estimate that exceeded~~on an estimated ~~a~~ cancer risk ~~of~~ greater than 1~~ x~~ x 10^{-6} or a HQ of 1~~. . These pesticides were not associated with shellfish consumption scenarios that resulted in a cancer risk estimate above 1 x~~ x 10^{-4}~~.~~
    - Aldrin~~, was identified as a contaminant potentially posing unacceptable risk~~ based on an estimated cancer risk ~~estimates above~~greater than 1~~ x~~ x 10^{-6} for ~~ingestion~~ consumption of clams at ~~RM~~ RM 8W and on a Study Area-wide basis~~, tissue, for the~~assuming a

consumption rate of 18 g/day ~~ingestion rate only, and for one location (near RM 8W) and Study Area-wide.~~ .

- Dieldrin, ~~was identified as a contaminant potentially posing unacceptable risk~~ based on an estimated cancer risk ~~estimates above~~greater than 1 ~~x~~ x 10^{-6} for ~~ingestion~~ consumption of clams near ~~RM~~ RM 8W and Study Area-wide, assuming a consumption rate of ~~tissue, for the~~ 18 g/day ~~ingestion rate only, and for one location (near RM 8W) and Study Area-wide~~.
- Total DDD, ~~was identified~~ based on an estimated cancer risk greater than 1 x 10^{-6} for consumption of clams near ~~RM~~ RM 8W and Study Area-wide, assuming a consumption rate of 18 g/day~~was identified as a contaminant potentially posing unacceptable risk based on cancer risk estimates above 1 x~~ x 10^{-6} ~~for ingestion of clam tissue, for the 18 g/day ingestion rate only, and for one location (near RM 6W) and Study Area-wide~~.
- Total DDE, ~~was identified~~ based on an estimated cancer risk greater than 1 x 10^{-6} for consumption of clams near ~~RM~~ RM 6W, ~~RM~~ RM 7W, ~~RM~~ RM 8W and Study Area-wide, assuming a consumption rate of 18 g/day~~was identified as a contaminant potentially posing unacceptable risk based on cancer risk estimates above 1 x~~ x 10^{-6} ~~for ingestion of clam tissue, for the 18 g/day ingestion rate only, and for three locations (near RM 6W, RM 7W, and RM 8W)~~.
- Total DDT, ~~was identified~~ based on an estimated cancer risk greater than 1 x 10^{-6} for consumption of clams near ~~RM~~ RM 6W and ~~RM~~ RM 7W, assuming a consumption rate of 18 g/day~~was identified as a contaminant potentially posing unacceptable risk based on cancer risk estimates above 1 x~~ x 10^{-6} ~~for ingestion of clam tissue, for the 18 g/day ingestion rate only, and for only two locations (near RM 6W and RM 7W)~~.

Based on the magnitude ~~of risk, the~~and relative contribution to the total risk estimates, and the frequency of detection, PCBs, dioxins/furans, and cPAHs are considered the primary contributors to risk for shellfish consumption. PCBs and dioxins/furans contribute approximately 58~~%~~ percent and 91 percent, respectively, of the cumulative cancer risk ~~for~~ from consumption of clams ~~consumption~~ and ~~approximately 91% percent for~~ crayfish ~~consumption for the Study Area.~~ . ~~Total~~ cPAHs contribute approximately 35~~%~~ percent and 5 percent, respectively, of the cumulative cancer risk ~~for~~ from consumption of clams ~~consumption (for(~~ undepurated samples~~))~~ and ~~approximately 5% percent for~~ crayfish ~~consumption for the Study Area.~~ . PCBs and dioxins/furans are considered primary contributors to risk on a Study Area-wide basis~~.~~ ., and cPAHs are considered primary contributors to risk on a localized basis (~~RM~~ RM 5W and ~~RM~~ RM 6W)~~.~~ . ~~PCBs are the primary contributors to risk and dioxins/furans are the secondary contributors to risk for shellfish consumption.~~

~~7.7.3~~7.2.3 In-Water Sediment Scenarios

PAHs (primarily benzo[a]pyrene), arsenic, PCBs, and dioxins ~~The contaminants~~ are identified as contaminants potentially posing unacceptable risk ~~identified~~ for in-water sediment ~~are PAHs (primarily benzo[a]pyrene), arsenic, PCBs, and dioxins~~. PAHs and dioxins ~~were~~ are identified ~~as contaminants potentially posing unacceptable risk~~ for all of the in-water sediment scenarios, ~~and~~ arsenic and PCBs were identified ~~as contaminants potentially posing unacceptable risk~~ for the tribal fisher and high frequency fisher scenarios only~~.~~. The relative contribution of each contaminant to cumulative cancer risk estimates ~~of the contaminants to the cumulative cancer risks~~ varied by river mile~~.~~. ~~Risks from cPAHs across all exposure areas and exposure scenarios ranged from 1 x x 10^{-10} to 2 x x 10^{-4}. .For the entire~~Throughout the Study Area, estimated risks from ~~total~~ cPAHs and dioxins/furans ~~through direct contact with sediment~~ each contributed approximately 50~~%~~ percent of the cumulative cancer risk estimate~~.~~. As previously discussed, cumulative cancer risks associated with arsenic may be due in part to naturally occurring concentrations in ~~background~~ sediment ~~concentrations.~~ . Cumulative cancer risks from PCBs ~~above~~ is greater than 1~~ x~~ x 10^{-6} ~~for PCBs are associated with only~~at four ~~½~~ one-half mile river segments, and ~~for~~ from dioxins ~~are associated with only~~at two ~~½~~ one-half mile ~~river~~ segments. Cumulative cancer risks from cPAHs ~~above~~ are greater than 1~~ x~~ x 10^{-6} for ~~PAHs are associated with~~at ~~twenty-two~~22 ~~½~~ one-half mile river segments. Carcinogenic PAHs are considered the primary contributors to risk ~~contaminant~~ for in-water sediment on a Study Area-wide basis due to the relative magnitude ~~of the cumulative risk and the number~~ and spatial scale of ~~the risk exceedances~~estimated risks greater than 1 x 10^{-4}~~.~~. PCBs and dioxins are considered primary contributors to risk on a localized basis ~~(~~at ~~RM RM~~ RM 8.5W ~~[~~for PCBs~~]~~ and ~~RM RM~~ RM 7W for ~~[~~dioxins/furans~~]).~~ .

~~7.7.4~~7.2.4 Beach Sediment Scenarios

PAHs (primarily benzo[a]pyrene) and arsenic ~~The contaminants~~were identified as potentially posing unacceptable risk ~~identified for~~in beach sediment ~~are PAHs (primarily benzo[a]pyrene) and arsenic~~. Risks ~~above~~ greater than 1~~ x~~ x 10^{-6} ~~resulting from~~associated with exposure to arsenic in beach sediment are likely due in part to naturally occurring ~~background~~ concentrations of arsenic. ~~If the contribution of naturally occurring background concentrations of arsenic is subtracted from the cumulative risk, then the primary contributor to risk for beach sediment is benzo(a)pyrene.~~ Risks ~~above~~ greater than 1~~ x~~ x 10^{-6} ~~resulting~~ associated with ~~from~~ exposure to benzo(a)pyrene was limited to a few locations, with the maximum cumulative cancer risk ~~associated with~~at beach location 06B025. ~~Therefore, direct exposure to beach sediment containing benzo(a)pyrene at beach 06B025 is considered a primary contributor to risk for beach sediment.~~ .

~~7.7.5~~7.2.5 Surface Water Scenarios

PAHs ~~The~~ are the primary contributor to risks ~~for~~ associated with direct contact ~~with~~ to surface water. Estimated cancer risks are greater than 1 x 10^{-4} assuming use of river

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water as a domestic water source, and greater than 1 x 10^{-6} for divers at ~~RM~~ RM 6W. However, as noted in Section 5.2.8, the estimated risks associated with dermal exposure to PAHs in water should be used with caution, as PAHs are not within the Effective Prediction Domain of the model used to estimate the dermally-absorbed dose.~~–. is exposure to PAHs in surface water by divers at RM 6.0 W, because this is the only scenario and location with risk exceedance of 1 x x 10^{-6} or HI greater than 1. However,~~Additional risk management considerations during remedy selection should consider the limited spatial scale and ~~high~~ degree of uncertainty associated with the diver exposure assumptions.

~~Risks were also evaluated for hypothetical exposure to untreated surface water used as a domestic water source by future residents. . Cumulative cancer risks were up to 3 x x 10^{-4} for adults, and up to 7 x x 10^{-4} for child residents primarily due to benzo(a)pyrene. . The only~~ HIs ~~that were~~ greater than 1 at Multnomah Channel and ~~RM~~ RM 8.5 ~~were~~ were associated with use of river water as a drinking water source~~for a child resident under the RME scenario at Multnomah Channel and RM 8.5, due primarily to ingestion of MCPP in surface water. . Because this is a hypothetical scenario, it is not considered a primary contributor to risk for the Study Area.~~

~~7.7.6~~7.2.6 Summary of Primary Contributors to Risk

~~As per EPA guidance for the role of risk assessment in remedy selection under CERCLA (EPA 1991a), EPA uses the general risk range of 1 x x 10^{-6} to 1 x x 10^{-4} as a "target range" within which the EPA manages risk during the remedy selection. Furthermore, if the cumulative cancer risk to an individual based on RME assumptions is less than 1 x x 10^{-4} and the non-cancer HQ is less than 1, remedial action generally is not warranted at a site (EPA 1991a). .DEQ guidance sets an acceptable risk level of 1 x x 10^{-6} for individual chemicals and 1 x x 10^{-5} for cumulative risks (OAR 340-122-0115). .While chemicals potentially posing unacceptable risks were identified based on exceeding a cancer risk of 1 x x 10^{-6} or HQ of 1, the only exposure scenarios with cancer risks exceeding 1 x x 10^{-4} or HQ greater than 1 are fish consumption and shellfish consumption and direct exposure to in-water sediment for two ½ river mile segments. .~~

~~The primary exposure scenario contributing to risk for the Study Area is fish consumption, and the contaminants contributing to that risk are PCBs and dioxins/furans. .PCBs and dioxins/furans both resulted in cancer risks greater than 1 x x 10^{-4} and HQs greater than 1 for fish consumption for both localized and Study Area-wide exposures. . PCBs and dioxins/furans contribute approximately 98% percent of the cumulative cancer risk for fish consumption. .Regionally, fish consumption also results in risk estimates exceeding cumulative risks of 1 x x 10^{-4} or HQ of 1 based on data collected from the Willamette and Columbia Rivers outside of the Study Area (EVS 2000, EPA 2002c). .In those studies, both PCBs and dioxins/furans resulted in cancer risks greater than 1 x x 10^{-4} and/or HQs greater than 1 for fish consumption. .The concentrations of PCBs in~~

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~~regional tissue are lower than in the Study Area, and the sources of PCBs in regional tissue are unknown. .~~ The secondary exposure scenario contributing to risk is ~~consumption of shellfish; however, it is not known to what extent shellfish consumption actually occurs on an ongoing basis within the Study Area. .~~

The identification of the primary contributors to human health risks can help provide focus to the FS by identifying a smaller number of chemicals and exposure scenarios that have the largest contribution to overall risk~~—~~. To provide context for the significance of the remedial actions to the protection of human health, the uncertainties associated with the exposure assumptions and potential contribution of background sources of contaminants to the Study Area should be considered when evaluating primary contributors to human health risks ~~during~~ in the FS.

9.0 CONCLUSIONS

A summary of chemicals contributing to risk by exposure scenario is provided in Table 7_1, and risk ranges by exposure scenario are presented in Table 5_203. .The following presents the major findings of this BHHRA:

SUMMARY OF RISK CHARACTERIZATION

Cancer risk and noncancer hazard from site-related contamination was characterized based on current and potential future uses at Portland Harbor, and a large number of different exposures scenarios were evaluated. Exposure to bioaccumulative contaminants (PCBs, dioxins/furans, and organochlorine pesticides, primarily DDE/DDD/DDT) via consumption of resident fish consistently poses the greatest potential for human exposure to in-water contamination. In general, the risks associated with consumption of resident fish are greater by an order of magnitude or more than risks associated with exposure to sediment or surface water. The greatest non-cancer hazard estimates are associated with bioaccumulation through the food chain and exposure to infants via breastfeeding. Because the smallest scale over which fish consumption was evaluated was per river mile, the resolution of cumulative risks on a smaller scale is not informative. The highest relative cumulative risk or hazard estimates are at RM 2, RM 4, RM 7, Swan Island Lagoon, and RM 11. However, assuming exposure to sediment alone, areas posing the greatest risk are RM 6W, RM 7W, RM 8.5W, and RM 11E, shellfish consumption alone poses the greatest risks at RM 4E, RM 5W, RM 6W, and RM 6E.

- Fish consumption is the exposure scenario that is considered the primary contributor to risk for this site. .Risks resulting from the consumption of fish are generally orders of magnitude higher than risks resulting from direct contact with sediment, surface water, or groundwater seeps. .Risks from fish consumption are within or above the cumulative cancer risk range of 1 x _x 10^{-6} to 1 x _x 10^{-4} and exceed an HI of 1 for most exposure scenarios evaluated, including both RME and CT assumptions. .Risk estimates for shellfish consumption scenarios were also within or above the cumulative cancer risk range of 1 x _x 10^{-6} to 1 x _x 10^{-4} and exceeded an HI of 1 for most exposure scenarios evaluated, including both RME and CT assumptions. The evaluation of shellfish consumption was completed at the direction of EPA. .With the exception of two ½-mile river segments for the tribal fisher scenario and one location for the hypothetical use of untreated surface water as a drinking water source by a future resident, all of the direct contact scenarios result in risks within or below the EPA target cancer risk range of 1 x _x 10^{-6} to 1 x _x 10^{-4}. .The direct contact scenarios also result in non-cancer hazards below the target HI of 1, with the exception of one ½-river mile segment for in-water sediment and one location for hypothetical use of untreated surface water as a drinking water source.

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- For fish consumption, which is the pathway with the highest risk estimates, PCBs are the primary contributor to risk, and dioxins/furans are the secondary contributor to risk. .

- The uncertainties associated with the tissue consumption scenarios should be considered during the FS. .The fish tissue consumption risks in this BHHRA incorporate assumptions that may under- or more likely over-estimate the actual risks. .

- The contribution of background sources is an important consideration in risk management decisions. . .For example, arsenic concentrations in beach sediment contribute approximately 50% percent of cumulative risk from exposure from this medium for the highest-risk scenarios, yet arsenic concentrations detected in beach sediment within the Study Area are comparable to Oregon DEQ-established background levels.

The results of the BHHRA will be used to produce derive risk-based PRGs and AOPCs for the FS, as well as to develop risk management recommendations for the Site. .In addition, the BHHRA may be consulted by risk managers as they deliberate practical risk management objectives during the course of the FS.

~~10.0~~8.0 REFERENCES

Adolfson Associates, Inc. (Adolfson). 1996. Technical Memorandum on the Results of the 1995 Fish Consumption and Recreational Use Surveys, Amendment Number 1. April 19, 1996.

ATSDR. 1996. Toxicological Profile for Endrin~~.~~. Accessed online October 2008 at http://www.atsdr.cdc.gov/toxprofiles/tp89.html.

ATSDR. 2002. Public Health Assessment, Initial Release: Portland Harbor, Portland, Multnomah County, Oregon. January 15, 2002.

ATSDR. 2006. Final Release: Public Health Assessment, Portland Harbor, Portland, Multnomah County, Oregon, EPA Facility ID: OR0001297969. March 22, 2006.

ATSDR. 2008. Toxicological Profile for Chromium~~.~~. Accessed online November 2008 at http://www.atsdr.cdc.gov/toxprofiles/tp7.html~~.~~

Burch, Dee (President of Advanced American)~~.~~. 2008~~.~~. Personal communication, telephone call, with Don Larson, Business Development Coordinator, Kennedy/Jenks Consultants, Portland, OR. July 14, 2008.

Cal EPA. 2008. Toxicity Criteria Database, September 2008. Office of Environmental Health Hazard Assessment. Accessed October 2008 at http://www.oehha.org/risk/pdf/TCDBalpha100108.pdf.

Centers for Disease Control (CDC). 1991. Preventing lead poisoning in young children: a statement by the Centers for Disease Control. Atlanta, Georgia: US Department of Health and Human Services, Public Health Service.

City of Portland~~.~~. 2006a. Comprehensive Plan Goals and Policies. City of Portland Bureau of Planning, Portland, OR~~.~~. July 2006.

City of Portland~~.~~. 2006b. River Concept~~.~~. City of Portland Bureau of Planning, Portland, OR~~.~~ April 26, 2006.

City of Portland. 2008. Water Management and Conservation Plan, Final Draft Report~~.~~. Portland Water Bureau~~.~~. Portland, OR, March 2008.

Columbia River Inter-Tribal Fish Commission (CRITFC). 1994. A Fish Consumption Survey of the Umatilla, Nez Perce, Yakama, and Wa~~rm RM~~rm Springs Tribes of the Columbia River Basin, Technical Report 94-3. Columbia River Inter-Tribal Fish Commission, Portland, OR. October 1994.

DEQ. 2000a. Guidance for Conduct of Deterministic Human Health Risk Assessments. Oregon Department of Environmental Quality. May 2000.

DEQ. 2000b. Portland Harbor RI/FS Work Plan, DRAFT. Oregon Department of Environmental Quality. 31 March 2000.

DEQ. 2003. Risk-Based Decision Making for the Remediation of Petroleum-Contaminated Sites. Land Quality Division, Environmental Tanks and Cleanup Program. Portland, OR. September 22, 2003.

DEQ. 2007. Guidance for Assessing Bioaccumulative Chemicals of Concern in Sediment~~.~~ . DEQ Environmental Cleanup Program. Portland, OR. April 2007.

DEQ. 2010. Human Health Risk Assessment Guidance~~.~~ . DEQ Environmental Cleanup Program. Portland, OR. October 2010.

EPA. 1989. Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual (Part A), Interim Final. Office of Solid Waste and Emergency Response, EPA/540/1-89/002. December 1989.

EPA. 1991a. Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions. Office of Solid Waste and Emergency Response. OSWER Directive 9355.0-30. April 1991.

EPA. 1991b. Risk Assessment Guidance for Superfund, Volume I. Human Health Evaluation Manual, Supplemental Guidance, Standard Default Exposure Factors, Interim Final. Office of Emergency and Remedial Response: OSWER Directive: 9285.6-03.

EPA. 1992. Supplemental Guidance to RAGS: Calculating the Concentration Term. OSWER Publication 9285.7-081.

EPA. 1993. Provisional Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons. Office of Health and Environmental Assessment, EPA/600/R-93/089. July 1993.

EPA. 1994. Memorandum: ~~–~~ OSWER Directive: Revised Interim Soil Lead Guidance For CERCLA Sites and RCRA Corrective Action Facilities~~.~~ . Office of Solid Waste and Emergency Response. Washington, D.C.

EPA. 1997a. *Exposure Factors Handbook*. Office of Research and Development, Volumes I-III~~General Factors~~, EPA/600/P-95/002Fa-c, Office of Research and Development, Washington, DC 20460.

EPA. 1997b. Should I Eat the Fish I Catch? A guide to healthy eating of the fish you catch. EPA 823-B-97-009. Office of Science and Technology. September 1997.

EPA. 1998. Memorandum: ~~–~~ OSWER Directive: Clarification to the 1994 Revised Interim Soil Lead (Pb) Guidance for CERCLA Sites and RCRA Corrective Action Facilities (August 1998)~~.~~ . Office of Solid Waste and Emergency Response. EPA/540/F-98/030.

EPA. 1999. A Guide to Preparing Superfund Proposed Plans, Records of Decision, and Other Remedy Selection Decision Documents. EPA Office of Solid Waste and Emergency Response. EPA 540-R-98-031. July 1999.

EPA. 2000a. EPA Region 10 Supplemental Human Health Risk Assessment Guidance, Office of Environmental Assessment, Soil Ingestion Rates. January 25, 2000.

EPA. 2000b. Estimated Per Capita Fish Consumption in the United States. EPA-821-R-00-025.

EPA. 2000c. Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, Volume 1, Fish Sampling and Analysis, Third Edition. Office of Water. EPA 823-B-00-007. November 2000.

EPA. 2000d. Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health. EPA-822-B-00-004.—. October 2000.—.

EPA. 2000e. Data Quality Objectives Process for Hazardous Waste Site Investigations. EPA QA/G-4HW. Final. EPA Office of Environmental Information. EPA/600/R-00/007. January 2000.

EPA. 2001a. Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual (Part D, Standardized Planning, Reporting, and Review of Superfund Risk Assessments), Final. Office of Emergency and Remedial Response, Publication 9285.7-47. December 2001.

EPA. 2001b. Trichloroethylene Health Risk Assessment: Synthesis and Characterization, August 2001, EPA/600/P-01/0002A – External Review Draft.

EPA. 2001c. Risk Assessment Guidance for Superfund, Volume 3, Part A: Process for Conducting Probabilistic Risk Assessment.—. Office of Emergency and Remedial Response.—. EPA 540-R-02-002. December 2001.

