TERMINAL 4 CONFINED DISPOSAL FACILITY DESIGN ANALYSIS REPORT (PREFINAL 60 PERCENT DESIGN DELIVERABLE) PORT OF PORTLAND, PORTLAND, OREGON

Prepared for

Port of Portland

Portland, Oregon

Prepared by

Anchor QEA, LLC

6650 SW Redwood Lane, Suite 333

Portland, Oregon 97224

In Association with

Berger/ABAM Engineers, Inc.

NewFields

Ash Creek Associates, Inc.

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LIST OF ACRONYMS AND ABBREVIATIONS

°C	degrees Celsius
µg/L	micrograms per liter
AASHTO	American Association of State Highway and Transportation Officials
AOC	Administrative Order on Consent
AOPCs	Areas of Potential Concern
ARARs	Applicable or Relevant and Appropriate Requirements
BATS	Business Analysis Terms Sheet
BMPs	best management practices
bpf	blows per foot
CDF	confined disposal facility
City	City of Portland
CLE	contingency level event
cm/yr	centimeters per year
CMPP	Conceptual Mitigation Plan Proposal
COCs	chemicals of concern
CPT	cone penetrometer test
CQAP	Construction Quality Assurance Plan
CST	Column Settling Test
CSZ	Cascadia Subduction Zone
CWA	Clean Water Act
cy	cubic yards
D_{50}	median diameter
DAR	Design Analysis Report
DO	dissolved oxygen
DOGAMI	Department of Geology and Mineral Industries
DRET	dredging elutriate test
DSL	State of Oregon Department of State Lands
EE/CA	Engineering Evaluation/Cost Analysis
FEMA	Federal Emergency Management Agency

fps	feet per second
FS	Feasibility Study
g/day	grams per day
GAC	granular activated carbon
H:V	horizontal to vertical
IDR	informal dispute resolution
IRM	International Raw Materials
kg/yr	kilograms per year
km	kilometers
km/day	kilometers per day
KMBT	Kinder Morgan Bulk Terminals
LTMRP	Long-term Monitoring and Reporting Plan
LWG	Lower Willamette Group
m/sec	meters per second
MCLs	maximum contaminant levels
MET	Modified Elutriate Test
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
mm	millimeters
MNR	monitored natural recovery
MSL	mean sea level
NGVD	National Geodetic Vertical Datum
NMFS	National Marine Fisheries Service
NTCRA	Non-Time-Critical Removal Action
NTU	Nephelometric Turbidity Units
OAR	Oregon Administrative Rules
ODEQ	Oregon Department of Environmental Quality
ODFW	Oregon Department of Fish and Wildlife
ODOT	Oregon Department of Transportation
OHW	ordinary high water
PAH	polycyclic aromatic hydrocarbon

PCBs	polychlorinated biphenyls
PCLT	Pancake Column Leaching Test
PEC	probable effects concentration
PGA	peak ground acceleration
Port	Port of Portland
psf	pounds per square foot
PSHA	Probabilistic Seismic Hazard Evaluation
QA	quality assurance
QC	quality control
RAO	Remedial Action Objective
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
RM	River Mile
RNA	regulated navigation area
ROD	Record of Decision
SAP	Sampling and Analysis Plan
SBLT	sequential batch leaching test
SPT	standard penetration test
SVOCs	semivolatile organic compounds
T4	Terminal 4
TCLP	Toxic Characteristic Leaching Procedure
TEC	threshold effects concentration
TMDL	total maximum daily load
TOC	total organic carbon
TPH	total petroleum hydrocarbons
TSS	total suspended solids
USACE	U.S. Army Corps of Engineers
USCG	U.S. Coast Guard
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey

VOCs	volatile organic compounds
WQMCCP	Water Quality Monitoring and Compliance Conditions Plan
WQMP	Water Quality Monitoring Plan

EXECUTIVE SUMMARY

This Design Analysis Report (DAR) and supporting appendices provide 60 Percent Design documents for a confined disposal facility (CDF) proposed to be built in an underused slip at the Port of Portland (Port) Terminal 4 (T4), Slip 1, near Willamette River Mile 4.2. Final design and construction of the CDF is contingent on the CDF being selected as a preferred disposal alternative during the Portland Harbor Feasibility Study (FS) and Record of Decision (ROD). The T4 CDF would have the capacity to hold 670,000 cubic yards (cy) of contaminated sediment from remedial actions in the Portland Harbor Superfund Site. A CDF is a proven technology implemented in the Pacific Northwest at other Superfund sites that provides isolation of contaminated sediments from the aquatic environment and thereby protects human health and the environment.