EPA. 2001d. Dioxin Reassessment-An SAB Review of the Office of Research and Development's Reassessment of Dioxin. Review of the Revised Sections (Dose Response Modeling, Integrated Summary, Risk Characterization, and Toxicity Equivalency Factors) of the EPA's Reassessment of Dioxin by the Dioxin Reassessment Review Subcommittee of the EPA Science Advisory Board (SAB). EPA-SAB-EC-01-006. Science Advisory Board, Washington, DC. May 2001.

EPA. 2002a. Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. Office of Emergency and Remedial Response. OSWER 9285.6-10. December 2002.

EPA. 2002b. Estimated Per Capita Fish Consumption in the United States. EPA 821-C-02-003. August 2002.

EPA. 2002c. Columbia River Basin Fish Contaminant Survey, 1996-1998. EPA 910-R-02-006. August 12, 2002.

EPA. 2002d. Feasibility for Derivation of Provisional Toxicity Values for delta-Hexachlorocyclohexane (CASRN 319-86-8). SRC SF 01-019a-c/10-17-02.

EPA. 2002e. Blood Lead Concentrations of U.S. Adult Females: Summary Statistics from Phases 1 and 2 of the National Health and Nutrition Evaluation Survey (NHANES III).—. EPA OSWER #9285.7-52 March 2002.

EPA. 2003a.—. National Primary Drinking Water Standards. Office of Water (4606M). Maximum Contaminant Levels. EPA 816-F-03-016.—. June 2003.

EPA. 2003b. OSWER Directive 9285.7-53. Human Health Toxicity Values in Superfund Risk Assessments. December 5, 2003.

EPA. 2003c. Recommendations of the Technical Review Workgroup for Lead for an Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil. EPA-540-R-03-001. January 2003.

EPA. 2004. Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment), Final. Office of Emergency and Remedial Response. EPA/540/R/99/005. July 2004.

EPA,. 2005a. Guidelines for Carcinogen Risk Assessment. Risk Assessment Forum. Washington, D.C. EPA/630/P-03/001F. March 2005.

EPA. 2005b. Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens. Risk Assessment Forum. Washington, D.C. EPA/630/R-03/003F. March 2005.

EPA, 2005c. Application of the draft framework for selecting and using tribal fish and shellfish consumption rates for risk-based decision making at CERCLA and RCRA cleanup sites in Puget Sound and the Strait of Georgia to the Lower Duwamish Waterway sediment cleanup action - June 16, 2005. US Environmental Protection Agency, Region 10, Seattle, WA.

EPA, Region 10. 2007a. Internal Memorandum from Michael Cox regarding Recommendations for Human Health Risk-based Chemical Screening and Related Issues at EPA Region 10 CERCLA and RCRA Sites. April 17, 2007.

EPA. 2007b.—. ProUCL Version 4.00.02 User Guide. EPA/600/R-07/038. April 2007.

EPA 2007c.—. Guidance for Evaluating the Oral Bioavailability of Metals in Soil for Use in Human Health Risk Assessment.—. OSWER 9285.7-80.—. May 2007.

EPA. 2007d. User's Guide for the Integrated Exposure Uptake Biokinetic Model for Lead in Children (IEUBK), Windows version 1.1.—. EPA 9285.7-42.—. May 2007.

EPA. 2008a. Region 6 Human Health Medium-Specific Screening Levels.—. http://www.epa.gov/region6/6pd/rcra_c/pd-n/screen.htm. Screening Levels last updated on March 8, 2008.—.

EPA 2008b. Region 10 Memorandum regarding Portland Harbor Superfund Site; Administrative Order on Consent for Remedial Investigation and Feasibility Study; Docket No. CERCLA-10-2001-0240. Comprehensive Round 2 Site Characterization and Data Gaps Analysis Report. Dated January 15, 2008.—.

EPA. 2008c. Region 10 Memorandum regarding Proposed Commercial Diver Exposure Scenario for the Portland Harbor Risk Assessment. September 15, 2008.

EPA 2009a~~.~~ , Toxicological Review of Thallium and Compounds (CAS No. 7440-28-0) In Support of Summary Information on the Integrated Risk Information System (IRIS). EPA/635/R-08/001F.

EPA 2010a. Regional Screening Levels for Chemical Contaminants at Superfund Sites~~.~~ , Dated May 2010~~.~~ , http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm. Screening Levels last updated on April 19, 2009.

EPA. 2010b. Integrated Risk Information System (IRIS). Accessed November 2010 at http://www.epa.gov/iris/.

EPA. 2011. *Exposure Factors Handbook: 2011 Edition*. National Center for Environmental Assessment, Office of Research and Development, EPA/600/R-09/052F.

EVS Environment Consultants, Inc. (EVS). 2000. Human health risk assessment of chemical contaminants in four fish species from the Middle Willamette River, November 21, 2000. Salem, OR: Oregon Department of Environmental Quality. (Willamette River Basin Studies: Human Health Technical Study; EVS Project No. 2/839-01).

Friberg, L., Nordberg, G.F., Kessler, E. and Vouk, V.B. (eds). Handbook of the Toxicology of Metals. 2nd ed. Vols I, II.: Amsterdam: Elsevier Science Publishers B.V., 1986.

Grooms, M~~.~~ , 2008. Personal communication (email of February 12, 2008 to T. Pinit, Kennedy/Jenks Consultants, Portland, OR, regarding crayfish catch reports). Oregon Department of Fish and Wildlife, Portland, OR.

Groundwater Solutions, Inc. (GSI) 2003. Technical Memorandum: Results of Seep Reconnaissance Survey River Mile 2 – 10.5, Lower Willamette River. USEPA Docket No: CERCLA-10-2001-0240.

Hartman, Bud (President of Pan Fish Association, Portland, OR). 2002. Personal communications, telephone call with Bill Williams, Senior Scientist, Kennedy/Jenks Consultants, Portland, OR. March 19, 2002.

Hope, B. 2008. A Model for the Presence of Polychlorinated Biphenyls (PCBs) in the Willamette River Basin (Oregon). Environ. Sci. Technol. 2008, 42, 5998-6006.

Hutton, Jesse (President of Northwest Underwater Construction, LLC)~~.~~ , 2008~~.~~ , Personal communication, telephone call with Taku Fuji, Senior Scientist, and Levi Fernandes, Engineer, Kennedy/Jenks Consultants, Portland, OR. July 11, 2008.

Integral Consulting, Inc~~.~~ , 2004~~.~~ , Round 2 Quality Assurance Project Plan Addendum 1: Surface Water~~.~~ , Prepared for The Lower Willamette Group. Portland, OR.

Integral Consulting, Inc., Kennedy/Jenks Consultants. 2004~~.~~ , Round 2 Quality Assurance Project Plan Addendum 3: Groundwater Pathway Assessment Pilot Study~~.~~ , Prepared for The Lower Willamette Group. Portland, OR.

Integral Consulting, Inc., Windward Environmental, LLC. 2004. Round 2 Quality Assurance Project Plan. Prepared for The Lower Willamette Group. Portland, OR.

Integral Consulting, Inc., Windward Environmental, LLC, Kennedy/Jenks Consultants, Anchor Environmental, LLC, Groundwater Solutions, Inc. 2004. Portland Harbor RI/FS Programmatic Work Plan. Prepared for The Lower Willamette Group. Portland, OR.

Integral Consulting, Inc.~~.~~ . 2007~~.~~ . Round 2 Quality Assurance Project Plan Addendum 9: Fish and Invertebrate Tissue and Collocated Sediment Sampling for Round 3B~~.~~ . Prepared for The Lower Willamette Group. Integral Consulting, Inc., Portland, OR.

Integral Consulting, Inc., Windward Environmental, LLC, Kennedy/Jenks Consultants, Anchor Environmental, LLC~~.~~ . 2007. Portland Harbor RI/FS Comprehensive Round 2 Site Characterization Summary and Data Gaps Analysis Report~~.~~ . Prepared for The Lower Willamette Group. Portland, OR. February 22, 2007.

Integral Consulting, Inc., 2008~~.~~ . Round 3B Fish and Invertebrate Tissue And Collocated Sediment Data Report Addendum 1:~~–~~ Lead and Antimony Results For Smallmouth Bass Sample LW3-SB010E-C00B. Prepared for the Lower Willamette Group. Portland, OR. September 26, 2008.

Johns, Mike (Vice President of Operations for Advanced American Construction)~~.~~ . 2008~~.~~ . Personal communication, telephone call, with Don Larson, Business Development Coordinator, Kennedy/Jenks Consultants, Portland, OR. July 16, 2008.

Kennedy/Jenks Consultants, Integral Consulting, Inc., Windward Environmental, LLC. 2004. Portland Harbor RI/FS Technical Memorandum Guidelines for Data Reporting, Data Averaging, and Treatment of Non-detected Values for the Round I Database. Prepared for The Lower Willamette Group. Kennedy/Jenks Consultants, Portland, OR; Integral Consulting, Inc., Mercer Island, WA; Windward Environmental, LLC, Seattle, WA.

Kennedy/Jenks Consultants. 2004a. Human Health Toxicity Values. Interim Deliverable. Prepared for The Lower Willamette Group. Kennedy/Jenks Consultants, Portland, OR.

Kennedy/Jenks Consultants. 2004b. Round I Tissue Exposure Point Concentrations. Interim Deliverable. Prepared for The Lower Willamette Group. Kennedy/Jenks Consultants, Portland, OR.

Kennedy/Jenks Consultants. 2004c. Salmon, Lamprey, and Sturgeon Tissue Exposure Point Concentrations for Oregon Department of Human Services. Prepared for The Lower Willamette Group. Kennedy/Jenks Consultants, Portland, OR.

Kennedy/Jenks Consultants. 2006. Portland Harbor RI/FS Technical Memorandum Human Health Risk Assessment: Exposure Point Concentration Calculation Approach and Summary of Exposure Factors. Prepared for The Lower Willamette Group. Kennedy/Jenks Consultants, Portland, OR.

National Academy of Sciences (NAS). 2003. Bioavailability of Contaminants in Soils and Sediments: Processes, Tools, and Applications. National Academies Press. Washington D.C.

National Academy of Sciences (NAS). 2006. Health Risks from Dioxin and Related Compounds, Evaluation of the EPA Reassessment. National Academies Press. Washington D.C.

National Library of Medicine (NLM). 2004. Hazardous Substances Data Bank (HSDB).

Oregon Department of Human Services (ODHS). 2007. Environmental Toxicology Program. Fish Advisories: Consumption Guidelines. Accessed January, 2007. http://oregon.gov/DHS/ph/envtox/fishconsumption.shtml#table

Oregon Fish and Wildlife Department (ODFW). 2005. Biology, Behavior, and Resources of Resident and Anadromous Fish in the Lower Willamette River. Final Report of Research, 2000-2004 . Thomas A. Friesen, editor. March 2005.

Pu X; Carlson G; Lee L. 2003. Oral bioavailability of pentachlorophenol from soils of varying characteristics using a rat model. Journal of Toxicology and Environmental Health, Part A. 2003, Nov 14; 1966(21):2001-13.

Ruby, MV; R Schoof; W Brattin; M Goldade; G Post; M Harnois; DE Mosby; SW Casteel; W Berti; M Carpenter; D Edwards; D Cragin; W Chappell. 1999. Advances in evaluating the oral bioavailability of inorganics in soil for use in human health risk assessment. Environmental Science and Technology; 33 (21). 1999. 3697-3705.

Saghir SA; Bartels MJ; Budinsky RA; Harris EE; Clark AJ; Staley JL; Chai Y; Davis JW. 2007. Effect of organic carbon content, clay type, and aging on the oral bioavailability of hexachlorobenzene in rats. Environmental Toxicology and Chemistry. 2007, Nov; 26(11):2420-9.

Siipola, M. Personal communication (telephone conversation on November 9, 2004 with Laura Kennedy, Kennedy/Jenks Consultants). U.S. Army Corps of Engineers, Portland, OR.

Steele, Ralph (Owner of Lure-em Tackle Shop, Portland, OR). 2002. Personal communication, telephone call with Bill Williams, Senior Scientist, Kennedy/Jenks Consultants, Portland, OR. April 8, 2002.

Striplin Environmental Associates, Inc. 2002. Round 1 Quality Assurance Project Plan Final Report. Prepared for The Lower Willamette Group. Striplin Environmental Associates, Inc., Olympia, WA.

Tetra Tech. 1995. Willamette River Basin Water Quality Study. Summary and Synthesis of Study Findings. Final Report 97-094. Prepared for Oregon Department of Environmental Quality, Portland, OR. Tetra Tech, Inc., Redmond, WA. 119 pp.

United States Department of Agriculture (USDA). 1998. Continuing Survey of Food Intake by Individuals, CSFII 1994-1996. Agricultural Research Service.

Van den Berg, M., et al. 2006. The 2005 World Health Organization Re-evaluation of Human and Mammalian Toxic Equivalency Factors for Dioxins and Dioxin-like Compounds. Toxicol Sci. 2006 Jul 7, 16829543. World Health Organization Collaborating Centre for Research on Environmental Health Risk Assessment and Institute for Risk Assessment Sciences, Faculties of Veterinary Medicine, Science and University Medical Center, Universiteit Utrecht, PO Box 80177, 3508 TD Utrecht, The Netherlands.

Wagner, P. 2004. Personal Communication: letter dated June 6, 2004 to Amanda Guay, Oregon Department of Human Services. Linnton Community Center.

Wallner-Kersanach, S. E. Lobo, E. M. da Silva. 1994. Depuration Effects on Trace Metals in *Anomalocardia brasiliana* (Gmelin, 1791). Bull. Environ. Contam. Toxicol. (1994) 52:840-847.

Washington Department of Ecology (Ecology). 2007. Washington State Toxics Monitoring Program: Contaminants in Fish Tissue from Freshwater Environments in 2004 and 2005. Publication No. 07-03-024. June 2007.

Washington Department of Health (WDOH). 2005. Analysis of Chemical Contaminant Levels in Store-Bought Fish from Washington State. *Proceedings of the 2005 National Forum on Contaminants in Fish*. Baltimore, MD. Powerpoint presentation accessed online at http://www.epa.gov/fishadvisories/forum/2005/index.htm.

Wilson et al. 1998. The effect of cooking practices on the concentration of DDT and PCB compounds in the edible tissue of fish. J. Expo. Anal. Environ. Epidemiol. Jul-Sep;8(3):423-40.

Windward. 2005. Lower Duwamish Waterway Remedial Investigation, Fish and Crab Data Report Addendum: PCB Congener Data, MS/MSD Analyses, and DDT Confirmation Final. Prepared for Lower Duwamish Waterway Group, Windward Environmental LLC, Seattle, WA. October 2005.

Windward. 2009. Portland Harbor RI/FS bioaccumulation modeling report. Draft. WW09-0003. Prepared for Lower Willamette Group. May 29, 2009. Windward Environmental LLC, Seattle, WA.

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PORTLAND HARBOR RI/FS

DRAFT FINAL REMEDIAL INVESTIGATION REPORT

ATTACHMENT F3:

RISKS FROM EXPOSURES TO PBDES

This draft document has been provided to EPA at EPA's request to facilitate EPA's comment process on the document in order for LWG to finalize the BHHRA. The comments or changes (including redlines) on this document may not reflect LWG positions or the final resolution of the EPA comments.

May 2, 2011

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~~Table F3-46. Calculation of Cancer Risks and Noncancer Hazards - Infant of Adult Shellfish Consumer, Single-Species Diet, Clam, Mean Exposure~~

1.0 INTRODUCTION

This Attachment F3 presents ~~the Lower Willamette Group's (LWG's)~~an evaluation of risks to human health from polybrominated diphenyl ethers (PBDEs) in the Portland Harbor Superfund Site (Site) in Portland, Oregon~~, which is being performed at the direction of the United States Environmental Protection Agency (EPA)~~. This Attachment is intended to supplement the Revised Baseline Human Health Risk Assessment (BHHRA) for the Site. The objectives and approach to assessing risks from exposures to PBDEs follows those outlined in the BHHRA.

2.0 PBDE DATA EVALUATION

The data included in the site characterization and risk assessment (SCRA) dataset are described in detail in Section 2 of the RI Report. The dataset used in this human health risk analysis for PBDEs is a subset of the data that comprised the SCRA dataset as of February 2011. All data included in the BHHRA PBDE dataset meets the data quality requirements for risk evaluation (Category 1/QA2), as agreed to between LWG, EPA, and EPA's partners in the Programmatic Work Plan (Integral et al. 2004). As directed by EPA, in-water sediment and fish tissue samples collected in 2004 and 2007 from the Portland Harbor that were analyzed for PBDE congeners and met the data criteria for inclusion in the BHHRA were used in this evaluation. Data management and reduction rules applied to the BHHRA PBDE dataset are the same as those described in Attachment F2.

2.1 IN-WATER SEDIMENT

In-water surface sediment PBDE data used in the BHHRA includes LWG- collected data from sampling rounds 2 and 3. These sampling events include:

Round 2A sediment grabs
Round 3 sediment from upstream and downstream
Round 3B Biota - Co-located sediments
Round 3B sediment grabs

These sampling events comprise 59 samples used in the BHHRA PBDE dataset, 51 of which are within the Study Area. The BHHRA PBDE dataset for in-water sediment is consistent with the criteria described in the data evaluation section of the BHHRA (Section 2 of Appendix F).

2.2 FISH TISSUE

Common carp and smallmouth bass fish tissue were collected by the LWG from within Portland Harbor in 2007 and analyzed by the EPA in 2009. The fish tissue samples were analyzed as composite samples, fillets with skin included. The remainder tissue of the common carp and smallmouth bass samples were also analyzed. For each analytical result, whole body concentrations were calculated based on a weighted average of fillet tissue and remainder tissue concentrations, as described in Attachment F2, and consistent with data handling for the rest of the BHHRA.

The BHHRA PBDE dataset consists of 18 smallmouth bass samples collected from RM 1.5 to 11.5, and 9 common carp tissue samples collected from RM 0 - 12.

2.3 SHELLFISH TISSUE

Shellfish tissue in the PBDE dataset included clam (*Corbicula* sp.) tissue collected during the Round 3B biota sampling event. All clam samples analyzed for PBDEs were undepurated. There were four samples collected within the Study Area (river mile (RM) 1.9 – 11.8), one sample collected from the downstream reach (RM 1.5), and one sample collected in the downtown reach (RM 12.1). All six of these sample results were included in the BHHRA PBDE dataset for clam tissue.

2.4 IDENTIFICATION OF CONTAMINANTS OF CONCERN

In-water sediment and tissue samples were analytes for eight different PBDE congeners, as follows:

BDE 028 (2,4,4'-Tribromodiphenyl ether)
BDE 047 (2,2',4,4'-Tetrabromodiphenyl ether)
BDE 099 (2,2',4,4',5-Pentabromodiphenyl ether)
BDE 100 (2,2',4,4',6-Pentabromodiphenyl ether)
BDE 153 (2,2',4,4',5,5'-Hexabromodiphenyl ether)
BDE 154 (2,2',4,4',5,6'-Hexabromodiphenyl ether)
BDE 183 (2,2',3,4,4',5',6-Heptabromodiphenyl ether)
BDE 209 (2,2',3,3',4,4',5,5',6,6'-Decabromodiphenyl ether)

All detected PBDE congeners were retained as contaminants of potential concern (COPCs) for each medium and species. PBDE congeners analyzed and detected in in-water sediment are BDE 47, 99, 153, and 209. PBDE congeners analyzed and detected in carp tissue are BDE 28, 47, 100, 153, and 154. PBDE congeners analyzed and detected in smallmouth bass tissue are BDE 28, 47, 99, 100, 153, and 154, and 183. In

clam tissue, detected congeners are BDE 47, 99, 100, 153, and 154. BDE 209 was not detected in fish or shellfish tissue.

3.0 EXPOSURE ASSESSMENT

PBDE risk assessment was performed for potentially exposed human populations that may come in contact with PBDEs in in-water sediment or tissue.

The exposure assessment performed for PBDEs is consistent with the exposure assessment performed in Section 3 of the BHHRA. As described in Section 3 of Appendix F, potentially exposed human populations identified for further evaluation for exposure to PBDEs are:

- In-water worker
- Diver
- Fisher (Fish consumer)
- Tribal fisher
- Infants exposed to human breast milk of the above populations

Exposure pathways were identified using the same methods described in Section 3 of the BHHRA. The potential exposure pathways to human populations at the Study Area include:

- Ingestion of and dermal contact with in-water sediment
- Ingestion of fish and shellfish
- Infant consumption of human milk

The identified receptors, exposure routes, and exposure pathways, and the rationale for selection are also summarized in Table 3-1 of Appendix F.

3.1 CALCULATION OF EXPOSURE POINT CONCENTRATIONS

Exposure point concentrations (EPCs) were calculated for media and pathways that were evaluated quantitatively in this Attachment. The process to estimate EPCs for tissue and in-water sediment is the same as the process followed in Section 3 of the BHHRA. Individual PBDE congeners were evaluated for adult and child receptors. Risks to infants were evaluated as total PBDEs to be consistent with Oregon Department of Environmental Quality (DEQ) guidance (DEQ 2010). PBDE EPCs for exposure to in-water sediment are presented in Table F3-1. PBDE EPCs for exposure to tissue are presented in Tables F3-2 to F3-7.

3.2 PROCESS TO CALCULATE INTAKES

Intakes were calculated in the manner described in Section 3 of the BHHRA. The BHHRA presents population-specific assumptions for the evaluated receptors. Values used for intake parameters for the evaluation of risks from PBDEs are the same as those used in the BHHRA, and are presented in Table 3-27 (for receptors exposed to PBDEs in in-water sediment) and Table 3-29 (for receptors exposed to PBDEs in tissue) of Appendix F.

4.0 TOXICITY ASSESSMENT

This quantitative evaluation of noncancer hazards and cancer risks included the four PBDE congeners for which the EPA has established human health toxicity values in the Integrated Risk Information System (IRIS) database: BDE 47, BDE 99, BDE 153, and BDE 209. The EPA has established oral reference doses for the congeners BDE 47, BDE 99, BDE 153, and BDE 209. BDE 209 is the only congener analyzed that is classified as a carcinogen. PBDE congeners without carcinogenic toxicity values were not evaluated for cancer risk. Table F3-8 presents the toxicity values for the PBDE congeners that were quantitatively evaluated.

5.0 RISK CHARACTERIZATION

The risk characterization for exposure to PBDEs in in-water sediment and tissue was performed as described in Section 5 of Appendix F. Noncancer hazards and cancer risks to children and adults were calculated for individual congeners at each exposure point, and then summed to provide cumulative hazards and cancer risk estimates. Noncancer hazards and cancer risks to breast-feeding infants were calculated based on cumulative hazards and cancer risks to adult mothers by applying a PBDE-specific infant risk adjustment factor (IRAF), consistent with DEQ guidance (DEQ 2010).

5.1 RISK AND HAZARD RESULTS

5.1.1 Direct Contact with In-Water Sediment Risk Characterization Results

Potential risks from exposure to PBDEs in in-water sediment through incidental ingestion and dermal absorption were estimated for the in-water workers, tribal fishers, high- and low-frequency fishers, and divers, for both reasonable maximum exposure (RME) and central tendency (CT) scenarios. Risks and hazards from exposures to PBDEs in in-water sediment are presented in Tables F3-9 through F3-19.

Cancer risks from exposure to PBDEs in in-water sediment were orders of magnitude below the EPA target risk range of 1 x 10^{-6} to 1 x 10^{-4}. Cancer risks for all receptors and exposure scenarios ranged from 2 x 10^{-15} for the CT exposure for a low-frequency fisher and diver in wet suit at RM 9.5 east, to 9 x 10^{-11} for the RME scenario for a tribal fisher at RM 8 west.

Hazards from exposure to PBDEs in in-water sediment were orders of magnitude below the EPA target hazard quotient (HQ) of 1. Cumulative HQs per exposure area ranged from 1 x 10^{-8} for the CT exposures for a low-frequency fisher and diver in wet suit at RM 1.5 west to a high of 4 x 10^{-5} for tribal fishers at RM 3.5 east.

5.1.2 Fish Tissue Consumption Risk Characterization Results

Potential risks from exposure to PBDEs in fish tissue through ~~ingestion~~ consumption were estimated for adult and child consumers of fish, for both fillet tissue and whole body ~~tissue~~ diets ~~consisting exclusively~~ of smallmouth bass or common carp~~. Both 95 percent upper confidence levels on the mean (95% UCL) or maximum exposures and mean exposures were assessed at three different ingestion rates,~~ , using the methodology ~~as~~ described in Section 5 of Appendix F. Hazards from exposures to PBDEs in tissue are presented in Tables F3-20 through F3-27.

Cancer risks were not calculated for ~~tissue ingestion scenarios~~fish consumption because the carcinogenic PBDE congener was not detected in the tissue samples evaluated.

HQs from exposure to PBDEs in smallmouth bass and common carp tissue ranged from ~~9 x 10^{-2}~~0.09 to 4, which is above the EPA target HQ of 1, over the ingestion rates, tissue types, and EPCs that were evaluated. The highest HQ occurred at RM 4 from the consumption of smallmouth bass whole body tissue ~~by a~~assuming a childhood consumption ~~at the~~rate 60 g/day~~ ingestion rate using exposure point concentrations equaling the maximum detected concentrations for the exposure area (due to limited sample size, as described in Section 3 of Appendix F)~~. HQs were ~~above~~ greater than 1 for adult consumption of carp and smallmouth bass ~~only at the~~assuming a 142 g/day consumption rate and ~~for~~ child consumption of carp and smallmouth bass at ~~both~~ the 60 g/day and 31 g/day consumption rates.

In general, hazards from consuming whole body tissue were greater than risks from consuming fillet tissue. Hazards from ~~ingestion~~ consumption of smallmouth bass whole body tissue are comparable to those from ingestion of common carp whole body tissue, but hazards from ingestion of smallmouth bass fillet tissue are approximately an order of magnitude lower than hazards from ingestion of common carp fillet tissue. Hazards from ingestion of either whole body smallmouth bass or common carp at a specified ingestion rate are within a factor of approximately two throughout the entire Study Area.

5.1.3 Shellfish Tissue Risk Characterization Results

Potential risks from exposure to PBDEs in shellfish tissue through ingestion were estimated for adult consumers of clam, for undepurated tissue analyzed as whole body without shell~~. Both 95% UCL~~/Reasonable Maximum~~maximum exposures and mean exposures were assessed at two different ingestion rates~~, as described in Section 5 of Appendix F. Hazards from exposures to PBDEs in tissue are presented in Tables F3-28 and F3-29.

Cancer risks were not calculated for consumption of shellfish ~~ingestion scenarios~~ because carcinogenic PBDE congeners were not detected in the tissue samples collected.

Hazards from exposure to PBDEs in clam tissue ~~were below the EPA target HQ~~less than ~~of~~ 1 for all scenarios evaluated~~. Cumulative HQs per exposure area ranged from 4 x 10^{-3} to 4 x 10^{-2}.~~

5.1.4 Infant Breastmilk Consumption Risk Characterization Results

The results of the infant breastmilk consumption pathway are presented for the breast-feeding infant of an adult receptor for each of the exposure scenarios previously discussed. Consistent with DEQ guidance (DEQ 2010) and based on an agreement with EPA, an IRAF was calculated for total PBDEs and applied to cumulative cancer risk and noncancer hazard estimates for each adult exposure scenario and exposure area. The cancer IRAF for total PBDEs is 0.5, and the noncancer IRAF for total PBDEs is 38. Cancer risks and hazards to an infant based on exposure to PBDEs from breastmilk consumption from the adult mothers described in the previous exposure scenarios are presented in Tables F3-30 through F3-46.

A cancer IRAF of 0.5 means that cancer risks to a breastfeeding infant from exposures to PBDEs would be half of the cancer risks from PBDE exposures to the nursing mother. The maximum cancer risk to an infant from consumption of PBDEs in breastmilk would be approximately 5 x 10^{-11}, due to breastfeeding from a mother who is a tribal fisher exposed to in-water sediment. ~~This is orders of magnitude below the EPA target cancer risk of 1 x 10^{-6}.~~ Cancer risks were not calculated for an infant breastfeeding from an adult fish or shellfish consumer because carcinogenic PBDE congeners were not detected in the tissue samples collected.

A noncancer IRAF of 38 for total PBDEs means that hazards to an infant from exposures to PBDEs in breast milk are 38 times greater than hazards to the mother from PBDE exposures. The maximum HQ for an infant from exposure to PBDEs in breastmilk is approximately 80, due to exposures to a mother who is a consumer of whole body smallmouth bass from RM 4 at a consumption rate of 142 g/day. There are no hazards ~~exceeding an~~greater than a HQ of 1 to a breastfeeding infant whose

mother is exposed to in-water sediment or to PBDEs through consumption of clams ~~consumption~~.

5.1.5 Summary of Risk Characterization

Hazards and cancer risks from exposures to PBDEs were evaluated for adult, child and infant receptors from exposures to in-water sediment and tissue.

This risk evaluation shows that there are ~~no~~ all estimated cancer risks ~~exceeding the EPA target risk level of~~are less than ~~1~~ 1 ~~x~~ x 10^{-6} for ~~any~~ all of the scenarios evaluated.

Hazards from exposures to PBDEs in in-water sediment are ~~below~~ leass the EPA target HQ of 1.

~~Hazards from ingestion of PBDEs in fish tissue exceed the EPA target HQ of 1 for both adult and child consumers at some ingestion rates. The highest HQ from fish consumption is four times higher than the EPA target HQ.~~

Hazards from exposures to PBDEs in shellfish are below the EPA target HQ of 1.

Hazards and cancer risks to an infant from ingestion of PBDEs in breast milk of a mother exposed to in-water sediment are below EPA target hazard and cancer risk levels. Hazards to an infant breastfeeding from an adult consumer of smallmouth bass or carp ~~are 38 times higher than hazards to the mother from that ingestion route; the hazards to the infant of an adult fish consumer exceed~~are greater than the EPA target HQs for all ~~ingestion~~ consumption rates ~~and exposure levels~~.

6.0 UNCERTAINTY ANALYSIS

The uncertainties associated with this evaluation of risks from exposures to PBDEs are the same uncertainties associated with the BHHRA methods discussed in Section 6 of the RI/FS Appendix F. This section emphasizes the uncertainties specific to the PBDE dataset.

Limited number of PBDE congeners analyzed.
The PBDE analysis of both in-water sediment and tissue samples included eight of 209 congeners. The congeners analyzed are those typically found most frequently in the environment and should be representative of total PBDE concentrations, but lack of analysis for the full suite of chemicals presents uncertainty in total PBDE concentrations.

Evaluation of congeners with known toxicity values.
Only PBDE congeners with published, peer reviewed toxicity values were evaluated in this risk assessment. This limited the number of congeners included in the

quantitative analysis to four (BDE 47, BDE 99, BDE 153, BDE 209). The uncertainty associated with lack of toxicity information for PBDE congeners could potentially impact the conclusions of this risk evaluation.

Selection of Tissue COPCs Based On Detection of An Analyte.
The selection of PBDE COPCs was based on whether an analyte was detected in each medium or tissue type, and not based on a comparison with health-protective screening levels. There is uncertainty associated with identification of tissue COPCs based on detections alone, and this could potentially impact the conclusions of this risk evaluation for PBDEs.

No Consideration of Background.
PBDEs leach from products with residential, commercial, and industrial uses and have wide-spread presence in the environment. The concentrations detected in sediment and tissue were generally similar throughout the Study Area, indicating the potential for a background contribution. Per EPA guidance (2002), the contribution of background, both natural and anthropogenic, to site concentrations should be distinguished if possible. However, anthropogenic background concentrations for PBDEs have not been established for the Study Area. While risks from PBDEs were evaluated without accounting for contributions from background, it is important to recognize that background concentrations may result in unacceptable risks based on the exposure assumptions used.

7.0 SUMMARY AND CONCLUSIONS

This attachment presents a risk evaluation of exposure to PBDEs measured in in-water sediment and fish and shellfish tissue collected during LWG sampling events from the Study Area, upstream reach, and downtown reach.

The methods and assumptions used in this evaluation are the same as those used in the BHHRA and are presented in the text of Appendix F.

This evaluation found that cancer risks associated with exposure to PBDEs in in-water sediment and tissue consumption are orders of magnitude below the EPA target risk level of 1×10^{-6}. Noncancer hazards from exposures to PBDEs in in-water sediment and shellfish tissue are also below the EPA target HQ of 1. Hazards from exposures to PBDEs in fish tissue and breastmilk exceed the EPA target HQ of 1.

PORTLAND HARBOR RI/FS

DRAFT FINAL REMEDIAL INVESTIGATION REPORT

APPENDIX F

BASELINE HUMAN HEALTH RISK ASSESSMENT

ATTACHMENT F6: SUPPORTING DOCUMENTATION FOR UNCERTAINTY ANALYSIS

This draft document has been provided to EPA at EPA's request to facilitate EPA's comment process on the document in order for LWG to finalize the BHHRA. The comments or changes (including redlines) on this document may not reflect LWG positions or the final resolution of the EPA comments.

May 2, 2011

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1.0 Overview

An uncertainty assessment is presented in Section 6 of the Baseline Human Health Risk Assessment (BHHRA) provided as Appendix F of the Portland Harbor Remedial Investigation Report. The uncertainty assessment presents some of the uncertainties with a quantitative evaluation, and some are discussed in a qualitative manner. This attachment to the BHHRA provides a description of the quantitative analyses performed in the uncertainty assessment.

2.0 Quantification of Uncertainties and Variability

A description of the quantification of uncertainties for the BHHRA is provided below.

2.1 USE OF EITHER WHOLE BODY OR FILLET SAMPLES TO REPRESENT ALL FISH CONSUMPTION

The uncertainty associated with using only whole body or only fillet tissue to evaluate risk from all types of fish tissue diets was evaluated by analyzing fish tissue data used in the BHHRA for selected chemicals. The uncertainty for preference of tissue type consumed is associated with both lack of knowledge and variability, given that the preference for tissue type may both be uncertain and vary from member to member of the receptor population. Differences between fillet and whole body samples depend upon the manner in which the fillet is separated from the rest of the fish.

Fillets with skin and the remainder of body were analyzed separately in Round 3B for smallmouth bass and common carp. Whole body concentrations were calculated from these results on a weighted average basis, which provided the opportunity to compare concentrations of chemicals in the fillet tissue with concentrations in the whole body tissue for the same fish tissue sample. The chemicals evaluated for this analysis were PCBs, since they contribute to the majority of risks from tissue consumption in the BHHRA and preferentially accumulate in fatty tissue; and mercury, because it preferentially accumulates in muscle tissue and would provide a range of the differences between concentrations in the two tissue types.

In the Round 3B smallmouth bass samples, the concentration of total PCBs in fillet tissue ranged from 11 to 22 percent of the whole body concentration (approximately 4 to 10 times higher in whole body tissue). In the Round 3B common carp samples, the concentration of total PCBs in fillet tissue ranged from 50 to 80 percent of the whole body concentration (approximately 1 to 2 times higher in whole body tissue).

In the Round 3B smallmouth bass samples, the concentration of mercury in fillet tissue ranged from 100 to 220 percent of the whole body concentration (approximately 1 to 2 times lower in whole body tissue). In common carp samples, the concentration of mercury in fillet tissue ranged from 110 to 140 percent of the whole body concentration (approximately 1 to 1.5 times lower in whole body tissue).

Table F6-1 compares PCB and mercury concentrations in fillet and whole body tissue for smallmouth bass and common carp.

2.2 USING N-QUALIFIED DATA

N-qualified data were used in the BHHRA for calculating tissue exposure point concentrations (EPCs). The N-qualifier indicates that the identity of the analyte is not definitive. The use of the N qualifier is generally a result of the presence in the sample of an analytical interference such as hydrocarbons or, in the case of pesticides, PCBs. Pesticide data and SVOCs analyzed by EPA Method 8081A were most commonly N-qualified. N-qualified data used in the calculation of EPCs for hexachlorobenzene and several pesticides resulted in cancer risk estimates exceeding 1×10^{-6} or HIs exceeding 1. Given the uncertainty in the identification of the analyte for N-qualified data, the use of N-qualified data introduces uncertainty in these risk estimates. This uncertainty is associated with the lack of knowledge regarding the identification of an analyte for N-qualified data.

For the purposes of this uncertainty assessment, EPCs and risk estimates were recalculated for adult fisher consumption of whole body fish tissue and shellfish tissue with the BHHRA dataset excluding N-qualified data. Results are shown in Table F6-2. For adult fisher consumption of black crappie, six of seven N-qualified chemicals are no longer identified as contaminants of potential concern (COPCs) when the N-qualified data are removed (i.e., these chemicals were no longer detected at least once in the respective fish tissue data set). Exposure to the revised EPC of the remaining N-qualified COPC, Total DDT, results in a change in risk estimates of less than one order of magnitude. For adult fisher consumption of brown bullhead, four of eight N-qualified chemicals are no longer identified as COPCs when N-qualified data are removed, and the revised EPCs for the remaining COPCs result in decreases of up to a factor of two in risk estimates, though do not change the identification of contaminants potentially posing unacceptable risks. For adult fisher consumption of smallmouth bass, common carp, and shellfish, removal of N-qualified data results in minor changes in risk estimates. However, beta-hexachlorocyclohexane is no longer identified as a COPC for clam consumption by an adult fisher.

Chemicals identified as contaminants potentially posing unacceptable risks (i.e., resulting in cancer risks greater than 1×10^{-6} or HQs greater than 1) based solely on N-qualified data were evaluated further. These chemicals are:

- Heptachlor epoxide for clams. The identification of heptachlor epoxide as a contaminant potentially posing unacceptable risks was based on one N-qualified result in an undepurated sample collected from river mile (RM) 6 during Round 1. Heptachlor epoxide was also detected in clam samples collected during Round 3, including samples from RM 6. The Round 3 data were not N-qualified and did not result in cancer risks greater than 1×10^{-6}.
- Alpha-hexachlorocyclohexane (alpha-HCH) for black crappie. The identification of alpha-HCH as a contaminant potentially posing unacceptable risks was based on a single N-qualified result in a whole body sample collected from RM 6 to 9. Alpha-HCH was also detected in smallmouth bass and common carp in the Round 3 samples (which did not include black

crappie). The Round 3 data were not N-qualified and did not result in cancer risks greater than 1×10^{-6} for those species.

- Beta-hexachlorocyclohexane (beta-HCH) for smallmouth bass. The identification of beta-HCH as a contaminant potentially posing unacceptable risks was based on a single N-qualified result in a fillet sample collected from RM 3 in Round 1. Beta-HCH was not detected in the whole body sample collected from RM 3 in Round 1 or in the fillet samples collected from RM 3 in Round 3. Beta-HCH was detected in other smallmouth bass samples collected during Round 3. The Round 3 data were not N-qualified and did not result in cancer risks greater than 1×10^{-6}.
- Gamma-hexachlorocyclohexane (gamma-HCH) for brown bullhead. The identification of gamma-HCH as a contaminant potentially posing unacceptable risks was based on two N-qualified results in whole body samples collected from RM 3 to 6 and one N-qualified result in a whole body sample collected from RM 6 to 9. Gamma-HCH was also detected in smallmouth bass and common carp in the Round 3 samples (which did not include brown bullhead). The Round 3 data were not N-qualified and did not result in cancer risks greater than 1×10^{-6} for those species.
- Heptachlor for black crappie. The identification of heptachlor as a contaminant potentially posing unacceptable risks was based on a single N-qualified result in a whole body sample collected from RM 3 to 6.

The chemicals identified as contaminants potentially posing unacceptable risks based only on N-qualified data were for fish and shellfish consumption scenarios. To assess whether the chemical might be present in the biota sample at concentrations potentially posing unacceptable risks even though the analytical result was not definitive, sediment data for those chemicals were also evaluated. Table F6-3 summarizes the results of the evaluation. For clams and smallmouth bass, which were collected over a smaller spatial scale than the other species, the evaluation suggests that the identification of the contaminants as potentially posing unacceptable risks is not supported by the sediment data. Heptachlor epoxide was detected in six in-water sediment samples collected from RM 6 east, and five of the six sediment samples were N-qualified as well. Beta-HCH was detected in all of the in-water sediment samples included in the BHHRA database. The maximum detected in-water sediment concentration of beta-HCH in RM 3 to 4 (7.99 micrograms per kilogram) is less than the maximum detected concentration in the Study Area (20.3 micrograms per kilogram), indicating that beta-HCH concentrations in RM 3 to 4 are not higher than at other locations within the Study Area. This analysis indicates there is uncertainty in identifying contaminants as potentially posing unacceptable risks based on N-qualified data only.

2.3 EXPOSURE PARAMETERS FOR TISSUE CONSUMPTION SCENARIOS

The uncertainty for tissue consumption rates is associated with both lack of knowledge and variability, given that the tissue consumption rate may both be uncertain and vary from member to member of the receptor population. The range of the magnitude of uncertainty associated with tissue consumption rates used in the BHHRA was determined by calculating the ratio of upper end consumption rates from the studies cited in Section 6 of the BHHRA with the mean consumption rates from the same studies, as follows:

Adult Fisher consumption of fish [*source*: CSFII (USDA 1998)]:

142 grams per day (g/day) divided by 7.5 g/day = 20 (after rounding)

Where:

142 g/day = 99th percentile rate from study, freshwater and estuarine fish and shellfish. Highest rate used in BHHRA.
7.5 g/day = mean rate from study.

Tribal Fisher consumption of fish [*source*: CRITFC 1994]:

175 g/day divided by 63 g/day = 3 (after rounding)

Where:

175 g/day = 95th percentile rate from study. Highest rate used in BHHRA.
63 g/day = mean rate from study.