The 60 Percent Design of the T4 CDF meets the intent of the U.S. Environmental Protection Agency (USEPA) CDF performance standards that were transmitted to the Lower Willamette Group (LWG) and the Port on February 18, 2010, as well as Portland Harbor Remedial Action Objectives (RAOs) and Applicable or Relevant and Appropriate Requirements (ARARs) as they are currently known. The USEPA CDF performance standards and follow-up clarifications by the Port and LWG are reproduced in their entirety in Appendix A. The DAR provides scientific and engineering analysis supporting that the designed CDF is in accordance with USEPA's interim CDF performance standards. An index of the relevant DAR sections where specific CDF performance standards are addressed is provided in Table 5-1.

Overview of CDF Design and Construction

An at-grade CDF having a footprint of approximately 14 acres would be constructed in T4 Slip 1. Sediments to be placed in the CDF would include sediments over-excavated from the berm key area of Slip 1, dredged sediments from T4 Slip 3, and dredged sediment from other Areas of Potential Concern (AOPCs) in the Portland Harbor Superfund Site. Groundwater modeling results show that sediments from ten high-priority AOPCs in Portland Harbor would be suitable for placement in the T4 CDF, as presented in Section 6.4 and Appendix A.

The construction elements of the CDF are shown in plan view and in cross-section on Figures 5-1 and 5-2, respectively.

Construction of the T4 CDF would be completed in three stages:

- **Stage 1** – Slip 1 preparation and construction of the CDF containment berm.
- **Stage 2** – Filling of the CDF with contaminated sediments from Portland Harbor.
- **Stage 3** – Completion of the CDF cover.

The entire project, including berm construction, filling the CDF, and placement of the final cover, is expected to take 5 to 10 years to complete, depending on the schedule of Harbor-wide remedial actions and the availability of suitable dredged material.

CDF Preparation and Berm Construction. Preparation work and construction of the CDF berm is expected to take approximately 1 to 2 years to complete. Initial preparation work consists of demolition and relocation of Slip 1 structures, and re-routing stormwater outfalls. Then the soft sediment in the berm key area will be removed using a clamshell dredge to prepare a stable berm foundation, and the excavated material will be placed in the head of Slip 1. The containment berm will require approximately 290,000 tons of select fill and 95,000 tons of rock for training terraces. The lower portion of the berm will be constructed from the water during the in-water work window, and after the berm breaches the water surface, the upper portion will be finished in the dry with upland equipment. Fish salvage efforts will be conducted in the CDF pond after it becomes isolated from the river.

Filling the CDF. The CDF can confine an estimated 670,000 cy of contaminated sediments, and potentially 30 to 45 percent additional volume depending on the amount of settlement that occurs. It is anticipated that dredged sediment from Portland Harbor remedial action areas would be offloaded from haul barges into the CDF using a high-solids dredge pump, and the make-up water used to prepare the dredge slurry would be drawn from the CDF pond to minimize the head difference between the pond and the river. The offloading facility is expected to be located at the replacement berth on the southern edge of the berm, and would likely be sized to offload 2,000 to 4,000 cy per day assuming a 10- to 12-inch-

diameter hydraulic dredge pump, respectively. The filling process is estimated to take up to 4 years.

Covering the CDF. The CDF cover consists of two layers. The lower layer, located directly above the confined dredged sediment, is the import fill layer. This layer is approximately 464,000 cy in volume, and is anticipated to be suitable dredged material brought to the site on haul barges and offloaded as described above. The top of the CDF is the CDF cover layer. This layer consists of approximately 272,000 tons of aggregate from an upland source, brought to the site by truck and/or barge and offloaded mechanically.

Habitat Mitigation. The Port is not proposing any specific mitigation in this document, but acknowledges that the determination of final mitigation requirements for construction of the CDF will be established in consultation with USEPA and its federal, state, and tribal partners after the ROD is issued.

Estimated Cost. The cost to construct the CDF is estimated between $44 and $63 million. The cost range reflects the uncertainties regarding the cost of obtaining 18 feet of imported fill material, to be placed over the contaminated dredged sediment; and to a lesser extent the uncertainties in habitat mitigation costs.

Conformance with CDF Performance Standards

The achievement of CDF performance standards will be verified through the implementation of numerous sampling and monitoring requirements for both short-term activities associated with CDF construction and filling, and long-term activities associated with the operation and maintenance of the CDF after it has been filled and closed. Table 2-1 summarizes the various CDF monitoring requirements.