Adult Fisher consumption of shellfish [*source*: CSFII (USDA 1998)]:

18 g/day divided by 3.3 g/day = 5 (after rounding)

Where:

18 g/day = 95th percentile rate for shellfish in freshwater and estuarine habitats combined, from study. Highest rate used in BHHRA.
3.3 g/day = mean rate from study.

The above calculations only show how the range of uncertainty was quantified for purposes of the BHHRA. A more detailed discussion of uncertainties in the tissue consumption scenarios is provided in Section 6 of the BHHRA.

2.4 ASSUMPTIONS ABOUT A MULTI-SPECIES DIET

The adult and child fisher multi-species diet assumes equal proportions of all four resident fish species. The adult and child tribal fisher multi-species diet consists of equal proportions of the four resident fish species, as well as dietary percentages of salmon, lamprey, and sturgeon that come from the CRITFC Fish Consumption Survey (CRITFC 1994). The uncertainty for assumptions for a multi-species diet are associated with both lack of knowledge and variability, given that the preference for fish species consumed may both be uncertain and vary from member to member of the receptor population. Uncertainties associated with these assumptions were evaluated by comparing risks from single-species diets with the risks from the multi-species diets, to encompass the full range of possible dietary proportions from each species of fish.

Table F6-4 shows that the cancer risk estimates from consumption of whole body fish tissue of a single species by an adult fisher ranged from 0.1 to 7 times the same cancer risk estimates from an equally proportioned multi-species diet. The cancer risk estimates from consumption of fillet fish tissue of a single species by an adult fisher ranged from less than 0.1 to 9 times the same risks from an equally proportioned multi-species diet. This indicates that assuming an individual consumes only a single species diet of fillet tissue could result in risks higher by a factor of less than 0.1 to 9, depending on the species, than an individual who consumes a multi-species diet..

2.5 USING 5-10 SAMPLES TO CALCULATE THE 95% UCL ON THE MEAN

Using fewer than ten sample results to calculate a 95% UCL on the mean increases the uncertainty associated with the 95% UCL for certain calculation methods. EPA's ProUCL software will not compute UCLs for datasets with less than 5 samples, and 8 to 10 samples are recommended in order to achieve reliable results. The Study Area-wide fish tissue EPCs that were calculated as 95% UCL on the mean concentrations using fewer than 10 samples included the Study Area-wide EPCs for whole body tissue of brown bullhead and fillet tissue of common carp. The maximum EPCs for the individual exposure points for whole body brown bullhead and fillet common carp were up to two times higher than the Study Area-wide EPCs.

The comparison of maximum detected concentrations and the Study Area-wide EPCs based on fewer than 10 samples is presented in Table F6-5 for PCBs and dioxins/furans. There was a 1 to 2-fold difference in the EPCs calculated with fewer than 10 samples versus the maximum detected concentrations.

2.6 USING THE MAXIMUM CONCENTRATION TO REPRESENT EXPOSURE

An evaluation was performed to quantify the range of uncertainty associated with using the maximum concentration to represent exposure, which was done in exposure areas with less than five detected concentrations. This uncertainty is associated with lack of knowledge given that increased sample size would reduce the lack of knowledge regarding the population distributions of sample concentrations. The use of maximum detected concentrations as EPCs for exposure areas with less than 5 detected concentrations was agreed upon with EPA as described in Attachment F1. The evaluation of this uncertainty included outlier tests and comparisons of maximum concentrations to mean concentrations for the same exposure area that are provided in Tables F6-6 to F6-9.

For in-water sediment, there were only two cases for which the maximum detected concentration was used as the EPC and the risk estimate was greater than 1×10^{-6}: exposure by a tribal fisher at the exposure points RM 1.5E (benzo[a]pyrene) and RM 11E (PCB congeners).

Except for the EPC calculated for location 7W for clams, for the calculation of all shellfish station tissue EPCs, the maximum concentrations were used because fewer than 5 composite tissue samples were collected per station. As shown in Tables F6-6 through F6-9, the ratios of the maximum concentrations to the mean concentrations are generally within an order of magnitude. The maximum values listed in the tables are limited to those chemicals and exposure media for which the maximum value was used as the RME and more than one sample was collected for the exposure area. For surface water (Table F6-6), all of the ratios between the maximum and minimum concentration values shown are less than 2, with the exception of benzo(a)pyrene at RM 6, which has a maximum to minimum concentration ratio of 2.7. Ratios for in-water sediments (Table F6-7) are typically less than 3, and all ratios are less than 4. When comparisons are made within an exposure area for fish tissue risk results, the majority of the ratios are equal to or less than 2, and none exceed 4 (Table F6-8). Maximum cancer risk values for fish tissue correspond to the 142 g/day consumption rate for adult non-tribal fishers, and maximum non-cancer HIs correspond to the 60 g/day consumption rate for child non-tribal fishers.

There was one smallmouth bass sample collected during the Round 3 sampling effort at RM 10E (LW3-SB010E-C00B) with anomalously high detected concentrations of lead and antimony in the tissue analyzed as whole body without fillet. The tissue sample was reanalyzed, as described in the Round 3B Fish and Invertebrate Tissue and Collocated Sediment Data Report, Addendum 1 (Integral 2008). Due to the consistently high detection of these compounds in this sample, the results of the lead and antimony analyses for this sample were averaged for use in the BHHRA. The lead concentration in body without fillet tissue for this sample is 1640 milligrams per kilogram (mg/kg), which is over 160 times higher than the next highest lead

concentration for smallmouth bass in the Study Area. The antimony concentration in body without fillet tissue for this sample is 8.41 mg/kg, which is also approximately 160 times higher than the next highest antimony concentration in smallmouth bass for the Study Area. As discussed in the Round 3B Fish and Invertebrate Tissue and Collocated Sediment Data Report, Addendum 1, these elevated concentrations are consistent with what would be expected from fish that swallowed fishing gear containing lead and antimony or other similar metal objects. These concentrations may not be representative of tissue concentrations resulting from exposure to CERCLA-related contamination within the Study Area. However, these concentrations were used with the corresponding fillet concentrations to calculate a whole body concentration for use in the BHHRA, which was also anomalously high. The concentrations of lead and antimony for this sample (LW3-SB010E-C00WB) were the maximum concentrations for the RM 10E smallmouth bass exposure area, and due to the low number of smallmouth bass samples within the exposure area, they were used as the EPCs. The maximum concentrations of this sample are an extremely conservative estimate of exposure from this river mile stretch, and do not represent average exposure from smallmouth bass tissue at this exposure area. The concentrations from this sample were also used in the calculation of Study Area-wide EPCs for smallmouth bass, creating a high bias in the dataset. Although lead would still be considered a contaminant potentially posing unacceptable risks for smallmouth bass if this sample were removed from the dataset, antimony would not be a contaminant potentially posing unacceptable risks.

2.7 POSSIBLE EFFECTS OF PREPARATION AND COOKING METHODS

As discussed in Section 6 of the BHHRA, cooking and preparation methods of fish tissue can modify the amount of contaminant ingested by fish consumers. The uncertainty for possible effects of preparation and cooking methods are associated with both lack of knowledge and variability, given that the preference for fish preparation methods may both be uncertain and vary from member to member of the receptor population. Furthermore, there is variability in the degree of cooking loss for each preparation method. The results of a study by Wilson et al. (1998) were used to bound the magnitude of uncertainty associated with the BHHRA, which did not account for possible effects of preparation and cooking. The Wilson study showed that PCB concentrations would be reduced by a factor up to 87 percent, depending on cooking methods. However, unless preparation and cooking methods are known for particular receptors, the overall uncertainty is unknown, and the overall effect will likely be more modest than 87 percent.

EPA guidance (2000) includes a summary of contaminant reductions due to skinning, trimming, and cooking. These reductions are summarized for PCBs in Table F6-10. The percent reductions range from 16 to 80 percent, depending on species and preparation/cooking method.

2.8 BIOAVAILABILITY OF CHEMICALS

Studies have shown that conditions in environmental media (e.g., pH, organic carbon content) can affect the bioavailability of a chemical (Ruby et al. 1999, Pu et al. 2003, Saghir et al. 2007). This uncertainty is associated with both lack of knowledge and variability. The uncertainty is associated with lack of knowledge because of the restrictions of scientific study to limit the number of environmental conditions, test organisms, and chemicals evaluated for bioavailability. This uncertainty is also associated with the temporal and spatial variability of conditions in environmental media (e.g., pH, organic carbon content) over the exposure duration and exposure area for each exposure scenario.

2.9 TOXICITY VALUES FOR POLYCHLORINATED BIPHENYLS AND APPLICABILITY TO ENVIRONMENTAL DATA

As discussed in Section 6, uncertainties exist in the toxicity values for PCBs and their applicability to environmental data. This uncertainty was bounded for the purposes of this uncertainty analysis by calculating the ratio of the oral slope factors for High Risk PCBs to Low Risk PCBs, as follows:

$$\frac{\text{2.0 Oral Slope Factor for High Risk PCBs}}{\text{0.07 Oral Slope Factor of Low Risk PCBs}} = 30 \text{ (after rounding)}$$

This uncertainty is associated with the lack of knowledge of toxicity of PCB mixtures present in the environmental media evaluated under each exposure scenario and exposure point.

The EPA document titled Cancer Dose-Response Assessment and Application to Environmental Mixtures (EPA/600/P–96/001F, September 1996) presents the rationale for the use of 3 different cancer slope factors for PCBs. Three slope factors are provided: 2 per milligrams per kilogram per day (mg/kg-day) for high risk and persistence PCBs, such as Aroclor 1260 and 1254; 0.4 per mg/kg-day for low risk and persistence PCBs, such as Aroclor 1242; and 0.07 per mg/kg-day for lowest risk and persistence PCBs, such as Aroclor 1016. The high risk and persistence value should be used for those exposure pathways associated with environmental processes that tend to increase risk, including: food chain exposure; sediment or soil ingestion; dust or aerosol inhalation; dermal exposure (if an absorption factor has been applied); the presence of dioxin-like, tumor-promoting, or persistent congeners in other media; and early-life exposure (all pathways and mixtures). The low risk and persistence value should be used for those exposure pathways that tend to decrease risk, including: ingestion of water-soluble congeners, inhalation of evaporated congeners, and dermal exposure if no absorption factor has been applied. The lowest risk and persistence value should be used where congener or isomer analyses verify that congeners with more than four chlorines comprise less than one-half percent of total PCBs, suggesting that potency is best represented by the least potent tested mixture. All of the pathways assessed in the BHHRA are included under the criteria for use of the

high risk and persistence cancer slope factor of 2 per mg/kg-day. Even for scenarios where adults only (not children) ingest water, surface water data would contain both water soluble congeners and those found in water-borne colloidal material and particulate matter.

2.10 RISKS FROM CUMULATIVE OR OVERLAPPING SCENARIOS

In calculating the cumulative risks from overlapping scenarios, the maximum cancer risk and noncancer hazard for each RME scenario was used, respectively. The uncertainty associated with this calculation was determined by comparing the difference between summing the maximum for each RME scenario and summing the respective minimum cancer risk and noncancer hazard estimates for each RME scenario. This uncertainty is associated with both lack of knowledge and variability. There is a lack of knowledge of the true extent to which exposure scenarios overlap and the true extent of overlapping exposure scenarios may vary from member to member of the population.

2.11 LIMITING ENDPOINT-SPECIFIC HIs FOR A CHEMICAL TO ONE ENDPOINT

In deriving endpoint-specific HIs, only one health endpoint is used for each chemical, even though most chemicals can have a myriad of health effects as exposures increase. While the individual HQ for additional effects will be lower than that based on the critical study, not considering these additional endpoints may underestimate the potential for adverse effects in the endpoint-specific HIs. Because cumulative HIs were calculated without regard for the toxicity endpoint prior to calculating the endpoint-specific HIs, the cumulative HIs in the BHHRA are not be affected by multiple endpoints for individual chemicals.

2.12 UNCERTAINTIES RESULTING FROM ELIMINATION OF EXPOSURE PATHWAYS IN THE BHHRA

Section 3.2.1 of the BHHRA initially describes different categories for exposure pathways (complete, incomplete, complete and significant, etc.). Complete and significant pathways are further discussed in the BHHRA, but uncertainty exists in the elimination of incomplete and insignificant pathways. However, the pathways chosen for further evaluation in the BHHRA are assumed to be protective of other pathways.

2.13 ELIMINATION OF DATA FROM OUTSIDE THE STUDY AREA IN SCREENING FOR COPCS IN IN-WATER SEDIMENT AND SURFACE WATER

During the screening for COPCs described in Section 3, data from outside the Study Area were not used for in-water sediments or for surface water. For in-water sediment, samples excluded from the COPC screening dataset were those samples collected in Multnomah Channel, samples collected from RM 1 to 1.9, and samples collected from RM 11.8 to 12.2. All analytes detected in samples outside of the Study Area were also detected inside the Study Area. For surface water, there was only one sample location outside of the Study Area that was excluded from the COPC screening dataset (Multnomah Channel). Analytes detected in Multnomah Channel were also detected in the Study Area. Elimination of these data introduce uncertainty in the COPC screening, however, this uncertainty is not expected to affect the overall conclusions of the BHHRA.

2.14 EXCLUSION OF NON-DETECTED CONCENTRATIONS THAT ARE HIGHER THAN THE HIGHEST DETECTED CONCENTRATION

EPA guidance notes that non-detect values for which the detection limit is greater than the maximum reported concentration for a specific chemical/media should be excluded when inclusion of the data results in a calculated EPC that exceeds the maximum reported concentration. For the BHHRA, all non-detect data greater than the maximum detection limit per exposure area were excluded, introducing uncertainty in the risk results. Tables F2-7 through F2-13 in Attachment F2 show non-detect data that are greater than the maximum detection limit per exposure area for different media, species, tissue type, and exposure area. These tables also indicate whether the non-detected results are at least two orders of magnitude greater than the maximum detected concentration. Many of these analytes are already classified as primary contributors to risk, and therefore this uncertainty is not expected to affect the overall conclusions of the BHHRA.

2.15 UNCERTAINTIES IN THE DERMAL TOXICITY ASSESSMENT

The approach used to evaluate dermal risk could underestimate risk by a factor of up to 2, since no adjustments to slope factors or RfDs are required if oral absorption efficiency is greater than 50 percent.

2.16 POLYCHLORINATED BIPHENYLS

Section 6.2.6 of the BHHRA describes an analysis of the correlation of the results of whole body tissue samples for PCBs as Aroclors and as individual congeners. A comparison of the results for PCBs as Aroclors and PCBs as individual congeners for tissue samples is provided in Table F6-11. This comparison is based on the whole

body tissue data from Round 1, which is the only sampling event where Aroclors and congeners were analyzed in the same tissue samples. As shown in Table F6-11, sometimes the congener results are higher and other times the Aroclor results are higher. Risks from total PCBs in tissue are calculated based on PCB congeners when congener data were available, which introduces uncertainty into the risk estimates.

Fillet tissue samples collected in Round 1 were analyzed for Aroclors only, and Round 3 samples (smallmouth bass and common carp) were analyzed for PCB congeners only. While risks were estimated for both the Aroclor and congener results, the cumulative risks were based on PCB congener data when congener data were available, which resulted in using the Round 3 data instead of the Round 1 data. To assess the uncertainty in using the Round 3 data versus the Round 1 data, the results for Aroclors and congeners in smallmouth bass and common carp fillet tissue were compared, as provided in Table F6-12. This comparison shows that for the same exposure area where both congener and Aroclor data are available, sometimes the congener results (i.e., Round 3 data) are higher and other times the Aroclor results (i.e., Round 1 data) are higher. However, these results are not for the same fish tissue samples so the difference in concentrations could be due to heterogeneity in the tissue samples as opposed to the sampling event or analytical method. On a Study Area-wide basis, the congener results are higher than the Aroclor results. The availability of only Aroclor or congener data depending on the sampling event introduces uncertainty into the risk estimates.

2.17 COMPARISON OF UNDEPURATED AND DEPURATED CLAM SAMPLES

Clam tissue throughout most of the Study Area was analyzed as undepurated samples, and a limited number of clam samples were depurated before analysis. The depurated clam tissue accounted for only five of the 22 clam samples collected for the BHHRA dataset, and the depurated samples were collected from edges of the site (northern and southern stretches). A comparison of the exposure point concentrations for depurated and undepurated clam tissue collected from the same exposure areas is provided in Table F6-13.

Copy of *2012_06_22_PH Cumulative risk tables.xlsx*, attached to the June 22, 2012 EPA Letter, not included due to volume.

TAB 17

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
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Seattle, WA 98101-3140

OFFICE OF
ENVIRONMENTAL
CLEANUP

June 29, 2012

Mr. Bob Wyatt
Chairman, Lower Willamette Group
c/o Northwest Natural
220 Northwest Second Avenue
Portland, Oregon 97209

Re: Portland Harbor Superfund Site, Administrative Order on Consent for Remedial Investigation and Feasibility Study; Docket No. CERCLA-10-2001-0240
Response to Lower Willamette Group (LWG) June 29, 2012, letter regarding EPA Directed Modifications and Additional Comments on Baseline Human Health Risk Assessment dated May 2, 2011

Dear Mr. Wyatt;

This letter is in response to the letter sent to EPA on June 29, 2012, from the LWG regarding a request for extension for dispute, document deliverable, and clarifications on intent of the EPA regarding the Administrative Order on Consent.

The LWG requested an extension of the dispute deadline from 14 days as described in the Administrative Order on Consent to 45 days "to evaluate EPA's allegations and directed revisions and prepare responses." EPA does not believe that 45 days are required for the LWG to read EPA's modifications and determine whether it will dispute one or more of those modifications. Due to the number of changes made, EPA agrees that an extension is warranted, but a 30 day extension on top of the 14 days is excessive. EPA is granting an additional 14 day extension from the date that the LWG received the letter, or July 24, 2012, to invoke dispute and provide its written objections and basis as required by Section XVIII, Paragraph 1.

Additionally, the LWG requested an extension of time to submit the revised Baseline Human Health Risk Assessment from 30 days to 90 days, or until September 21, 2012. This extension time infers that the LWG will spend 45 days only reviewing the changes and deciding whether to dispute but not actively working to revise the Risk Assessment document during that time. EPA will agree to extend the time for revising the Baseline Human Health Risk Assessment to 90 days from the date the LWG's receipt of our June 22nd modifications, which would be September 21, 2012, but the basis is due to the extensive revisions needing to be made to the tables. EPA does not expect written responses to the modified text as part of its resubmission of the document or any

requested changes to the tables since all the comments were directive. If the LWG decides to dispute one or more of EPA's modifications, revisions related to disputed issues will be deferred until after a final dispute decision.

Lastly, the LWG requested clarification on the intent of EPA regarding stipulated penalties. In accordance with Paragraph 1, Section IX of the Administrative Order on Consent, EPA has determined that the LWG failed to produce a BHHRA of acceptable quality, or otherwise failed to perform in accordance with the requirements of the Order by failing to fully correct all deficiencies and incorporate and integrate all information and comments supplied by EPA on prior versions of the BHHRA. It is EPA's intent that the written notice dated June 22, 2012 was the date upon which the LWG failed to produce a BHHRA of acceptable quality and, in accordance with the AOC, the day stipulated penalties began accruing and will continue to accrue until a satisfactory deliverable is produced. However, as further stated in Paragraph 1, Section XIX of the Administrative Order on Consent, "EPA may, at its discretion, waive imposition of stipulated penalties if it determines that Respondents have attempted in good faith to comply with this Order, or have timely cured defects in initial submissions." EPA shall make this determination after receipt of the revised BHHRA and it has been determined that the corrections required by EPA have been conducted both timely and completely.

The LWG's letter further indicated that if EPA did not grant the extension of time requested that the LWG was invoking dispute resolution. The LWG's June 29, 2012 letter is insufficient to invoke dispute under the AOC. If the LWG chooses to invoke dispute resolution, it must do so in compliance with Section XVIII, Paragraph 1.

If you have any questions regarding this letter, please contact Chip Humphrey at (503) 326-2678, or humphrey.chip@epa.gov, Kristine Koch at (206) 553-6705, or koch.kristine@epa.gov. All legal inquiries should be directed to Lori Cora at (206) 553-1115, or cora.lori@epa.gov.