Short-Term Performance Standards

Short-Term Water Quality. Dredging, filling, and related sediment-disturbing CDF construction activities will be conducted in a manner that meets water quality criteria at

specified points of compliance. Proposed monitoring methods, measurement parameters, locations, and frequencies are presented in the Water Quality Monitoring Plan (WQMP; Appendix E), and will be further detailed in the USEPA Water Quality Monitoring and Compliance Conditions Plan (WQMCCP) to be developed during 100 Percent Design. Based on the results of dredging elutriate tests, the favorable monitoring record during the T4 Phase I Removal Action, and the relatively low contaminant concentrations in the berm key area, adverse short-term water quality effects are not expected during T4 CDF construction.

Currently, the filling of the CDF is not anticipated to occur using hydraulic dredging methods. If hydraulic dredging is shown to be a preferable dredging and placement method for certain AOPCs in Portland Harbor, causing return flows of dredging elutriate water to the river, additional water quality analyses will need to be conducted.

Construction Verification. The Construction Quality Assurance Plan (CQAP; Appendix D) provides quality control (QC) measures that will be implemented during construction to verify that the CDF is built in accordance with the project Drawings (Appendix B) and Construction Specifications (Appendix C). Construction QC measures have been developed to verify the following:

1. Design dredge depths and lateral extents are achieved during berm key excavation
2. Design grades, elevations, extents, and densities are achieved during berm construction and CDF filling
3. Demolition of structures and piles is performed as specified, and remaining structures are protected
4. Import material meets specified physical and chemical requirements, depending on its use (Note: import material acceptance criteria will be developed in the 100 Percent Design)

Long-Term Performance Standards

Long-Term Water Quality. The CDF has been designed to ensure that groundwater exiting the CDF meets state and federal chronic water quality criteria for aquatic life, human health

fish consumption criteria, and drinking water maximum contaminant levels (MCLs). These water quality criteria are to be met in the porewater of the berm, without dilution in the water column, and in the base case scenario without consideration of biodegradation.

A numerical groundwater model of the T4 CDF was developed to predict the movement of contaminants between the dredge fill and the river for 500 to 1,000 years. The model (MODFLOW/MT3DMS) describes groundwater advection and dispersion, mixing of leachate with rainfall and regional groundwater, adsorption and desorption of contaminants onto berm and aquifer soils, and conservative biodegradation processes in some cases, as presented in Section 6.4 and Appendix A. The model uses site-specific input parameters to the extent possible, including hydraulic measurements of T4 sediments and aquifer materials, Portland Harbor leachate tests, Willamette River gage records, and the physical characteristics of local import materials. A representative suite of Portland Harbor index contaminants were modeled including copper, naphthalene, benzo(a)anthracene, DDx, and Total polychlorinated biphenyls (PCBs).

Groundwater transport pathways are dominated by downward vertical flow through the contaminated dredge fill toward the underlying aquifer and laterally into the berm. The groundwater residence time in the contaminated dredge fill varies from about 20 years along the front and bottom of the CDF, to 200+ years at the rear and upper portion of the CDF. During the model simulation period, the concentrations of all chemicals of concern (COCs) remained below their respective evaluation criteria under the base case scenario of no biodegradation for approximately 500 years or more. When conservatively slow rates of biodegradation are incorporated into model simulations for organic compounds, groundwater exit concentrations are reduced by two to three orders of magnitude. These results indicate the CDF will be protective of long-term water quality. Model sensitivity and uncertainty analyses confirm that model results are robust over a relatively wide range of input parameter values.

Long-Term CDF Stability Performance. Long-term monitoring activities will be conducted to verify that the T4 CDF is structurally stable and performing as intended. Visual surveys of

the exposed berm, hydrographic surveys of the submerged berm, water level monitoring of groundwater wells, and settlement surveys will be conducted to confirm the following:

1. The containment berm is geotechnically stable under design static and seismic events
2. The containment berm is resistant to erosion from flooding, vessel waves, turbulence, or other hydraulic forces
3. The CDF is consolidating and settling as predicted over the long term.

1 INTRODUCTION

1.1 Background

The Port of Portland (Port) entered into an Administrative Order on Consent (AOC) with the U.S. Environmental Protection Agency (USEPA) in October 2003 to perform a Non-Time-Critical Removal Action (NTCRA) at the Terminal 4 (T4) site on the Willamette River in Portland, Oregon (Figure 1-1) (USEPA 2003a). The AOC requires the Port to perform an Early Action to address known contamination found in T4 sediment samples during a Remedial Investigation (RI) directed by the Oregon Department of Environmental Quality (ODEQ). In 2005, the Port prepared and submitted the *Terminal 4 Early Action Engineering Evaluation/Cost Analysis* (EE/CA), which provided a comparative analysis of remedial options for T4 (BBL 2005). Based on this information, USEPA, in consultation with its federal, state, and tribal partners, evaluated and selected a Removal Action for T4 that included a combination of monitored natural recovery (MNR), capping, and dredging, with placement of contaminated sediment in a confined disposal facility (CDF) to be built on site in Slip 1. The USEPA-selected Removal Action was detailed in an Action Memorandum prepared by USEPA in 2006 (Action Memo; USEPA 2006a).