Sincerely,

Chip Humphrey
Remedial Project Manager

Kristine Koch
Remedial Project Manager

cc: Mr. Jim Anderson
Oregon Department of Environmental Quality

Mr. Rob Neely
National Oceanic and Atmospheric Administration

Mr. Ted Buerger
U.S. Fish and Wildlife Service

Mr. Brian Cunninghame
Confederated Tribes of the Warm Springs Reservation of Oregon

Ms. Rose Longoria
Confederated Tribes and Bands of the Yakama Nation

Mr. Michael Karnosh
Confederated Tribes of the Grand Ronde Community of Oregon

Mr. Tom Downey
Confederated Tribes of the Siletz Indians

Mr. Audie Huber
Confederated Tribes of the Umatilla Indian Reservation

Ms. Erin Madden
Nez Perce Tribe

Mr. Greg Ulirsch
ATSDR

Mr. Kurt Burkholder
Oregon Department of Justice

Mr. Todd Hudson
Oregon Health Authority

Mr. Rick Keppler
Oregon Department of Fish and Wildlife

LOWER WILLAMETTE GROUP

Chairperson: Bob Wyatt, NW Natural
Treasurer: Fred Wolf, Legacy Site Services for Arkema

Via Federal Express

July 23, 2012

Chip Humphrey
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Portland, OR 97205

Kristine Koch
United States Environmental Protection Agency, Region 10
Office of Environmental Cleanup, Mail Code ECL-115
1200 Sixth Avenue, Suite 900
Seattle, Washington 98101-3140

Re: Notice of Objection to EPA Notice of Non-Compliance and Directed Revisions to the Portland Harbor Draft Final Baseline Human Health Risk Assessment and Request for Dispute Resolution
Lower Willamette River, Portland Harbor Superfund Site, USEPA Docket No: CERCLA-10-2001-0240

Dear Chip and Kristine:

On June 22, 2012, EPA provided a redlined version of the main text and certain attachments to the Lower Willamette Group's May 2, 2011 draft final Baseline Human Health Risk Assessment (BHHRA) ("June 22 letter"). The June 22 letter directed the LWG to revise the BHHRA consistent with the accompanying redline and with additional directed comments on tables and figures to the BHHRA. EPA's cover letter states that "EPA has determined that the LWG failed to produce a BHHRA of acceptable quality, or otherwise failed to perform in accordance with the requirements of the Order by failing to fully correct all deficiencies and incorporate all information and comments supplied by EPA on prior versions of the BHHRA." In its follow-up letter dated June 29, 2012 ("June 29 letter"), EPA stated that stipulated penalties are accruing as of June 22 because the BHHRA was not of acceptable quality.

Pursuant to § XVIII of the September 28, 2001 Administrative Settlement Agreement and Order on Consent (Consent Order), the LWG hereby initiates dispute resolution with regard to (1) EPA's June 22, 2012 determination that the LWG "failed to produce a BHHRA of acceptable quality, or otherwise failed to perform in accordance with the requirements of the Order" and (2) EPA's June 22, 2012 directed revisions to the BHHRA's text, tables, and figures. The LWG's objections and the bases for those objections are stated below and in the enclosed tables.

The LWG strongly disagrees with and objects to EPA's directed revisions to the draft final BHHRA, EPA's determination that the LWG has failed to comply with the Consent Order, and the potential imposition of stipulated penalties. In the interest of streamlining the dispute, the LWG has provided representative examples rather than an in-depth submittal for each directed revision. LWG hereby reserves its right to supplement the record with more specific substantive responses to each of the redlined changes and comments on the tables and figures that are new, inconsistent or otherwise without technical or substantive merit.

The LWG does not expect the dispute resolution process to interfere with EPA's review of the draft Feasibility Study submitted on March 30, 2012. EPA has committed to the Portland community that it intends to prepare a proposed plan and issue a Record of Decision by 2014, and EPA has separate technical staff members assigned to the draft FS and BHHRA.

The BHHRA faithfully reflects EPA's extensive prior comments and agreed upon resolutions

The BHHRA was the subject of extensive review by, and repeated comments from, EPA. Between December 2009 and July 2010, EPA provided more than 200 comments on the October 2009 draft BHHRA. EPA's July 16, 2010 cover letter transmitting these comments, as well as several hundred additional comments on the draft Remedial Investigation Report and draft Baseline Ecological Risk Assessment, stated that EPA was providing its "complete set of comments" on the draft RI and baseline risk assessments and had "attempted to provide clear direction on the specific revisions that are needed to resolve the comments." EPA and the LWG thereafter engaged in several months of detailed technical negotiations to resolve EPA's comments. The resolution of all of EPA's comments was documented in tables generated by the LWG and acknowledged by EPA as follows:

- LWG *General Responses to EPA Directive Comments on the Baseline Human Health Risk Assessment*, September 15, 2010 (acknowledged by EPA letter dated September 22, 2010)
- LWG *General Responses to EPA Non-Directive Comments on the Baseline Human Health Risk Assessment*, November 18, 2010 (acknowledged by EPA letter dated December 8, 2010)
- LWG *Response to EPA's General Comments on the RI, BHHRA and BERA*, January 12, 2011 (acknowledged by EPA letter dated February 25, 2011).

EPA's letters acknowledging the written resolution of the comments are clear and unambiguous. The LWG relied on and complied with the written resolutions, as well as pertinent EPA national risk assessment guidance, in preparing the revised version of the BHHRA. EPA's June 22, 2012 letter and the directed revisions to the BHHRA entirely disregard these agreements to resolve EPA's comments on the BHHRA, which EPA advised LWG were its "complete set of comments" necessary to finalize the BHHRA.

A detailed compilation of the instances in which EPA's June 22 revisions to the draft BHHRA either fail to honor EPA's agreements with the LWG or are inconsistent with EPA's own prior comments and directed changes on the BHHRA is provided in the enclosed Tables 1

and 2.[1] EPA's comments on the October 2009 draft BHHRA, documentation of EPA and LWG agreements related to the revision of the BHHRA, and the May 2, 2011 draft final BHHRA, redlined to show changes in response to EPA comments on the October 2009 draft, are attached at Tabs 1 through 17.[2]

The LWG was surprised at the scope and magnitude of EPA's comments, given the previous substantive resolutions. The LWG had no reason to believe, then or now, that EPA was reversing the written resolutions of comments it had previously negotiated with the LWG. We are hopeful that the positions stated in EPA's June 22 and 29 letters are inadvertently in conflict with EPA's prior directions and that EPA will simply withdraw those letters and revise its comments such that they are consistent with and honor EPA's prior direction.

EPA's change of its prior approach and documented resolution is arbitrary and capricious

EPA's change of its prior negotiated and approved approach to developing the BHHRA and its abandonment of existing agreements with the LWG constitutes arbitrary and capricious agency action in violation of the Administrative Procedure Act. "[A]n agency acts arbitrarily and capriciously when it abruptly departs from a position it previously held without satisfactorily explaining its reason for doing so." *Wisconsin Valley Improvement Company v. Federal Energy Regulatory Commission*, 236 F. 3d 738, 748 (D.C. Cir. 2001). *See also, Northwest Environmental Defense Center v. Bonneville Power Administration*, 477 F.3d 668, 687 (9th Cir. 2007), *quoting Greater Boston Television Corp. v. FCC*, 444 F.2d 841, 852 (D.C. Cir. 1970) ("an agency changing its course must supply a reasoned analysis indicating that prior policies and standards are being deliberately changed, not casually ignored…."); *Sierra Club v. Jackson*, 833 F.Supp.2d 11, 32 (D. D.C. 2012), *quoting Jicarilla Apache Nation v. U.S. Department of the Interior*, 613 F.3d, 1112, 1120 (D.C. Cir. 2010) (" '[a]n agency's failure to come to grips with conflicting precedent constitutes an inexcusable departure from the essential requirement of reasoned decisionmaking.' EPA has failed … to come to grips with its prior precedents. For that reason the Delay Notice is arbitrary and capricious."); *Sierra Club North Star Chapter v. LaHood*, 693 F.Supp.2d 958, 973 (D. Minn. 2010) ("A failure to acknowledge [National Park Service's] previous position, let alone explain why, in NPS's opinion, a change is justified, is the hallmark of an arbitrary and capricious decision.")

The LWG has complied with the Consent Order

EPA's assertion that the LWG is not in compliance with the Consent Order because of what appears to be EPA's arbitrary and unexplained change of mind is unreasonable. Although Tables 1 and 2 provide conclusive evidence of why EPA should retract this determination immediately, we highlight below the lack of any merit in the four "deficiencies" EPA's June 22 letter identifies in support of its determination that the LWG has failed to comply with the Consent Order.

[1] On June 29, 2012, EPA denied the LWG's request for a 30 day extension to prepare for dispute resolution, allowing the LWG only 14 additional days to review and evaluate over 200 pages of EPA revisions to a document EPA had under review for approximately 14 months. The LWG reserves the right to supplement the materials provided with this letter.

[2] Because EPA's comments on the BHHRA and the agreed resolution of those comments amount to nearly 1400 pages, the LWG is providing the documentation supporting this letter and Tables 1 and 2 on a CD, rather than in hard copy. If EPA would like paper copies of this backup documentation, please let us know.

First, EPA finds that the BHHRA provided "incorrect or misleading information." EPA provides a single example in support of this finding:

> "[T]he BHHRA repeatedly stated that the exposure assessment assumed someone ate fish every day of the year for 30 years. The LWG is fully aware that such a statement is not accurate…. EPA commented on this issue in our February 9, 2010 comment letter; however, the LWG failed to address it."

As an initial matter, EPA commented on this issue in its July 16, 2010 comments; its February 9, 2010 letter does not address this topic at all. EPA's July 16, 2010 comments request five specific edits to text in the BHHRA (comments S91, S96, S143, S150, and S179).[3] Only two of these five comments (S96 and S150) were identified by EPA as "directed changes."[4] In fact, however, the LWG revised the text in all five instances precisely as EPA requested.[5]

Second, EPA finds that "the BHHRA does not fully reflect EPA's directions for change, directions given years before and reiterated in our comments to prior versions." As its single example, EPA quotes a "February 2010 comment" related to the description of exposure point concentrations. Again, this comment is found in EPA's July 16, 2010 comment letter, not the February 2010 letter. And again, this comment (S52) is identified by EPA as "clarify," not as "directed change."[6] Finally, there was a specific agreement between EPA and the LWG as to how to resolve comment S52. That resolution is documented in the LWG's November 18, 2010 *General Responses to Non-Directed Comments on the BHHRA* and was acknowledged by EPA on December 8, 2010.[7] In part, the LWG and EPA agreed that "the EPC will be identified as the mean, 95% UCL or maximum." [8] Notwithstanding this agreement, EPA now concludes that the BHHRA is "deficient" because it includes EPCs based on the arithmetic mean. Clearly, this cannot be the basis of any deficiency, because the BHHRA text faithfully reflects the documented agreement on comment S52. Therefore, EPA's finding of "deficiency" on this point is incorrect in at least three particulars: (1) the comment was not made in February 2010; (2) it was not a directed change; and (3) the May 2, 2011 draft final BHHRA is consistent with the November 18, 2010 agreed resolution of that comment.

Third, EPA finds the BHHRA deficient because "[t]here were many instances in the BHHRA where the only explanation the LWG provides for why something is done was that EPA directed or otherwise required it be done."[9] This is an entirely new comment on the BHHRA,

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[3] See, Table 1. EPA's July 16, 2010 comments on the BHHRA are at Tab 8.
[4] *Id*. at p. 150.
[5] See, May 2, 2011 Draft Final RI Report Appendix F BHHRA Main Text redline, attached at Tab 15, pp. 114, 117, 121, 155, 156, 175, and 176.
[6] July 16, 2010 comments on the BHHRA, pp. 52-53 (at Tab 8).
[7] November 18, 2010 *General Responses to EPA's Non-Directive Comments on the* BHHRA at p. 6 (at Tab 11); EPA December 8, 2010 letter (at Tab 12).
[8] Note that the Programmatic Work Plan (approved by EPA on June 29, 2004) states, "…the arithmetic mean concentrations will be used as EPCs for individual sampling locations" and "[s]ite-wide tissue EPCs will also be estimated using mean concentrations…" Programmatic Work Plan, Appendix C, page 26. While EPA guidance recommends using the 95 percent UCL to estimate the EPC, DEQ rules require use of the arithmetic mean concentration as an EPC. OAR 340-122-0084(1)(g). Therefore, both calculations were performed in the BHHRA.
[9] EPA's June 22 revisions actually delete all references to assumptions or evaluations in the BHHRA being directed by EPA. This revision itself violates EPA's agreement with the LWG that "language stating that evaluations were done at the direction of EPA can remain in the revised BHHRA. Language implying opinion or judgment about the prudence of that direction will be removed." September 15, 2010 *General Responses to Directed Comments on BHHRA* at p. 4 (at Tab 9). This agreement was acknowledged by EPA's September 22, 2010 letter (at Tab 10).

and EPA has no basis for determining that the LWG is in violation of the Consent Order for failing to make revisions to the BHHRA that EPA has not previously requested, particularly in light of EPA's statement in July 2010 that it was providing a "complete set of comments" on the BHHRA and "clear direction on the specific revisions" necessary to resolve those comments. EPA's determination of noncompliance cannot be sustained on the basis of an alleged "deficiency" that relates to a brand-new issue.

Similarly, EPA's fourth identified "deficiency" in the BHHRA is that "EPA had to extensively modify the report to make the report understandable to the general public." Again, this is a completely new comment. We note, however, that, in July 2010, EPA provided 25 individual comments on the executive summary to the BHHRA.[10] The LWG made detailed revisions to the executive summary consistent with the agreed resolution of these comments, and EPA has now deleted the entire executive summary. EPA has also deleted the conclusions of the draft final BHHRA, which the LWG modified extensively to address EPA's July 2010 comments. It is difficult for us to see how removing the executive summary and the conclusions from the BHHRA serve to make the report "understandable to the general public," and EPA's June 22 edits are themselves inconsistent with the agreed resolution of EPA's "complete set of comments" on the BHHRA. If EPA felt the LWG's initial BHHRA draft was not understandable to the general public, the LWG should have been able to assume any changes EPA thought were necessary to make it understandable would have been included in EPA's "complete comments" to that draft, not that EPA would feel the need to make new revisions in the final BHHRA to text that it did not even comment on in the first draft.

The June 22nd letter marks a breakdown in the RI/FS process

The LWG has worked with EPA at the Portland Harbor Site for over 11 years. Although there have been disagreements, the overall tone of the working relationship has been positive. Up until now, the LWG has never formally invoked dispute resolution, preferring to work diligently and creatively with EPA's staff and management to ensure the process moves forward to the shared goal of implementing cleanups at the Site. Based on all of the work described above that had been done to resolve EPA's comments on the 2009 version of the BHHRA, and EPA's representations to the LWG over the last several months that its comments would be clarifying in nature, the LWG was surprised and disappointed in the nature of EPA's June 22 letter.

EPA's June 22 letter is an indication of a breakdown in the process. Both sides reasonably expect that if meetings are conducted and resolutions are agreed to in writing, those agreements will be honored, even if key representatives who participated in the meetings and wrote the resolutions are no longer working on the project. If EPA subsequently had questions or concerns about how comments were resolved, they should have been raised at an early point in the process, not as an unsupported assertion of noncompliance and a threat of stipulated penalties at this late date.

The cleanup and monitoring process at this Site will likely occur over an extended period of time, certainly much longer than the 11 years already spent on the RI/FS. It is reasonable to assume that new staff, managers, and representatives will be assigned to the project for EPA, its

[10] None of these 25 comments requested or directed deletion of the executive summary. *See*, July 16, 2010 EPA comments on the BHHRA, pp. 11-19 (at Tab 8).

partners, and the PRPs. The parties need to work well together to manage the inevitable disagreements that will arise on technical and legal issues. All parties involved in the cleanup process, including the members of the LWG, the dozens of additional parties that may participate in Consent Decree(s) negotiations, EPA, and EPA's partners need to have a reasonable assurance that every party will act in good faith and not renege on or disregard written resolutions of issues and disagreements.

EPA is likely aware that its assertion of noncompliance has generated several stories in the media. The LWG is serious about its responsibility to provide an RI/FS that is consistent with the National Contingency Plan and EPA national guidance, in compliance with the Consent Order, and that will support a cleanup at the Site that will protect public health and the environment. The fact that EPA's assertion of deficiencies and noncompliance is now a public issue is a significant concern to all of the members of the LWG. Rather than misstating the LWG's performance in public, the LWG strongly urges that EPA reconsider its position on the BHHRA and retract its letter. If EPA does have remaining issues or questions on the BHHRA, it should discuss and resolve those issues and questions with the LWG in accordance with the working relationship we have had to date with EPA.

EPA should retract its June 22 and June 29 letters and the directed revisions to the BHHRA

In summary, EPA's June 22 and 29 letters fail to demonstrate that the LWG has not complied with the Consent Order. EPA should retract the letters and their allegations of non-compliance immediately. EPA's directed revisions to the BHHRA are without factual support, an unexplained reversal of prior agency positions and agreements, are arbitrary and capricious, and represent a breakdown in the RI/FS process, and should be retracted as well.

Sincerely,

The Lower Willamette Group

Enclosures: Table 1: Deficiencies Identified by EPA in its June 22, 2012 Cover Letter
Table 2: General Categories of LWG Objections to the EPA June 22, 2012 Revisions
Table of Contents of Supporting Documentation
Supporting Documentation (on CD)

cc: Lori Cora, EPA Region 10 (via Federal Express)
Confederated Tribes and Bands of the Yakama Nation (via EPA Shared Server)
Confederated Tribes of the Grand Ronde Community of Oregon (via EPA Shared Server)
Confederated Tribes of Siletz Indians of Oregon (via EPA Shared Server)
Confederated Tribes of the Umatilla Indian Reservation (via EPA Shared Server)

Confederated Tribes of the Warm Springs Reservation of Oregon (via EPA Shared Server)
Nez Perce Tribe (via EPA Shared Server)
Oregon Department of Fish & Wildlife (via EPA Shared Server)
United States Fish & Wildlife (via EPA Shared Server)
Oregon Department of Environmental Quality (via EPA Shared Server)
LWG Legal
LWG Repository

Table 1: Deficiencies identified by EPA in its June 22, 2012 Cover Letter:

Issue Number	Deficiency	April 23, 2004 Programmatic Work Plan	EPA Comment on 2009 Draft BHHRA	LWG/EPA Comment Resolution	May 2, 2011 Draft Final BHHRA (redline)	EPA June 22, 2012 Revised BHHRA
1	*"The discussion of the process used to evaluate risks to humans and the conclusions were not clearly presented and, in fact, there were several instances of incorrect or misleading information. For example, the BHHRA repeatedly stated that the exposure assessment assumed someone ate fish every day of the year for 30 years.* *The LWG is fully aware that such a statement is not accurate. Consumption rates are average lifetime intake doses mathematically averaged to give an average daily rate. EPA commented on this issue in our February 9, 2010 comment letter[1]; however, the LWG failed to address it.*"	This issue was not raised by EPA during development and finalization of the Programmatic Work Plan.	On July 16, 2010, EPA provided five specific comments on text in the BHHRA (**comments S91, S96, S143, S150, and S179, discussed below as 1.a through 1.d**). EPA identified only two of these comments as a "directed change."	LWG agreed to revise all text as requested.	All text revised or deleted as requested. One instance (§6.2.5.3) of this "every day of every year" formulation of the fish consumption rate was carried through into the May 2011 draft as an oversight. EPA did not comment on this specific sentence in the 2009 draft.	
1a			July 16, 2010, **comment S91** (revise): §5.2.5, pp. 86-91: "When discussing fish consumption in the Uncertainty Section, revise the text as indicated: *"Fish consumption was assumed to occur at this level every day of every year for 70 years (or 30 years)."* Fish ingestion rates are annually amortized based on the estimated number of fish meals per month and typical serving sizes. This rate does not imply that fish is ingested every day. In fact, all ingestion for a given rate could in theory occur over a few to several months, with no fish consumption for the rest of the year. In addition, such patterns could change over the course of 30 years, and greater fish consumption could occur in some years and less in others. The assumption is that over the course of 30 years, individual fish ingestion rates don't change substantively. This comment also applies to the discussion regarding consumption of shellfish on page 91.	LWG November 18, 2010 *General Responses to EPA's Non-Directive Comment Key Issues on the BHHRA*: "The BHHRA will be revised consistent with the comment."	Text modified consistent with the comment resolution.	
1b			July 16, 2010, **comment S96 b** (directed change): §5.2.6, pp. 91-92: "Uncertainties should be discussed in Section 7, Uncertainty Analysis. Move the last paragraph in this section to the uncertainty section Modify the following sentence: "*The shellfish consumption scenario assumes the same ingestion rate every day*	LWG September 15, 2010 *General Responses to Directed Comments on BHHRA*: "As discussed at the September 9 meeting, the BHHRA will be revised per these directed changes."	Text modified consistent with the comment resolution.	

[1] Note that EPA's February 9, 2010 letter does <u>not</u> discuss this issue; EPA's comments on average consumption rates are found in the July 16, 2010 BHHRA Specific Comments table.