The T4 Removal Action process is separate from the Portland Harbor Superfund Remedial Investigation (RI) and Feasibility Study (FS) process, which has been progressing concurrently. Subsequently, USEPA and the Port acknowledged an increased relationship between the T4 CDF and the Harbor-wide RI/FS process. Presently, USEPA and the Port anticipate that final design and construction of the CDF is contingent on the CDF being selected as a preferred disposal alternative during the Portland Harbor FS and Record of Decision (ROD).

The Port submitted a Conceptual 30 Percent Design Analysis Report (Anchor 2006a) and Prefinal 60 Percent Design Analysis Report (Anchor 2006b) for the T4 Early Action consistent with the Action Memo in 2006. In January 2007, USEPA issued a letter to the Port along with comments and directed changes on the T4 Early Action 60 Percent Design. The letter stated that: "…the 60 percent design is not approved, rather to keep the process

moving forward, EPA expects that issues identified with the 60 percent design will be resolved with interim deliverables…". The January 2007 USEPA comment letter was the subject of an informal dispute resolution (IDR) process that occurred throughout much of 2007. The November 15, 2007 letter from USEPA to the Port represents the final agreements reached during the IDR process and the agreed path forward relative to the original T4 Early Action 60 Percent Design.

Implementation of the Action Memo is now occurring in phases because many of the design issues required for full implementation are linked to the overall Portland Harbor-wide RI/FS process, which is taking more time than what was anticipated when the Action Memo was issued. For this reason, in a letter to USEPA dated August 22, 2007, the Port requested that USEPA revise the schedule for implementation of the T4 Removal Action to realign the Early Action project with the Harbor-wide RI/FS schedule. The Port also prepared an Abatement Measures Proposal in October 2007 (Anchor 2007a) to detail specific components of the Removal Action that could be implemented as a Phase I action to address conditions at T4 that posed an imminent threat to human health and the environment. In November 2007, USEPA approved the schedule realignment request on condition that the Port would implement the Phase I Removal Action components outlined in the Abatement Measures Proposal (letter dated November 15, 2007 from Deborah Yamamoto, USEPA, to Tom Imeson, Port of Portland). The Final Design of the Phase I Removal Action was completed and implemented in 2008. The Phase I Removal Action consisted of the following activities (see Figures 1-2 and 1-3):

- Dredging and off-site disposal of sediment from within three areas exhibiting the highest chemical concentration at T4. Specifically, these areas were adjacent to Berth 411 and Pier 5 in Slip 3, and north of Berth 414. A portion of the Phase I areas could not be dredged to the planned removal depth due to concerns regarding potential impacts to the stability of the adjacent side slopes and waterfront structures. Therefore, after dredging was completed to the extent feasible, selected areas were covered with a thin layer of sand.
- Dredging and off-site disposal of contaminated sediment in an area adjacent to Berth 410 within Slip 3 to support water-dependent maritime use in a manner consistent

with the Action Memo (USEPA 2006a). Material was removed down to navigational depths of between -39.3 to -41.3 feet National Geodetic Vertical Datum (NGVD).

- Construction of a nearshore cap at the head of Slip 3 in front of and behind the existing timber bulkhead to isolate petroleum-contaminated sediment from aquatic receptors and control a potential ongoing source to Slip 3.
- Stabilization and capping of the Wheeler Bay shoreline to minimize contaminant migration to the river.

These activities were all planned as part of the overall Removal Action at T4 as described in USEPA's Action Memo (USEPA 2006a). The activities were implemented as part of Phase I because they addressed areas within the site that exhibited some of the highest concentrations, presented potential ongoing sources, and/or were not expected to be significantly impacted by the outcome of the Harbor-wide RI/FS process. The remainder of the Removal Action will be implemented as Phase II. Phase II of the Removal Action consists of a combination of dredging, capping, and MNR in areas not completely addressed by Phase I, as well as construction of a CDF in Slip 1. The cap in the head of Slip 3 and the Wheeler Bay shoreline stabilization activities are intended to be the final Removal Action for these areas, consistent with the Action Memo (USEPA 2006a). The areas that were dredged as part of Phase I will be reassessed and, if necessary, addressed further as part of Phase II along with any remaining areas of contamination at T4 including Slip 3, Berth 414, and Berth 401.

At the time of the schedule realignment in 2007, design and implementation of the Phase II Removal Action was based on a Harbor-wide schedule that anticipated resolution of key Harbor-wide issues and submittal of the Draft FS prior to submittal of the Phase II 60 Percent Design. Resolution of key Harbor-wide issues and submittal of the Draft FS did not occur on the timeline anticipated. As such, the Port requested a second schedule realignment for Phase II that was contingent on the issuance of the Portland Harbor ROD (letter dated September 23, 2009 from Tom Imeson, Port of Portland, to Deborah Yamamoto, USEPA). This second realignment was proposed to ensure that the Phase II Removal Action is environmentally protective, cost-effective, and consistent with the Harbor-wide cleanup,

especially the design and implementation of the Slip 1 CDF and its associated cost. The Port and USEPA discussed this request through various meetings and letters from September 2009 through January 2010. In the Port's November 23, 2009 letter to USEPA, the Port re-iterated the commitment to implement the T4 CDF action with the following qualifications:

- USEPA selects the CDF in the ROD in accordance with the National Contingency Plan and determines that other sediment from the Portland Harbor Superfund Site can be disposed in the CDF.
- CDF is cost-effective alternative when compared to other Harbor-wide alternatives.
- Other CDF users and a mechanism to finance the significant capital costs for CDF construction are identified.

In a letter dated January 22, 2010, USEPA granted the Port's second schedule realignment request based on the following three conditions:

- The Port shall submit the 60 Percent Design for the T4 CDF by September 1, 2010, using performance criteria provided by USEPA so that this information can be included in the Harbor-wide FS. [Note: The 60 Percent Design for the T4 CDF is the subject of this document.] USEPA agrees to extend the schedule for the 90 and 100 Percent Design and construction of the CDF until after the Harbor-wide ROD is issued. After issuance of the ROD, USEPA, in consultation with the Port, will also develop a schedule for completion of the other components of the Phase II Removal Action at T4.
- Within 30 days (of the January 22, 2010 letter), USEPA would provide both the Lower Willamette Group (LWG) and the Port with a set of performance standards to be used in evaluating all CDF alternatives in the Harbor-wide FS, including the T4 CDF. These performance criteria will address short-term impacts during CDF construction and filling, medium-term impacts during dormant periods between CDF filling seasons and before final closure, and long-term impacts following final closure of the CDF.
- The Port shall evaluate the T4 CDF using the performance standards provided by USEPA. These performance standards may be considered just one facet of a

sensitivity analysis of the performance of various CDF designs, and the Port shall determine the feasibility and cost of a CDF design that fully achieves these performance standards. As necessary, the Port may need to adjust sediment acceptance criteria, CDF design criteria, or filling/operational parameters to demonstrate achievement of the USEPA performance standards.

In a letter dated February 5, 2010, the Port acknowledged USEPA's decision to set the final CDF design, construction, and cleanup effort at T4 until after the Harbor-wide ROD.

Since the February 5, 2010 letter, the following additional activities have occurred related to the T4 CDF 60 Percent Design:

- On February 18, 2010, USEPA provided the performance standards to the LWG and the Port for use in development and evaluation of CDF alternatives in the Harbor-wide FS (USEPA 2010a).
- The Port submitted the T4 CDF Groundwater Model Input Parameter Memorandum on April 1, 2010, and USEPA provided comments on April 19, 2010. On April 28, 2010, the Port, USEPA, and its federal, state, and tribal partners held a meeting to get further clarification of USEPA's CDF performance standards, and USEPA comments on the Groundwater Model Input Parameter Memorandum (see April 28 meeting minutes in Appendix A).
- The Port submitted the T4 CDF Long-Term Groundwater Modeling Results Memorandum on June 18, 2010. USEPA provided comments back to the Port on July 16, 2010. The Port and USEPA met on July 29, 2010 to discuss USEPA's comments on the memorandum and to obtain clarification on significant technical issues before moving forward with the T4 CDF 60 Percent Design. Meeting notes were prepared by the Port and approved by USEPA with few clarifications on August 4, 2010. On August 30, 2010, the Port provided written responses to USEPA comments on the memorandum, and on September 13, 2010, USEPA approved the Port's responses with few comments.

The Groundwater Model Input Parameter Memorandum, the Long-Term Groundwater Modeling Results Memorandum, USEPA comments on the two memoranda, USEPA-approved Port responses, and USEPA-approved meeting notes for April 28 and July 29, 2010 are provided in Appendix A.