Table 1: Deficiencies identified by EPA in its June 22, 2012 Cover Letter:

Issue Number	Deficiency	April 23, 2004 Programmatic Work Plan	EPA Comment on 2009 Draft BHHRA	LWG/EPA Comment Resolution	May 2, 2011 Draft Final BHHRA (redline)	EPA June 22, 2012 Revised BHHRA
			of every year for 30 years." to note that, as stated in the comments above on fish consumption, shellfish consumption rates are annually amortized based on the estimated number of shellfish meals per month and typical serving sizes. This rate does not imply that the same amount of fish is consumed every day."			
1c			July 16, 2010, **comment S143,** §7.2.5.3, p. 121 (issue): Delete or modify this sentence as shown: "In addition to the uncertainties behind the rates of fish consumption, it was assumed that the frequency of consumption occurred at the same ingestion rate every day of every year for 30 years for the adult fisher scenarios." The reference to consuming fish or shellfish "every day of the year" is misleading, as the values for ingestion of fish and shellfish represent annualized rates. For example, the rate of 17.5 g/day is equivalent to two 8-oz meals per month. Using a daily rate is a method to simplify the risk calculations, and does not imply that fish and shellfish are consumed on a daily basis.	See comment resolution in 1a above.	"In addition to the uncertainties behind the rates of fish consumption, it was assumed that the frequency of consumption occurred at the same ingestion rate ~~every day of every year~~ for 30 years for the adult fisher scenarios."	
1d			July 16, 2010, **comment S150**, §7.2.5.3, p. 123 (directed change): Delete or revise the following sentence to clearly note that daily consumption rates represent mathematical artifacts to account for annual rates: *"Shellfish consumption was assumed to occur at the same rate every day of every year for 30 years."*	See comment resolution in 1b above.	~~"Shellfish consumption was assumed to occur at the same rate every day of every year for 30 years.~~ Daily shellfish consumption rates used in this BHHRA represent mathematical artifacts to account for annual consumption rates. The daily consumption rates for shellfish represent approximately two and a half 8-ounce meals per month (18 g/day ingestion rate), and just less than one 8-ounce meal every two months (3.3 g/day ingestion rate)."	
1e			July 16, 2010, **comment S179**, §8.1.1.1, pp. 138-139 (revise): Delete or revise the text in the third sentence and in all subsequent text in this section and Section 8.1.1.2 as indicated: *"Fish consumption was assumed to occur at the same ingestion rate, every day of every year"* The reference to consuming fish or shellfish "every day of the year" is misleading in that the fish and shellfish ingestion rates represent annual rates converted to average daily rates.	See comment resolution in 1a above.	"Fish consumption was assumed to occur at the same ingestion rate ~~, every day of every year,~~ for 30 years for an adult and for 6 years for a child." "Shellfish consumption was assumed to occur at the same ingestion rate~~, every day of every year,~~ for 30 years."	
2a	*"There were several instances where the BHHRA does not fully reflect EPA's directions for change, directions given years before and reiterated in our comments to previous versions.*	§3.4.3.1, p. 25-26. "Replicate composite samples were collected for each fishing zone for carp, crappie, and bullhead and at three of the eight river mile stations for bass. The replicate composite samples will be averaged	July 16, 2010, **comment S52** §3.4, p. 31 (clarify): "In this section and subsequently throughout the risk assessment, replace the term "95% UCL/max EPC" with "RME EPC." The repeated references to a "mean" EPC relative to one based on a 95 percent UCL	LWG November 18, 2010 *General Responses to EPA's Non-Directive Comment Key Issues on the BHHRA*: "The EPCs will be described in a factual manner in the BHHRA (i.e., the EPC will be identified as the mean, 95% UCL, or	Revised text §3.4. "~~The EPCs used in this BHHRA incorporate CT and RME methods, consistent with EPA guidance. Because the RME scenarios in this BHHRA use either the maximum detected concentration or the 95% upper confidence limit (95% UCL) on the~~	"EPCs for RME evaluations represent either the 95 percent UCL, or the maximum detected value when either there was insufficient data to calculate a UCL or the calculated UCL was greater than the maximum reported

Table 1: Deficiencies identified by EPA in its June 22, 2012 Cover Letter:

Issue Number	Deficiency	April 23, 2004 Programmatic Work Plan	EPA Comment on 2009 Draft BHHRA	LWG/EPA Comment Resolution	May 2, 2011 Draft Final BHHRA (redline)	EPA June 22, 2012 Revised BHHRA
	For example, EPA's February 2010[2] comment on Section 3.4, page 31 was: *"In this section and subsequently throughout the risk assessment, replace the term "95% UCL/max EPC" with "RME EPC." The repeated references to a "mean"* *EPC relative to one based on a 95 percent UCL or maximum concentration is misleading. The text in the second paragraph incorrectly states that exposure point concentrations would be calculated differently for central tendency (CTE) and reasonable maximum (RME) exposures. Consistent with EPA guidance (1992,2000), the EPC should represent an estimate of the arithmetic average concentration for a contaminant based on a set of site sampling data. Because of the uncertainty associated with estimating the true average concentration at a site, the 95 percent UCL of the arithmetic mean should be used for this variable. The 95 percent UCL provides reasonable confidence that the true site average will not be underestimated. The average concentration, defined as the 95 percent UCL, should be used for both CTE and RME evaluations. The RME evaluation should be distinguished from CTE by accounting for variability in such variables as exposure frequency and intake rates."* *However, the LWG did not make the change, claiming that the EPCs were described in a factual manner. Use of the term 95% UCL/Max Scenario is incorrect and needs to be changed throughout the document. RME*	and the arithmetic mean concentrations will be used as EPCs for individual sampling locations. To address potential variation in tissue concentrations, the maximum composite results for each fishing zone and at the three river mile segments will also be used as EPCs for individual sampling locations. The uncertainty associated with using the average and maximum concentrations as EPCs will be discussed in the risk assessment. At the one-mile river mile stations where replicate composite samples were not collected for bass, the results of the single composite sample will be used as EPCs for these stations. Site-wide tissue EPCs will also be estimated using mean concentrations and 95 percent upper confidence limit (UCL) on the average or maximum composite results. Where sufficient data are available, the 95% UCLs will be calculated using an approach agreed to by the LWG and EPA and its partners, and the 95% UCLs will be used as site-wide EPCs. If sufficient data are not available, the maximum composite results will be used as site-wide EPCs. In addition, the arithmetic mean of individual sampling location EPCs will be used as site-wide EPCs."	or maximum concentration is misleading. The text in the second paragraph incorrectly states that exposure point concentrations would be calculated differently for central tendency (CTE) and reasonable maximum (RME) exposures. Consistent with EPA guidance (1992, 2000), the EPC should represent an estimate of the arithmetic average concentration for a contaminant based on a set of site sampling data. Because of the uncertainty associated with estimating the true average concentration at a site, the 95 percent UCL of the arithmetic mean should be used for this variable. The 95 percent UCL provides reasonable confidence that the true site average will not be underestimated. The average concentration, defined as the 95 percent UCL, should be used for both CTE and RME evaluations. The RME evaluation should be distinguished from CTE by accounting for variability in such variables as exposure frequency and intake rates."	maximum). The terms RME and CT will not be used in reference to the EPCs." "EPA will not require the addition of beach user exposure to groundwater seeps, use of the 95% UCL/maximum concentration for all exposure scenarios, or new child receptors." EPA December 8, 2010 *EPA General Responses to EPA Non-Directed RI, BHHRA and BERA Comments*: "EPA has reviewed the LWG responses, as summarized in the tables, and has determined that the vast majority of issues associated with addressing EPA's comments have been resolved. However, there were three comments for which the LWG did not agree to make the specified changes." Includes three unrelated comments and additional unrelated clarifications.	~~arithmetic mean as the EPC for an exposure area, this BHHRA uses the term "95% UCL/max" to reference RME EPCs, and "mean" to reference CT EPCs.~~ EPCs were calculated for the 95% upper confidence limit on the arithmetic mean (95% UCL) and the arithmetic mean for each exposure area. In some exposure areas, the maximum concentration was used instead of the 95% UCL. Therefore, the EPCs are referred to as the 95% UCL/max and mean throughout this BHHRA."	value. Although inconsistent with EPA guidance (EPA 1992), EPCs for sediment and surface water CT evaluations were calculated as the simple arithmetic mean. EPCs for fish/shellfish consumption scenarios are the lesser of the 95 percent UCL or the maximum detected concentration, central tendency evaluations were achieved by using mean or median consumption rates."

[2] See note 1.

Table 1: Deficiencies identified by EPA in its June 22, 2012 Cover Letter:

Issue Number	Deficiency	April 23, 2004 Programmatic Work Plan	EPA Comment on 2009 Draft BHHRA	LWG/EPA Comment Resolution	May 2, 2011 Draft Final BHHRA (redline)	EPA June 22, 2012 Revised BHHRA
	and CT are not defined based solely on calculation of EPC. Actually, EPC should be the same for both the RME and CT. Since *the LWG used different EPCs for the RME and CT calculations, EPA is requiring the removal of the CT evaluations for the consumption scenarios in the BHHRA."*					
2b	"*Further, reference to RME and CT in the BHHRA were not consistent with those agreed to in the Programmatic Work Plan. EPA has modified the BHHRA to reflect those agreements and adequately describe the RME and CT."*	§3.4.3, p. 25. "The fish consumption evaluation will be based on a range of fish consumption rates. Because these consumption rates will not be designated as representing either RME or CT exposures, the EPCs for tissue will not be developed specifically for RME or CT scenarios." §3.5.1.4, p. 32. "Site-specific fish consumption information is not available for the recreational fisher or high consumption non-tribal fisher scenarios. Therefore, to evaluate the potential range in consumption patterns that may exist for these receptors, 3 ingestion rates will be used to calculate intakes for adults and 3 will be used for children. For adults, the fish ingestion rates that will be used in the HHRA are 17.5 grams per day (g/day), 73 g/day, and 142 g/day. The corresponding rates that will be used for children are 7 g/day, 31 g/day, and 60 g/day. These ingestion rates are anticipated to represent average to high end ranges of fish consumption for these receptors."	There were 10 comments provided on July 16, 2010 that requested or directed revisions to text describing the fish consumption scenarios. None of those comments referenced RME or CT scenarios. For example, July 16, 2010, **comment G1** (directed change): "The draft Portland Harbor Baseline Human Health Risk Assessment (BHHRA) includes numerous statements regarding the fish consumption rates used to evaluate the risks to human health. The three primary non-tribal fish ingestion rates used in the draft BHHRA are characterized as high (17.5 grams per day [g/day]), higher (73 g/day), and highest (142 g/day). EPA disagrees with this characterization, believes them to be misleading, and believes that significantly higher ingestion rates may be appropriate to represent different local and ethnic populations that rely on fishing as part of their culture and/or as a substantial food source. As such, the three ingestion rates presented in the BHHRA should be characterized as low, moderate, and high. The rate of 17.5 g/day (equivalent to two 8-ounce meals per month) is based on the 90th percentile rate for uncooked freshwater and estuarine finfish and shellfish for individuals (consumers and non-consumers) of age 18 and over in the United States (EPA 2002b, data from USDA CSFII Study). The 90th percentile for fish consumers only from this USDA study is much higher, at 200 g/day. EPA uses the 17.5 g/day rate to approximate a fish-consuming population that does not include tribal or subsistence fishers. It is not an unreasonable rate, and should not be referred to as a high ingestion rate, but rather as a low ingestion rate. A non-tribal adult fish consumption rate of 73 g/day was used in this risk assessment based on data from the Columbia Slough. The possible uncertainties associated with the consumption rates derived from this study are appropriately discussed in the	LWG September 15, 2010 *General Responses to Directed Comments on BHHRA*: "As discussed at the September 9th meeting, ingestion rates will be presented in the revised BHHRA as the numeric rates (i.e., grams per day or meals per month) and the source of the rates will be presented, consistent with the text in the Programmatic Work Plan. Characterization or descriptors of the ingestion rate (e.g., "low", "high") will not be included in the revised BHHRA." EPA September 22, 2010 *EPA General Responses to EPA Directed BHHRA and BERA Comments*: "EPA has reviewed the September 15, 2010 letter and attachments and agrees, with clarifications, that EPA's directed comments on the BERA and BHHRA should be revised in accordance with the general framework, and that the proposed resolution described in LWG's general responses matches our understanding of the meeting outcome." Includes three unrelated clarifications.	Revised text in §3.5.1.5.3: "The fish consumption scenario included three different fish ingestion rates, as well as single species and multiple species diets of resident fish species. Study Area-specific fish consumption information is not available for the fish consumption scenarios. Therefore, to evaluate the potential range in consumption patterns that may exist, three ~~high end~~ ingestion rates were used to calculate intakes for adults and three were used for children. EPA specified the ingestion rates used in this BHHRA. For adults, the fish ingestion rates were 17.5 grams per day (g/day), 73 g/day, and 142 g/day. These rates correspond to approximately 2 meals per month, 10 meals per month, and 19 meals per month, based on an 8-ounce serving size, every month of the year, consisting exclusively of fish caught within the Study Area. It should be noted that the current fish consumption advisory, based on PCBs, for the LWR recommends that children and expectant mothers do not eat resident fish from the Portland Harbor, and that healthy adults eat no more than one 8-ounce meal per month of resident fish from the Portland Harbor (ODHS 2007). However, it is unclear to what extent this advisory is followed by people who consume fish from the Study Area."	"No studies were located that document specific consumption rates of recreational or subsistence anglers in Portland Harbor prior to its listing as a Superfund site. Surveys conducted subsequent to the listing would not be representative of historical, baseline consumption patterns due to subsequent fish advisories and efforts to limit consumption of fish caught from the harbor. Therefore, fish consumption rates from published studies were used to describe the range of reasonably expected exposures relevant to the different populations known to occur in the Portland Harbor area. Three different rates were evaluated: 17.5 grams per day (approximately 2 eight ounce meals per month), 73 g/ day (10 eight ounce meals per month), and 142 g/day per day (19 eight ounce meals per month). The term "recreational fishers" is intended to encompass a range of the population while focusing on those who may fish on a more-or-less regular basis, and "subsistence fishers" to represent populations with high fish consumption rates, recognizing that fish are not an exclusive source of protein in their diet. Accordingly, 17.5 g/day is considered representative of a CT value for recreational fishers, and 73 g/day was selected as the RME value representing the higher-end consumption practices of recreational fishers. The consumption rate of 142 g/day represents a RME value for high fish consuming, or subsistence, fishers. No CT value was selected because the evaluations based on 17.5 g/day and 73 g/day inform the risks associated with lower consumption rates. Consumption rates for children aged 6 years and younger were calculated by assuming that their rate of fish consumption is

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			BHHRA. The BHHRA discussion and the data from the USDA study support use of a fish consumption value of 73 g/day as moderate consumption rate, not a higher consumption rate. The rate of 142 g/day used as the highest rate for non-tribal fishers in the draft BHHRA is the 99th percentile for consumers and non-consumers from the same USDA study; the consumption rate for consumers only from this study is 506 g/day. The ingestion rate of 142 g/day is used by EPA in developing Ambient Water Quality Criteria (AWQC) for consumers who obtain much of their daily protein from fish. The consumption rate of 142 g/person/day was selected in the BHHRA to represent high-frequency, non-tribal fishers, and represents an appropriate "high" ingestion rate for the Portland Harbor (PH) risk assessment." See also July 16, 2010, **comments S49, S63, S64, S93, S94, S98, S101, S138, and S140**			approximately 42 percent of an adult, based on the ratio of child-to-adult consumption rates presented in the CRITFC Fish Consumption Survey (CRITFC 1994). The corresponding rates that were used for children are 7 g/day, 31 g/day, and 60 g/day."
3	"*There were many instances in the BHHRA where the only explanation the LWG provides for why something is done was that EPA directed or otherwise required it be done. While it may be true EPA directed changes, the LWG is fully aware of the technical basis for the direction and should have included such technical basis in the report. The LWG's failure to fully explain the basis for how the risk assessment was done is not consistent with EPA guidance nor is the report complete and transparent without it. Therefore, EPA had to modify the report to provide the rational for the directions in the text of the BHHRA for clarity and relevance for the assessment.*"	This issue was not raised by EPA during development and finalization of the Programmatic Work Plan.	EPA did not provide any comments on the 2009 Draft BHHRA indicating that the rationale for EPA's directions needed to be provided. Several of the July 16, 2010 comments request or direct deletion of specific text indicating that an assumption or evaluation was directed or required by EPA. For example, **comment S125**, §7.2.3, p. 115 (directed change): Delete the following sentences: ~~*"As required by EPA Region 10, this BHHRA included exposure scenarios that are not well documented, so it is unknown to what extent exposures currently occur, if at all, within the Study Area. In addition, this BHHRA evaluated risks associated with a hypothetical future scenario, which is not anticipated to reasonably occur in the future based on current information for the Study Area. The uncertainties associated with these potential and hypothetical exposure scenarios are discussed in the following subsections."*~~ Consistent with EPA Superfund guidance, EPA and its partners chose only those scenarios that are reasonably anticipated to occur and are consistent with current statutory or regulatory requirements (e.g. designated beneficial use of the river as a source for drinking water).	LWG September 15, 2010 *General Responses to Directed Comments on BHHRA*: "The LWG disagrees with EPA's directed changes requiring the deletion of references to prior EPA direction from the draft BHHRA. As discussed at the August 20th and September 9th meetings, language stating that evaluations were done at the direction of EPA can remain in the revised BHHRA. Language implying opinion or judgment about the prudence of that direction will be removed." EPA September 22, 2010 *EPA General Responses to EPA Directed BHHRA and BERA Comments*: "EPA has reviewed the September 15, 2010 letter and attachments and agrees, with clarifications, that EPA's directed comments on the BERA and BHHRA should be revised in accordance with the general framework, and that the proposed resolution described in LWG's general responses matches our understanding of the meeting outcome." Includes three unrelated clarifications.	Revised text in §7.2.3 (now §6.2.3): "Some of the exposure scenarios evaluated in this BHHRA have limited documentation regarding the actual extent of exposure to receptors in the Portland Harbor. These scenarios were included in this BHHRA at the direction of EPA Region 10. The uncertainties associated with these scenarios are discussed in the following subsections. ~~As required by EPA Region 10, this BHHRA included exposure scenarios that are not well documented, so it is unknown to what extent exposures currently occur, if at all, within the Study Area. In addition, this BHHRA evaluated risks associated with a hypothetical future scenario, which is not anticipated to reasonably occur in the future based on current information for the Study Area. The uncertainties associated with these potential and hypothetical exposure scenarios are discussed in the following subsections.~~"	All references to EPA directing the use of specific scenarios, assumptions or evaluations in the BHHRA have been deleted. For example, the text addressed by EPA's June 16, 2010 **S125** (now §6.2.2), has been revised to read, "Some of the uncertainties associated with the exposure scenarios evaluated in the BHHRA are discussed in the following subsections."
4	*"Overall, the BHHRA did not present the process and information in a clear and*	This issue was not raised by EPA during development and finalization of the Programmatic Work Plan.	EPA did not provide any comments on the 2009 Draft BHHRA indicating that the process or information was not presented in			This is a new comment from EPA, and is reflected in extensive text revisions throughout EPA's redline/strikeout

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	transparent manner that would allow anyone outside those intimately involved in the development of this assessment to follow and understand. Thus, EPA had to extensively modify the report to make the report understandable to the general public."		a clear and transparent manner. Note EPA December 23, 2009 *Preliminary Comments on the Baseline Human Health and Ecological Risk Assessments*: "Overall, most of the procedures followed in the BHHRA and BERA are consistent with and followed the procedures agreed upon by EPA and the LWG for completing the baseline risk assessments." See also, EPA July 16, 2010 *EPA Comments on Portland Harbor draft Remedial Investigation Report*: "EPA has attempted to provide clear direction on the specific revisions that are needed to resolve the comments" on the baseline risk assessments.			edits.