Following the resolution of USEPA's comments on the T4 CDF Long-Term Groundwater Modeling Results Memorandum, and in accordance with the USEPA-approved schedule for submittal of the T4 CDF 60 Percent Design documents, the schedule of the documents was extended until October 5, 2010. The T4 CDF 60 Percent Design documents are the subject of this report. These documents are being submitted to USEPA and the LWG, and the information will be included in the Harbor-wide FS to evaluate sediment disposal options for the Portland Harbor remedial action. The T4 CDF 90 and 100 Percent Design documents and the additional T4 Phase II Removal Action activities will be developed after issuance of the Portland Harbor ROD.

1.2 Remedial Action Objectives

The Portland Harbor site Remedial Action Objectives (RAOs) are objectives that apply to all remedial action activities that occur within the Harbor. As such, these will also apply to the T4 CDF and are provided below for reference. The draft Portland Harbor RAOs listed below were provided by USEPA to the LWG on September 30, 2009 (USEPA 2009a); however, they are not final and are subject to refinement through the RI/FS process.

- **RAO 1: Reduce to acceptable levels human health risks from exposure to contaminated sediments[1] resulting from incidental ingestion of and dermal contact**

[1] Sediments are defined as soils, sand, organic matter, or minerals that accumulate on the river bottom. For purposes of describing the RAOs, sediment also includes the interstitial water and transition zone water (TZW) that is influenced by groundwater and surface water and thus can also be contaminated by groundwater, surface water, or chemicals dissolving off of the sediments. Sediments extend up to the ordinary high water mark (OHWM; 13.3 feet NAVD88) along the banks (including beach sediments) within the Portland Harbor Superfund Site. Riparian soils are found along the river banks from the OHWM to the mean high water mark (20 feet NAVD88). High water mark datum is from Proposed Round 3 Scope of Work, Portland Harbor Superfund Site, February 17, 2006.

with sediments, and comply with identified Applicable or Relevant and Appropriate Requirements (ARARs).

This RAO applies to direct human health sediment exposure scenarios found to have an unacceptable risk in the risk assessment. The goal for this RAO is to reduce risks to human health from chemicals of concern (COC) concentrations in contaminated sediments through sediment remedies at the site, comply with chemical-specific ARARs identified for the site, and protect beneficial uses of the Willamette River at the site.

- **RAO 2: Reduce to acceptable levels human health risks from indirect exposures to COCs through ingestion of fish and shellfish that occur via bioaccumulation pathways from sediment, and/or surface water and comply with identified ARARs.**

  This RAO applies to fish and shellfish consumption scenarios found to have an unacceptable risk in the risk assessment. The goal is to reduce risks to human health through sediment remedies that protect humans from indirect exposures to COCs through eating fish and shellfish exposed to COCs via bioaccumulation and bioconcentration, comply with chemical-specific ARARs identified for the site, and protect the beneficial uses of the Willamette River at the site. This RAO is expected to contribute to the reduction and elimination of Portland Harbor polychlorinated biphenyl (PCB) fish consumption advisories. It is recognized that reduction and elimination of the Portland Harbor fish advisory can only be achieved when conducted in conjunction with other Portland Harbor source controls and other PCB reduction efforts conducted under other regulations and programs within the Willamette River watershed.

- **RAO 3: Reduce risks from COCs in surface water at the site to acceptable exposure levels that are protective of human health risks from ingestion of, inhalation of, and**

dermal contact with surface water; protect the drinking water beneficial use of the Willamette River at the site; and comply with identified ARARs.

This RAO applies to direct human health surface water exposure scenarios found to have an unacceptable risk in the risk assessment and the protection of the drinking water beneficial use of the Willamette River. The goal is to reduce risks from COC concentrations in surface water, to the extent practicable, through sediment remedies that protect humans from the ingestion of and dermal contact with surface water; comply with chemical specific ARARs identified for the site; and protect the beneficial uses (domestic/private water supply) of the Willamette River at the site.

- **RAO – Human Health Groundwater: Reduce to acceptable levels human health risks resulting from direct exposure to contaminated groundwater and indirect exposure to contaminated groundwater through fish and shellfish consumption, and comply with identified ARARs.**

  This RAO applies to human health risks via exposure to contaminated groundwater plumes that exceed ARARs and indirect exposure to COCs in groundwater plumes discharging to the Willamette River found to have an unacceptable risk in the risk assessment based on fish and shellfish consumption with the understanding that groundwater plumes will be controlled to achieve ARARs and risk-based remediation goals through upland source control actions. The goal for this RAO is to reduce risks to human health from COC concentrations in contaminated groundwater through sediment remedies at the site, comply with chemical-specific ARARs identified for the site, and protect beneficial uses of groundwater and the Willamette River at the site. For groundwater plumes that are controlled through effective upland source control measures, this RAO would apply to groundwater plumes downgradient of the source control measure.