Table 2: General categories of LWG objections to the EPA June 22, 2012 revisions[1]:

Issue Number	Basis for LWG objection	April 23, 2004 Programmatic Work Plan	EPA Comment on 2009 Draft BHHRA	LWG/EPA Comment Resolution	May 2, 2011 Draft Final BHHRA (redline)	EPA June 22, 2012 Revised BHHRA
1a	**The LWG objects to EPA's revisions that delete factual information regarding clam consumption because these revisions are inconsistent with prior agreements between EPA and the LWG.**	This scenario was not included in the Programmatic Work Plan. The scenario was added to the BHHRA per EPA's Identification of Round 3 Data Gaps (December 2, 2005).	July 16, 2010, **comment G2** (note): "The fact that collection of *Corbicula* is illegal is relevant but not particularly important for the pathway in general. Indications are that *Corbicula* are being collected and consumed to some extent (e.g., from the Linnton Community Center's discussion with transients). It is reasonable to assume that bivalve consumption is a current and potential future exposure pathway and that future biomass would increase. Therefore, the low clam mass that may limit current bivalve consumption does not apply to future exposure."	LWG September 15, 2010 *General Responses to Directed Comments on BHHRA*: "As discussed at the August 20th and September 9th meetings, the clam consumption scenario can be factually discussed in the revised BHHRA. Language regarding the evaluation of shellfish consumption at the direction of EPA and that the harvest and possession of Asian clams is illegal can remain in the revised BHHRA. Information from the Linnton study will be cited as such. Language implying opinion or judgment about the clam consumption scenario will not be included in the revised BHHRA." EPA September 22, 2010 *EPA General Responses to EPA Directed BHHRA and BERA Comments*: "EPA has reviewed the September 15, 2010 letter and attachments and agrees, with clarifications, that EPA's directed comments on the BERA and BHHRA should be revised in accordance with the general framework, and that the proposed resolution described in LWG's general responses matches our understanding of the meeting outcome." Includes three unrelated clarifications.	Text modified consistent with the comment resolution and related specific comments listed below.	EPA deleted or modified text that was specifically agreed-upon in the 2010 comment resolution process.
1b			EPA's comments on the 2009 Draft BHHRA did not include comments on §3.3.6.		Text in §3.3.6. "Like fish, shellfish may bioaccumulate certain chemicals in their tissue. Populations that consume shellfish may be exposed to COPCs that accumulate in the shellfish tissue. In the Programmatic Work Plan, crayfish was identified as the species to use to evaluate shellfish consumption. Additionally, as required by EPA, consumption of clams is also evaluated in this BHHRA. Harvest and possession of Asian clams, which is the clam species that was found in the LWR during sampling events, is illegal in the State of Oregon because Asian clams are on the prohibited species list of the ODFW rules regarding the importation, possession, confinement, transportation and sale of nonnative wildlife (OAR 635–056–0050)."	"Certain contaminants can bioaccumulate in shellfish, and populations may be exposed to COPCs through consumption of shellfish that are collected within the Study Area."
1c			July 16, 2010, **comment S51** §3.3.6.1, p. 40 (revise): "The language in this section should be deleted and replaced with the following text: *"Although the extent of shellfish consumption in the lower Willamette River is not known, information regarding the consumption of shellfish in the lower Willamette River is available. The Oregon Office of Environmental Public Health, Department of Health Services (DHS) had*	LWG November 18, 2010 *General Responses to EPA's Non-Directive Comment Key Issues on the BHHRA*: "This issue was addressed in the responses to EPA's Directive Comments." EPA December 8, 2010 *EPA General Responses to EPA Non-Directed RI, BHHRA and BERA Comments*: "EPA	Revised text in §3.3.6.1. "In theory, shellfish consumption could occur throughout the Study Area wherever shellfish are found. However, it is not known to what extent shellfish consumption occurs~~, as there is no documentation of ongoing shellfish consumption by humans occurring in the Study Area~~. The Linnton Community Center project (Wagner 2004) reported that some transients	"Certain contaminants can bioaccumulate in shellfish, and populations may be exposed to COPCs through consumption of shellfish that are collected within the Study Area. The actual extent shellfish harvesting and consumption is presently occurring is not known. The Linnton Community Center project (Wagner 2004) reported that some transients reported eating clams and

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			previously received information from ODFW indicating that an average of 4300 lbs of crayfish were commercially harvested from the portion of the Willamette River within Multnomah County each of the 5 years from 1997-2001. Most of this catch was sold to the Pacific Seafood Company of Oregon. DHS also has information from local commercial crayfish harvesters indicating that Europe is a major portion of their market. Furthermore, as part of the McCormick and Baxter assessment in 1991, Ken Kauffman at DHS talked with the wife of a licensed commercial crayfish harvester who served (at that time) as the secretary-treasurer of the Oregon Crayfish Association. She indicated that the area around McCormick and Baxter was a very productive Cray fishery and that she and her husband had harvested there prior to the advisory on many occasions. *"In addition to this historical commercial crayfish harvesting information in the Lower Willamette, DHS also occasionally receives calls from citizens interested in harvesting crayfish from local waters who are interested in fish advisory information. Between 2001 and 2007, DHS fielded 8 calls from citizens who reported catching and eating crayfish from Portland-area waters, although only one was specifically from the Study Are). It is not known what percent of individuals who catch and eat crayfish contact DHS to ask for fish advisory information. DHS estimates that for each person who contacts them regarding the safety of consuming crayfish from the Lower Willamette, there are many more that catch and consume the animals without contacting DHS* *"Although the collection of Corbicula is illegal, this is not particularly important for the pathway in general. There are indications that Corbicula are being collected and consumed (e.g., from the Linnton Community Center's discussion with transients). It is reasonable to assume that bivalve consumption is a current and possible future exposure pathway and that future biomass would increase.""*	has reviewed the LWG responses, as summarized in the tables, and has determined that the vast majority of issues associated with addressing EPA's comments have been resolved. However, there were three comments for which the LWG did not agree to make the specified changes." Includes three unrelated comments and additional unrelated clarifications.	reported eating clams and crayfish; however, many of the individuals indicated that they were in the area temporarily, move from location to location frequently, or have variable diets based on what is easily available. The Superfund Health Investigation and Education (SHINE) program in the Oregon Department of Human Services (DHS) stated that is unknown whether or not crayfish are harvested commercially within Portland Harbor (ATSDR 2006). ~~In addition,~~ ODFW has records for crayfish collection in the Columbia and Willamette Rivers, but these records do not indicate whether the collection actually occurs within the Study Area. Based on ODFW's data for 2005 to 2007, no commercial crayfish landings were reported for the Willamette River in Multnomah County. DHS had previously received information from ODFW indicating that an average of 4300 pounds of crayfish were harvested commercially from the portion of the Willamette River within Multnomah County each of the five years from 1997-2001. In addition to this historical commercial crayfish harvesting, DHS occasionally receives calls from citizens who are interested in harvesting crayfish from local waters who are interested in fish advisory information. According to a member of the Oregon Bass and Panfish club, crayfish traps are placed in the Portland Harbor Superfund Site boundaries and collected for bait and possibly consumption (ATSDR 2006). Even if collection does occur within the Study Area, it is not known whether those crayfish are consumed by humans or used as bait."	crayfish, although many of the individuals indicated that they were in the area temporarily, move from location to location frequently, or have variable diets based on what is easily available. The Superfund Health Investigation and Education (SHINE) program in the Oregon Department of Human Services (DHS) stated that is unknown whether or not crayfish are harvested commercially within Portland Harbor (ATSDR 2006). ODFW has records for crayfish collection in the Columbia and Willamette Rivers, but these records do not indicate whether the collection actually occurs within the Study Area. Based on ODFW's data for 2005 to 2007, no commercial crayfish landings were reported for the Willamette River in Multnomah County. DHS had previously received information from ODFW indicating that an average of 4,300 pounds of crayfish were harvested commercially from the portion of the Willamette River within Multnomah County each of the five years from 1997-2001. In addition, DHS occasionally receives calls from citizens who are interested in harvesting crayfish from local waters and are interested in fish advisory information. According to a member of the Oregon Bass and Panfish club, traps are placed in the Portland Harbor Superfund Site boundaries and crayfish collected for bait and possibly for consumption (ATSDR 2006). Although consumption of shellfish was considered a potentially complete pathway for dockside workers, in-water workers, recreational beach users, divers, and recreational fishers, it was quantitatively evaluated only for subsistence fishers, as they were considered the most likely population to regularly harvest and consume shellfish."
1d			July 16, 2010, **comment S96** §5.2.6, pp. 91-92 (b) (directed change): "When consumption of shellfish is discussed in the Uncertainty Section, the following phrase should be deleted: "*despite the fact that there is no documented ongoing consumption of shellfish in the Study Area and the harvest*	See comment resolution in 1a above.	Deleted text from §5.2.6, p. 121. "~~despite the fact that there is no documented ongoing consumption of shellfish in the Study Area and the harvest or possession of Asian clams, the species assessed in the BHHRA, is illegal.~~"	

Table 2: General categories of LWG objections to the EPA June 22, 2012 revisions[1]:

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			or possession of Asian clams, the species assessed in the BHHRA, is illegal.""			
1e			July 16, 2010, **comment S126** §7.2.3.1, pp. 115-116 (directed change): The following sentence in the first paragraph should be deleted: "~~*However, there is no documentation of ongoing shellfish consumption by humans occurring in the Study Area, and the harvest or possession of Asian clams, which is the species assessed in this BHHRA, is illegal*~~."	See comment resolution in 1a above.	Revised text in §7.2.3.1 (now §6.2.3.2): "This BHHRA evaluated risks from shellfish consumption based on crayfish and clam tissue data. However, ~~there is no documentation of ongoing shellfish consumption by humans occurring in the Study Area, and~~ the harvest or possession of Asian clams, which is the species assessed in this BHHRA, is illegal."	All text deleted.
1f			July 16, 2010, **comment S147** §7.2.5.3, p. 122 (directed change): "Revise the text in the second paragraph following the bulleted list as indicated: "*However, it is not known to what extent shellfish consumption occurs~~, as there is no documentation of ongoing shellfish consumption by humans occurring in the Study Area~~*.""	See comment resolution in 1a above.	Revised text in §7.2.5.3 (now §6.2.5.3): "The information suggesting that shellfish consumption may occur at the Study Area comes from a community project sponsored by the Linnton Community Center, as discussed in Section 3.3.6. However, it is not known to what extent shellfish consumption occurs~~, as there is no documentation of ongoing shellfish consumption by humans occurring in the Study Area~~."	"Information regarding consumption of shellfish from the Study Area relies in part from information obtained from a community project sponsored by the Linnton Community Center, as discussed in Section 3.3.6. However, it is not known to what extent shellfish consumption actually occurs."
1g			July 16, 2010, **comment S182** §8.1.1.2, p. 139 (revise): "Revise the first sentence as follows: "~~*It is not known to what extent*~~ *Current and potential future shellfish consumption rates for the site are not known.* ~~*actually occurs, and there is no documentation of ongoing shellfish consumption by humans occurring in the Study Area.*~~""	See comment resolution in 1c above.	Revised text in §8.1.1.2 (now §7.1.1.2): "~~It is not known to what extent shellfish consumption actually occurs, and there is no documentation of ongoing shellfish consumption by humans occurring in the Study Area.~~ Current and potential future shellfish consumption rates for the site are not known."	Section deleted.
2a	**The LWG objects to EPA's revisions describing the drinking water scenario, including deleting the term "hypothetical", because these revisions are inconsistent with prior agreements between EPA and the LWG.**	This scenario was not included in the Programmatic Work Plan. The scenario was added to the BHHRA per EPA's Identification of Round 3 Data Gaps (December 2, 2005).	July 16, 2010, **comment G6** (directed change): "Much of the language in the draft BHHRA that discusses the Willamette River as a potential future drinking water source is inappropriate. Under OAR 340-041-0340, Table 340A, domestic water supply is a designated beneficial use of the Willamette River, with adequate pretreatment. CERCLA sets out a mandate for remedies that are protective for both private and public users of surface water or groundwater. The Willamette River is potable and capable of serving as a potential drinking water source; thus, the expectation is that this resource will be protected and remediated to achieve such use (40 CFR 300.430(a)(1)(ii)(F)). This expectation is reflected in the current remedial action objectives and ARARs for the PH site and must be reflected in the HHRA for the site. Throughout the draft HHRA, where reference is made to the risk characterization done for potential future domestic use of surface water, much of the language will need to be deleted and/or modified to be consistent with the fact that surface water is potable and capable of serving as a potential drinking water source and that the expectation is that the resource	LWG September 15, 2010 *General Responses to Directed Comments on BHHRA*: "As discussed at the August 20th and September 9th meetings, the term "hypothetical" can be used when describing the use of the Lower Willamette River (LWR) as a domestic water source, as long as factual information is provided to support that characterization. Language regarding the designated beneficial use of the LWR and the need to protect the resource will be included in the revised BHHRA. Language regarding the need to remediate the resource will not be included. The following language is an example of how the scenario will be described in the revised BHHRA: "*Even though no current or future uses of the LWR within Portland Harbor as a domestic water source have been identified, as discussed above under OAR 340-041-0340 Table 340A, domestic water supply is a designated beneficial use of the Willamette River, with adequate pretreatment. Because the Willamette River is capable of serving as a potential drinking water*	Text modified consistent with the comment resolution and related specific comments listed below.	EPA deleted or modified text that was specifically agreed-upon in the 2010 comment resolution process.

Table 2: General categories of LWG objections to the EPA June 22, 2012 revisions[1]:

Issue Number	Basis for LWG objection	April 23, 2004 Programmatic Work Plan	EPA Comment on 2009 Draft BHHRA	LWG/EPA Comment Resolution	May 2, 2011 Draft Final BHHRA (redline)	EPA June 22, 2012 Revised BHHRA
			will be protected and remediated to achieve such use. EPA has provided comments on this inappropriate language which occurs throughout the draft BHHRA."	*source, the expectation is that this resource will be protected to achieve such use with adequate pretreatment.*"" EPA September 22, 2010 *EPA General Responses to EPA Directed BHHRA and BERA Comments*: "EPA has reviewed the September 15, 2010 letter and attachments and agrees, with clarifications, that EPA's directed comments on the BERA and BHHRA should be revised in accordance with the general framework, and that the proposed resolution described in LWG's general responses matches our understanding of the meeting outcome." Includes three unrelated clarifications.		
2b			July 16, 2010, **comment S36** §2.3.4, p. 26 (directed change): "Replace "Hypothetical" with "Potential" in the title for this section. 1st paragraph- Add the following sentence: *"Even though no current or future uses of the LWR within Portland Harbor as a domestic water source have been identified, as discussed above under OAR 340-041-0340 Table 340A, domestic water supply is a designated beneficial use of the Willamette River, with adequate pretreatment. Because the Willamette River is potable and capable of serving as a potential drinking water source, the expectation is that this resource will be protected and remediated to achieve such use (40 CFR 00.430(a)(1)(ii)(F)) under CERCLA.""*	See comment resolution in 2a above.	Revised text in §2.3.4. "Even though no current or future uses of the LWR within Portland Harbor as a domestic water source have been identified, under OAR 340-041-0340 Table 340A, domestic water supply is a designated beneficial use of the Willamette River, with adequate pretreatment. Because the Willamette River is capable of serving as a potential drinking water source, the expectation is that this resource will be protected to achieve such use with adequate pretreatment. Although surface water within the Study Area is not currently used as a domestic water source, nor are there future plans for domestic water use within the Study Area, surface water data were quantitatively evaluated in the BHHRA as a hypothetical future domestic water source at the direction of EPA (see Section 2.4.5 below). The same criteria and screening values used for data to assess direct contact with surface water and the groundwater seep were used to select COPCs for surface water as a hypothetical future domestic water source. As with the surface water and groundwater seep screening, the noncarcinogen RSLs were divided by 10 to account for potential multiplicative effects, and the modified RSLs were used as the screening values."	Section deleted.
2c			July 16, 2010, **comment S41** §2.4.5, pp. 29-30 (directed change): "Delete "Hypothetical" from the title and from the first and second sentences on page 30, The word "hypothetical" should be deleted throughout the BHHRA when referring to SW for domestic use. Note that "future" implies by itself something that is "hypothetical," "potential," "possible," etc. 1st Paragraph - As stated in General Comment 5, under OAR 340-041-0340, Table 340A, domestic water supply is a designated beneficial use of the Willamette	See comment resolution in 2a above.	Revised text in §2.4.5."There is no known current or anticipated future use of surface water within the Study Area for a drinking water supply. Even though no current or future uses of the LWR within Portland Harbor as a domestic water source have been identified, under OAR 340-041-0340 Table 340A, domestic water supply is a designated beneficial use of the Willamette River, with adequate pretreatment. Because the Willamette River is capable of serving as a potential drinking water source, the expectation is that this resource will be	Section deleted.

Table 2: General categories of LWG objections to the EPA June 22, 2012 revisions[1]:

Issue Number	Basis for LWG objection	April 23, 2004 Programmatic Work Plan	EPA Comment on 2009 Draft BHHRA	LWG/EPA Comment Resolution	May 2, 2011 Draft Final BHHRA (redline)	EPA June 22, 2012 Revised BHHRA
			River, with adequate pretreatment, and the surface water is potable and capable of serving as a potential drinking water source. Therefore, the first paragraph in this section should be deleted. Uncertainties associated with future use of surface water can be included in the Uncertainty section. Section 2.4.5 should also include a brief discussion of the sources of surface water contaminants. Although EPA agreed that "integrated data" could be used to select COPCs and develop EPCs for surface water as a drinking water source, it was assumed that surface water data from throughout the Portland Harbor site that could be integrated (i.e., by combining near bottom and near surface samples in a given location) would be used and that these data would be integrated as appropriate. Instead only surface water data from the river transects, Willamette Cove, Cathedral Park and the Shipyard were used. Water could be withdrawn from the river at any point for use as drinking water. Therefore, the COPC screening for this pathway should be revised using all appropriate data sets, including data from Round 3. See additional comments on Section 3.4.3.4."		protected to achieve such use with adequate pretreatment. Potential sources of contaminants to surface water are discussed in the RI. ~~Even in the unlikely event that surface water in the Study Area were to be used for a domestic water supply, which includes drinking and bathing, such use would be subject to requirements for adequate pretreatment in accordance with the Safe Drinking Water Act, and Oregon rules. However, for this BHHRA, EPA required assessment of domestic uses of untreated surface water from the Study Area.~~ Because future use of the LWR as a domestic water supply would require adequate pretreatment, the evaluation of untreated surface water as a drinking water source is designated a hypothetical scenario. The inclusion of the assessment of domestic use of untreated surface water from the Study Area was done at the direction of EPA."	
2d			July 16, 2010, **comment S43** §3.1, p. 31 (directed change): "The difference between a "potentially exposed" and "hypothetically exposed" population is not clear. In the first sentence here and throughout the risk assessment, delete the term "hypothetical" when discussing potential exposure pathways."	See comment resolution in 2a above.	No change to text.	"Potentially exposed populations were identified based on consideration of current and potential future uses of the Study Area."
2e			July 16, 2010, **comment S44** §3.2, p. 33 (directed change): "In the bulleted list continued from page 32, replace "Hypothetical domestic water use" with "residents" or a similar term. "Domestic water use" is an exposure pathway, not a current or potentially exposed concentration. In addition, The CSM in Figure 3-1 should delete "Hypothetical" for residential ingestion of surface water. As previously indicated, future is a sufficient caveat."	See comment resolution in 2a above.	Revised text in §2.4.5."~~Hypothetical d~~Domestic water user"	
2f			July 16, 2010, **comment S48** §3.3.3.4, p. 38 (directed change):" Delete "Hypothetical" in the title for this section. The text in this section should be modified to be consistent with the comments in General Comment 5 and on Section 2.4.5, as follows: *"As mentioned in Section 2.4.5, no known current ~~or anticipated future~~ use of surface water within the Study Area for a domestic*	See comment resolution in 2a above.	Title change: "~~Hypothetical Future~~ Domestic Water User" Revised text in §3.3.3.4. "As mentioned in Section 2.4.5, there is no known ~~or anticipated future~~ current use of surface water within the Study Area for a domestic water supply. ~~Due to a requirement by EPA~~ However, because domestic water use is a designated beneficial use of the Willamette River following adequate pretreatment, ~~river water,~~ the ~~hypothetical~~ use	Section deleted.