- **RAO 4: Reduce to acceptable levels the risks to ecological receptors resulting from the ingestion of and direct contact with contaminated sediments and comply with identified ARARs.**

  This RAO applies to all ecological receptors found to have an unacceptable risk in the risk assessment via direct sediment exposure. The goal is to reduce risks to ecological receptors from COC concentrations in contaminated sediments and groundwater through sediment remedies at the site, prevent unacceptable effects on the survival, growth, and reproduction of ecological receptors at the site, and comply with chemical-specific ARARs identified for the site.

- **RAO 5: Reduce to acceptable levels risks to ecological receptors from indirect exposures through ingestion of prey to COCs in sediments via bioaccumulation pathways from sediment and/or surface water and comply with identified ARARs.**

  This RAO applies to all ecological receptors found to have an unacceptable risk in the risk assessment through ingestion of prey. The goal is to reduce risks from COCs through sediment remedies that protect ecological receptors from exposures to COCs through consumption of fish and shellfish, benthic organisms and other prey items exposed to COCs via bioaccumulation and bioconcentration; comply with chemical-specific ARARs identified for the site; and protect the beneficial uses of the Willamette River. This RAO is expected to contribute to reduction of prey ingestion related ecological risks through reduction in sediment chemical contributions to fish tissue. It is recognized that reduction of and elimination of these risks can only be achieved when conducted in conjunction with other Portland Harbor source control efforts conducted under other regulations and programs within the Willamette River watershed.

- **RAO 6: Reduce risks from COCs in surface water at the site to acceptable exposure levels that are protective of ecological receptors based on the ingestion of and direct contact with surface water and comply with identified ARARs.**

  This RAO applies to all ecological receptors found to have an unacceptable risk in the risk assessment through exposure to surface water. The goal is to reduce the risk from COC concentrations in surface, water to the extent practicable, through sediment remedies that prevent unacceptable effects on survival, growth, and reproduction of ecological receptors; comply with identified chemical-specific ARARs; and protect the beneficial uses of the Willamette River.

- **RAO – Ecological Groundwater: Reduce to acceptable levels the risks to ecological receptors resulting from the ingestion of and direct contact with contaminated groundwater and indirect exposures through ingestion of prey via bioaccumulation pathways from groundwater, and comply with identified ARARs.**

  This RAO applies to all ecological receptors found to have an unacceptable risk in the risk assessment via exposure to contaminated groundwater plumes discharging to the Willamette River and through ingestion of prey with the understanding that groundwater plumes will be controlled to achieve ARARs and risk-based remediation goals through upland source control actions. The goal is to reduce risks to ecological receptors from COC concentrations in contaminated groundwater through sediment remedies at the site, prevent unacceptable effects on the survival, growth, and reproduction of ecological receptors at the site, and comply with chemical-specific ARARs identified for the site. For groundwater plumes that are controlled through effective upland source control measures, this RAO would apply to groundwater plumes downgradient of the source control measure.

1.3 Description and Organization of this Document

The T4 CDF 60 Percent Design progresses the project details from the Conceptual Design in terms of refining CDF dredging and filling areas and volumes; selecting construction processes, technology, and equipment where appropriate; identifying material borrow sources; and other project details. The T4 CDF 60 Percent Design involves the preparation of design calculations and analyses to work out design details, the preparation of design drawings and specifications, and the establishment of quality control (QC) and monitoring procedures that will be used to verify that USEPA performance standards have been met.

The CDF 60 Percent Design deliverables provided in this document and related appendices include the following information:

- Design Analysis Report (DAR) providing the design criteria and basis of design for the CDF, including technical parameters and supporting calculations upon which the design will be based including, but not limited to, design requirements for the development of the CDF
- Construction documents and schedule including Drawings (Appendix B) and Construction Specifications (Appendix C)
- Design plans including a Draft Construction Quality Assurance Plan (CQAP) detailing the CDF construction verification methods and approach to quality assurance (QA) during construction (Appendix D); and a Draft Water Quality Monitoring Plan (WQMP) detailing the water quality monitoring approach (Appendix E)

The remainder of this document provides detailed information on the development of the T4 CDF 60 Percent Design as follows:

- **Section 2 – Confined Disposal Facility Description** provides a general overview of the CDF setting, performance standards, construction activities, and monitoring activities.
- **Section 3 – Existing Conditions** summarizes the information and data collected within the CDF area that will be used as the basis of the design, including physical conditions, hydrogeologic and geotechnical conditions, hydrodynamic characteristics, sediment quality, and former and current site uses.