Table 2: General categories of LWG objections to the EPA June 22, 2012 revisions[1]:

Issue Number	Basis for LWG objection	April 23, 2004 Programmatic Work Plan	EPA Comment on 2009 Draft BHHRA	LWG/EPA Comment Resolution	May 2, 2011 Draft Final BHHRA (redline)	EPA June 22, 2012 Revised BHHRA
			water supply is known or planned. However, ~~Due to a requirement by EPA, the hypothetical~~ because domestic water use is a designated beneficial use of the Willamette River, ~~a use of untreated~~ river water as a domestic water source was assessed as a ~~hypothetical~~ future pathway for both adult and child residents, resulting in exposures through ingestion and dermal contact. In this scenario, exposure to surface water could ~~hypothetically~~ potentially occur throughout the Study Area.””		of untreated river water as a domestic water source was assessed as a hypothetical future pathway for both adult and child residents, at the direction of EPA.~~, resulting in exposures through ingestion and dermal contact.~~ In this scenario, exposure to untreated surface water could hypothetically occur from ingestion and dermal contact throughout the Study Area. At the direction of the EPA, volatilization of chemicals from untreated surface water to indoor air through household uses was identified as a potentially complete exposure pathway for hypothetical future domestic water use.”	
2g			July 16, 2010, **comment S56** §3.4.3.4, p. 48 (directed change): “Delete “Hypothetical” in the title for this section.”	See comment resolution in 2a above.	Title change: “~~Hypothetical Future~~ Domestic Water User”	
2h			July 16, 2010, **comment S68** §3.5.1.8, p. 59 (directed change): “Title - Replace “Hypothetical” with “Potential” in the title for this section. Change the word “hypothetical” to “potential” when referring to domestic water in this section and throughout the HHRA. Inhalation of contaminants from surface water should be included as a part of the scenario, unless it can be shown that this is not an issue for the surface water contaminants that are selected for evaluation in Section 6.”	See comment resolution in 2a above.	Title change: “~~Hypothetical~~ Domestic Water Users” Revised text in §3.5.1.8. “~~Although s~~ Surface water within the Study Area is not currently used as a domestic water source and there are no known plans to use it as a domestic water source in the future. However, the designated beneficial uses of the Willamette River include domestic water supply, assuming adequate pretreatment of the water prior to consumption. EPA specified that the BHHRA evaluate use of untreated river water as a domestic water supply. This scenario is considered hypothetical because pretreatment of surface water for domestic use would be required under current state laws.”	Paragraph deleted.
2i			July 16, 2010, **comment S85** §5.2.3.4, p. 83 (directed change): “Replace “Hypothetical” with “Potential” in the title for this section and elsewhere within Section 5.2.3. As previously discussed, additional surface water sampling data should be used for the screening for selection of COPCs, using both MCLs and EPA RSLs.”	See comment resolution in 2a above.	Title change: “~~Hypothetical~~ Domestic Water User” Revised text in §5.2.3.4. “There is no known or anticipated future use of surface water within the Study Area for a domestic water supply. Because the designated beneficial use of the Willamette River is as a domestic water supply with adequate pretreatment~~However~~, ~~at~~ EPA’~~s direction, untreated~~ directed that surface water ~~was~~ be evaluated as a ~~hypothetical~~ future domestic water source for both adult and child residents. For purposes of this BHHRA, untreated surface water was used to assess risks from future domestic water uses, so the risks are considered hypothetical.”	Paragraph deleted.
2j			July 16, 2010, **comment S128** §7.2.3.3, p. 116 (directed change): “Replace “*Hypothetical*” with “*Potential Future*” in the title for this section. As described in General Comment 6, under OAR 340-041-0340, Table 340A, domestic water supply is a designated beneficial use of the Willamette River, with adequate	See comment resolution in 2a above.	Title change: “~~Hypothetical~~ Domestic Water Users” Revised text in §7.2.3.3 (now §6.2.3.4). “The domestic water user risks are based on the hypothetical use of untreated surface water drawn from the Study Area as a domestic water source. Surface water in the	“The evaluation of surface water as a domestic water source is based on the assumption that surface water is drawn from the Study Area. Within the Study Area, the LWR is not currently used as a domestic water source. According to the City of Portland, the primary domestic water source for

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			pretreatment. CERCLA sets out a mandate for remedies that are protective for both private and public users of surface or groundwater. Surface water is potable and capable of serving as a potential drinking water source; thus, the expectation is that the resources will be protected and remediated to achieve such use (40 CFR 300.430(a)(1)(ii)(F)) in the absence of pretreatment. Therefore, the text in this section should be revised as indicated:" *Surface water in the LWR within the Study Area is not currently used as a domestic water source~~, nor are there plans to use surface water within the Study Area as a domestic water source in the future~~. According to the City of Portland, the primary domestic water source for Portland is the Bull Run watershed, which is supplemented by a groundwater supply from the Columbia South Shore Well Field (City of Portland 2008). ~~In addition, the Willamette River was determined not to be a viable water source for future water demands through 2030 (City of Portland 2008)~~). Under OAR 340-041-0340, Table 340A, domestic water supply is a designated beneficial use of the Willamette River, with adequate pretreatment. CERCLA sets out a mandate for remedies that are protective for both private and public users of surface or groundwater. Willamette River surface water is potable and capable of serving as a potential drinking water source; thus, the expectation is that the resources will be protected and remediated to achieve such use (40 CFR 300.430(a)(1)(ii)(F)) in the absence of pretreatment. The fact that surface water is not currently being used or that no one currently plans to use this resource is not justification for not attaining or using criteria to protect the river.* *~~Even if the Willamette River were to be used as a domestic water source, which is not likely, that would only occur after adequate pretreatment to meet Safe Drinking Water Act standards and Oregon rules. Under OAR 340-041-0340 Table 340A, domestic water supply is a designated beneficial use of the Willamette River, but only with adequate pretreatment and natural quality that meets drinking water standards.~~ Therefore, the evaluation of ~~untreated~~ surface water as a potential future domestic water source~~, even under hypothetical future conditions,~~ is a ~~conservative~~ health protective approach and consistent with		LWR within the Study Area is not currently used as a domestic water source~~, nor are there plans to use surface water within the Study Area as a domestic water source in the future~~. According to the City of Portland, the primary domestic water source for Portland is the Bull Run watershed, which is supplemented by a groundwater supply from the Columbia South Shore Well Field (City of Portland 2008). In addition, the Willamette River was determined not to be a viable water source for future water demands through 2030 (City of Portland 2008). ~~Given that current knowledge of the City of Portland planning for water supply does not indicate that the reach of the Willamette River including the Study Area will be used for domestic purposes in the future.~~ ~~Even if the Willamette River were to be used as a domestic water source, which is not likely, that would only occur after adequate pretreatment to meet Safe Drinking Water Act standards and Oregon rules.~~ Under OAR 340-041-0340 Table 340A, domestic water supply is a designated beneficial use of the Willamette River, but only with adequate pretreatment and natural quality that meets drinking water standards. The use of the Willamette River as a domestic water source would only occur after adequate pretreatment to meet Safe Drinking Water Act standards and Oregon rules. As a result, the term hypothetical was used to describe the scenario, which was based on the use of untreated surface water. Therefore, the evaluation of untreated surface water as a domestic water source, even under hypothetical future conditions, is a conservative approach and is not based on current knowledge of future planned uses of the Willamette River within the Study Area as a domestic water source or based on Oregon rules that require adequate pretreatment. ~~an indication of current or reasonably anticipated future risks at the Study Area.~~"	Portland is the Bull Run watershed, which is supplemented by a groundwater supply from the Columbia South Shore Well Field (City of Portland 2008). In addition, the Willamette River was determined not to be a viable water source for future water demands through 2030 (City of Portland 2008). Therefore, the evaluation of surface water as a domestic water source is a conservative approach and is not based on current knowledge of future planned uses of the Willamette River within the Study Area as a domestic water."

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			EPA regulations and guidance.~~approach and is not an indication of current or reasonably anticipated future risks at the Study Area.~~"			
2k			July 16, 2010, **comment S132** §7.2.5, pp. 117-118 (directed change): "Modify the 3rd sentence in the 2nd paragraph as follows: **"***In the case of the scenarios assessing the use of untreated surface water as a domestic water source, both the RME and CT scenarios represent ~~hypothetical~~ potential future exposures."*	See comment resolution in 2a above.	Revised text in §7.2.5 (now §6.2.5). "In the case of the scenarios assessing the use of untreated surface water as a domestic water source, both the RME and CT scenarios represent hypothetical exposures."	Sentence deleted.
2l			July 16, 2010, **comment S136** §7.2.5.2, pp. 119-120 (directed change): "The following changes should be made in the 3rd paragraph in this section: *In addition to the direct contact scenarios mentioned above, risks were assessed from exposure to surface water as a ~~hypothetical~~ potential future domestic water source. This scenario assumes untreated surface water is used as a domestic water source ~~is drunk and bathed in~~ 350 days a year for 30 years (adult resident) or 6 years (child) ~~resident), using tap water ingestion rates. As with the transient scenario, this scenario is equally unlikely for residents in the area.~~ The LWR within the Study Area is not currently used as a domestic water source, but could be used as such in the future ~~nor are there any future plans to use the LWR within the Study Area as a domestic water source.~~"*	See comment resolution in 2a above.	Revised text in §7.2.5.2 (now §6.2.5.2). "In addition to the direct contact scenarios mentioned above, risks were assessed from exposure to surface water as a hypothetical future domestic water source. This scenario assumes untreated surface water is used as a domestic water source ~~drunk and bathed in~~ 350 days a year for 30 years (adult resident) or six years (child resident)~~, using tap water ingestion rates. As with the transient scenario, this scenario is equally unlikely for residents in the area~~. The LWR within the Study Area is not currently used as a domestic water source, ~~nor are there any future plans to use the LWR within the Study Area as a domestic water source~~ but could be used as such in the future."	Paragraph deleted.
2m			July 16, 2010, **comment S173** §8.0, p. 137 (directed change): "Revise the last bullet as follows: "*~~Hypothetical~~ Potential future resident – ~~Hypothetical direct~~ Future exposure to untreated surface water used as a domestic water source."*	See comment resolution in 2a above.	Revised text in §8.0 (now §7.0). "~~Hypothetical future resident~~ Domestic Water User – Hypothetical direct exposure to untreated surface water used as a domestic water source"	"Domestic Water Use – Direct exposure to surface water used as a domestic water source"
3a	**The LWG objects to EPA's revisions deleting references to evaluations being done at the direction of EPA because these revisions are inconsistent with prior agreements between EPA and the LWG.**	This issue was not raised by EPA during development and finalization of in the Programmatic Work Plan.	July 16, 2010, **comment S28** §1.0, p. 12 (revise): "The document suggests that this report is somehow different from other risk assessments because EPA directed the use of conservative assumptions. In fact, risk assessments performed under guidance from other federal agencies, states, and even other countries, assess risks and inform risk management decisions based on assumptions that report risks in the upper range of those possible. The risk assessment for PH is thus typical in this regard. Accordingly, with the exception of the first sentence, the text in the third paragraph should be deleted."	LWG September 15, 2010 *General Responses to Directed Comments on BHHRA: "*As discussed at the August 20th and September 9th meetings, language stating that evaluations were done at the direction of EPA can remain in the revised BHHRA. Language implying opinion or judgment about the prudence of that direction will be removed." EPA September 22, 2010 *EPA General Responses to EPA Directed BHHRA and BERA Comments*: "EPA has reviewed the September 15, 2010 letter and attachments and agrees, with clarifications, that EPA's directed comments on the BERA and BHHRA should be revised in accordance with the general framework, and that the	Revised text in §1.0. "The LWG has worked with the United States Environmental Protection Agency (EPA) to develop the methods and assumptions used in this BHHRA. At the direction of EPA, this BHHRA incorporates ~~conservative~~ assumptions to provide a health protective assessment of risks associated with contaminants present at the Site, which is consistent with EPA guidance on risk assessment (1989). For many of the exposure scenarios evaluated in this BHHRA, upper-bound literature values are used to quantify exposure due to the lack of site-specific exposure information. In some cases, the maximum detected concentrations are used to quantify long-term exposures~~. While the use of maximum detected concentrations provides a health protective approach, it~~ which may not be representative of ~~conditions~~ ongoing exposures in the Study	"The LWG has worked with the United States Environmental Protection Agency (EPA) to develop the methods and assumptions used in this BHHRA. Consistent with EPA guidance (1989), this BHHRA incorporates assumptions to provide a health protective assessment of risks associated with contaminants present at the Site. The risk assessment for Portland Harbor is a baseline risk assessment in that it evaluates human health risks and hazards associated with contamination in the absence of remedial actions or institutional controls."

Table 2: General categories of LWG objections to the EPA June 22, 2012 revisions[1]:

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				proposed resolution described in LWG's general responses matches our understanding of the meeting outcome." Includes three unrelated clarifications.	Area. Therefore, the results of the BHHRA have a margin of conservatism built into the risk conclusions consistent with EPA guidance (1989). ~~The conservative assumptions about exposure and toxicity also affect the preliminary remediation goals (PRGs) and early activities in the Feasibility Study (FS).~~"	
3b			July 16, 2010, **comment S30** §1.2, p. 14 (directed change): "Modify the last paragraph in Section 1.2 as shown: *"The approach of this BHHRA is based on EPA (1989, 1991b, 2001a, 2004, 2005a) and Region 10 EPA (2000a) guidance.~~,~~ ~~except where further health protective assumptions were used at the request or direction of EPA.~~"* The risk assessment for PH follows EPA guidance and is not atypical or overly health protective for risk assessments done for a Superfund RI/FS."	See comment resolution in 3a above.	Revised text in §1.2. "The approach of this BHHRA is based on EPA (1989, 1991b, 2001a, 2004, 2005a) and ~~Region 10~~ EPA Region 10 (2000a) guidance~~, except where further health protective assumptions were used at the request or direction of EPA~~ and direction from EPA. The approach is also consistent with DEQ guidance for HHRAs (DEQ 2000a, 2010)."	"The BHHRA is based on EPA (1989, 1991b, 2001a, 2004, 2005a) and EPA Region 10 (2000a) guidance, and is also consistent with DEQ guidance (DEQ 2000a, 2010)."
3c			July 16, 2010, **comment S45** §3.2.2 (revise): "Infant ingestion of mother's milk and ingestion and dermal contact with household uses of surface water should be added as potential exposure pathways to the bulleted list."	LWG November 18, 2010 *General Responses to EPA's Non-Directive Comment Key Issues on the BHHRA*: "This issue was addressed in the responses to EPA's Directive Comments." EPA December 8, 2010 *EPA General Responses to EPA Non-Directed RI, BHHRA and BERA Comments*: "EPA has reviewed the LWG responses, as summarized in the tables, and has determined that the vast majority of issues associated with addressing EPA's comments have been resolved. However, there were three comments for which the LWG did not agree to make the specified changes." Includes three unrelated comments and additional unrelated clarifications.	Revised text in §3.2.2. "The conceptual site model (CSM) for human exposures based on the current understanding of the Study Area and requirements from EPA is presented in Figure 3-1. The CSM graphically depicts possible sources of COPCs based on current information, possible COPC-affected media, mechanisms of COPC transfer between media, and the processes through which human receptors may be exposed to chemicals. Additional information on potential sources of COPCs is provided in Section 5 of the RI Report. Potentially complete exposure pathways were identified in the Programmatic Work Plan or based on subsequent requirements from EPA. In-water workers exposure to river sediment, transients exposure to shoreline seeps, divers exposure to surface water and in-water sediment, infant exposure via consumption of human milk for all receptors with bioaccumulative COPCs, and hypothetical future exposures of ~~residents~~ domestic water users to surface water were included as potentially complete pathways per requirements from EPA. Pathways that are potentially or hypothetically complete and may result in significant exposure, or for which significance is unknown, were evaluated quantitatively in this BHHRA, per direction from EPA. Pathways included at the direction of EPA include clam consumption, exposure to surface water and in-water sediment by a commercial diver, and hypothetical exposure to untreated surface water ~~as domestic water source~~ by a ~~hypothetical future resident~~ domestic water user."	"The conceptual site model (CSM) describes potential contaminant sources, transport mechanisms, potentially exposed populations, exposures pathways and routes of exposure. As discussed in Sections 4, 5, and 6 of the RI Report, contaminated media within the Study Area are sediment, water, and biota. Current and historical industrial activities and processes within the Study Area have led to chemical releases from either point or nonpoint sources, including discharges to the river from direct releases or via outfalls and groundwater within the Study Area. In addition, releases that occur upstream of the Study Area and atmospheric deposition from global, regional, and local emissions may also represent potential contaminant sources to the Study Area. Chemicals in sediment and water may be accumulated by organisms living in the water column or by benthic organisms in sediments. Fish and shellfish within the Study Area feeding on these organisms can accumulate chemicals in their tissues through dietary and direct exposure to sediment and water. Additional information on potential contaminant sources is provided in Section 4 of the RI Report, and a more detailed CSM is presented in Section 10. A graphical representation of the exposure CSM is presented on Figure 3-1."
3d			July 16, 2010, **comment S125** §7.2.3, p.	See comment resolution in 3a above.	Revised text in §7.2.3 (now §6.2.3). "Some of	"Some of the uncertainties associated

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			115 (directed change): "Delete the following sentences: "~~*As required by EPA Region 10, this BHHRA included exposure scenarios that are not well documented, so it is unknown to what extent exposures currently occur, if at all, within the Study Area. In addition, this BHHRA evaluated risks associated with a hypothetical future scenario, which is not anticipated to reasonably occur in the future based on current information for the Study Area. The uncertainties associated with these potential and hypothetical exposure scenarios are discussed in the following subsections."~~* Consistent with EPA Superfund guidance, EPA and its partners chose only those scenarios that are reasonably anticipated to occur and are consistent with current statutory or regulatory requirements (e.g., designated beneficial use of the river as a source for drinking water)."		the exposure scenarios evaluated in this BHHRA have limited documentation regarding the actual extent of exposure to receptors in the Portland Harbor. These scenarios were included in this BHHRA at the direction of EPA Region 10. The uncertainties associated with these scenarios are discussed in the following subsections. ~~As required by EPA Region 10, this BHHRA included exposure scenarios that are not well documented, so it is unknown to what extent exposures currently occur, if at all, within the Study Area. In addition, this BHHRA evaluated risks associated with a hypothetical future scenario, which is not anticipated to reasonably occur in the future based on current information for the Study Area. The uncertainties associated with these potential and hypothetical exposure scenarios are discussed in the following subsections.~~"	with the exposure scenarios evaluated in the BHHRA are discussed in the following subsections."
3e			July 16, 2010, **comment S172** §8.0, p. 137 (revise): "Revise the first sentence in the second paragraph as follows: *"Populations evaluated in the risk characterization portion of the BHHRA were identified based on human activities that are known to occur now and/or which could occur in the future within the Study Area, …""*	See comment resolution in 3c above.	Revised text in §8.0 (now §7.0). "The populations evaluated in the risk characterization portion of the BHHRA were identified based on human activities that are known to occur now and/or which could occur in the future within the Study Area, as described in the Programmatic Work Plan, or were directed by EPA for evaluation in this BHHRA."	"The populations evaluated in the BHHRA were identified based on human activities currently known to occur within the Study Area or could occur in the future, as described in the Programmatic Work Plan."
3f			EPA's comments on the 2009 Draft BHHRA did not include comments on the cited text in §1.2.		Text in §1.2. "Exposure scenarios that were not included in the Programmatic Work Plan were evaluated in this BHHRA based on direction from EPA. Specific agreements with and direction from EPA related to the approach for this BHHRA are documented in Attachment F1."	"Specific documents related to the approach for this BHHRA are presented in Attachment F1."
3g			EPA's comments on the 2009 Draft BHHRA did not include comments on the cited text in §3.1.		Text in §3.1. "The above populations were identified based on human activities that are known to occur within the Study Area, as described in the Programmatic Work Plan, or were required by EPA for evaluation in this BHHRA."	"The above populations were identified based on human activities know to occur within the Study Area, with the exception the use of surface water as a domestic water source."
3h			EPA's comments on the 2009 Draft BHHRA did not include comments on the cited text in §3.3.2.2.		Text in §3.3.2.2. "The diver exposure scenarios were directed by EPA in a memorandum regarding the *Proposed Commercial Diver Exposure Scenario for the Portland Harbor Risk Assessment* (EPA 2008c)."	Sentence deleted.
3i			EPA's comments on the 2009 Draft BHHRA did not include comments on the cited text in §5.2.3.3.2.		Text in §5.2.3.3.2. "The commercial diver in a dry suit was not evaluated for CT exposure, as directed by EPA."	"a CT evaluation was not done for a commercial diver in a dry suit."
4a	**The LWG objects to EPA's revisions that modify the Study Area boundaries because these revisions are inconsistent with prior agreements between EPA and**	This issue was not raised by EPA during development and finalization of in the Programmatic Work Plan.	No comments.	April 15, 2009 table, *Outstanding Portland Harbor RI/FS Issues, Status as of 4/15/2009*: #22 (Study Area Boundary): "On 6/11/08 EPA and LWG agreed that the site-wide risk scenarios would be	Text in §1.3. "The approximate 10-mile portion of Portland Harbor from RM 1.9 to 11.8 is referred to as the Study Area (Map 1-1)." Text in §5.2.2. "In addition to calculating risks from in-water sediment exposure within the	"The approximate 11-mile portion of Portland Harbor from RM 0.8 to 12.2 is referred to as the Study Area (Map 1-1)."

Table 2: General categories of LWG objections to the EPA June 22, 2012 revisions[1]:

Issue Number	Basis for LWG objection	April 23, 2004 Programmatic Work Plan	EPA Comment on 2009 Draft BHHRA	LWG/EPA Comment Resolution	May 2, 2011 Draft Final BHHRA (redline)	EPA June 22, 2012 Revised BHHRA
	the LWG.			developed for the Study Area from RM 2 to RM 11.8 and that separate EPCs and baseline risk evaluations would be prepared for the areas between RM 1 and RM2, upper Multnomah Channel, and RM 11.8 to RM 12.2."	Study Area (which includes exposure areas from RM 1.9 to RM 11.8, including Swan Island Lagoon), risks from in-water sediment exposure were calculated for three river segments outside of the Study Area: the downstream reach (RM 1.0-1.9), the downtown river segment (RM 11.8 – 12.2), and Multnomah Channel."	Text deleted.
5a	**The LWG objects to EPA's revisions that were not the subject of prior comments.**		July 16, 2010 Cover Letter: "EPA has attempted to provide clear direction on the specific revisions that are needed to resolve the comments." "EPA's comments are focused on areas of the report that were deficient, and changes are needed to make the report acceptable to EPA."		The Executive Summary was revised in accordance with EPA's July 16, 2010 comments, which included 25 specific comments, of which 3 were directed changes, on the Executive Summary.	Executive Summary section deleted
5b					The Conclusions section was revised in accordance with EPA's July 16, 2010 comments, which included 2 specific comments, of which one was a directed change, on the Conclusions.	Conclusions section deleted
5c						The above are two specific examples; throughout the 200-page document, there are extensive additional directed changes to the text, table, and figures that were not part of the July 16, 2010 comments.

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July 23, 2012 LWG Notice of Objection to EPA Notice of Non-Compliance and Directed Revisions to the Portland Harbor Draft Final Baseline Human Health Risk Assessment and Request for Dispute Resolution

Lower Willamette River, Portland Harbor Superfund Site

USEPA Docket No: CERCLA-10-2001-0240