- **Section 4 – Dredge Plan** provides the conceptual dredge plan for excavating the berm key area of the CDF, including the design approach, dredge design surface, neatline dredge prism, volumes, and equipment selection.
- **Section 5 – Confined Disposal Facility Design** provides the conceptual CDF design including the basis for design, design approach, containment berm stability, containment berm erosion resistance, consolidation and settlement, CDF cover layer, CDF filling procedures, assessment of potential impacts on Willamette River flood stage, demolition of Slip 1 structures, outfall and stormwater rerouting, waterfront structures and berth replacement, volumes (capacity), and equipment selection.
- **Section 6 – Water Quality** discusses water quality criteria, contaminant mobility testing, and predicted water quality associated with the construction and long-term operation of the CDF, including analysis of both short-term and long-term effects.
- **Section 7 – Habitat Mitigation** generally describes the habitat mitigation components and design process.
- **Section 8 – Applicable or Relevant and Appropriate Requirements** discusses the regulatory requirements that must be achieved during CDF construction and operation.
- **Section 9 – Construction Schedule and Sequencing** describes the duration and order of the CDF construction activities.
- **Section 10 – Engineering Cost Estimate** provides anticipated costs to build the T4 CDF, including direct and indirect construction costs, habitat mitigation, and long-term monitoring.
- **Section 11 – Access and Easement Requirements** provide access and easement information related to construction of the CDF.
- **Section 12 – Institutional Controls** details the actions required to maintain the CDF.
- **Section 13 – References** summarizes the references used in the document.

The appendices provide the following information:

- Appendix A—Contaminant Transport Modeling of the CDF
- Appendix B—Drawings
- Appendix C—Construction Specifications

- Appendix D—Construction Quality Assurance Plan
- Appendix E—Water Quality Monitoring Plan
- Appendix F—River Current Analysis
- Appendix G—Berm Armor Design
- Appendix H—Geotechnical Assessment of the Containment Berm
- Appendix I—Flood Analysis
- Appendix J—Confined Disposal Sediment Management Plan
- Appendix K—Long-term Monitoring and Reporting Plan (Outline)
- Appendix L—Engineering Cost Estimate

2 CONFINED DISPOSAL FACILITY DESCRIPTION

2.1 T4 CDF Project Area

The Port is a port district of the State of Oregon, which owns the T4 uplands between River Miles (RMs) 4.1 and 4.5 on the Lower Willamette River at 11040 North Lombard, Portland, Multnomah County, Oregon. The Port also owns a portion of the submersible and submerged lands in Slip 1 within the CDF project area. The remainder of the submersible or submerged land is owned by the State of Oregon and managed by the State of Oregon Department of State Lands (DSL). The Port has been, and will continue to be, in discussions with DSL as the CDF design progresses to acquire the remaining submersible land from DSL that is necessary to implement the project.

A vicinity map and site plan showing the T4 CDF project area is provided in Figure 1-1.

2.2 Overview of CDF Elements

An at-grade CDF having a footprint of approximately 14 acres will be constructed in T4 Slip 1. Sediments to be placed in the CDF will include sediments over-excavated from the berm key area of Slip 1, dredged sediments from T4 Slip 3, and dredged sediment from other Areas of Potential Concern (AOPCs) in the Portland Harbor Superfund Site. Groundwater modeling results show that sediments from ten high-priority AOPCs in Portland Harbor would be suitable for placement in the T4 CDF (see Appendix A), thus validating the overall effectiveness and applicability of the facility for confining Portland Harbor dredged sediment. The AOPCs that would be suitable for placement in the T4 CDF include potential dredge prisms adjacent to Evraz Oregon Steel, Schnitzer, T4, BP-Arco, Mar-Com Marine, Willamette Cove, Cascade General Shipyard, Swan Island Lagoon, Gunderson, and Fireboat Cove, although estimated dredge volumes have not yet been developed for these sites. However, the CDF must be selected as an appropriate disposal site through the Portland Harbor ROD.

By constructing the CDF to an at-grade surface, the newly gained land can be used for water-dependent commercial purposes. A containment berm will be constructed at the mouth of

Slip 1 to serve as an isolation/retention structure for the dredged sediment. The Port is planning to acquire State of Oregon property for the purpose of constructing the CDF. Section 5 provides more details on the conceptual design of the CDF. The construction elements of the CDF are shown in plan view and in cross-section on Figures 5-1 and 5-2, respectively.

2.3 Overview of CDF Construction Sequencing

Construction of the T4 CDF will be completed in three main stages as summarized below:

- **Stage 1** – Construction of the CDF containment berm.
- **Stage 2** – Filling of the CDF with contaminated sediments from Portland Harbor AOPCs.
- **Stage 3** – Completion of the CDF cover.

The preparation, berm construction, filling, and covering of the CDF is expected to take approximately 7 to 10 years to complete, depending on the schedule of Harbor-wide remedial actions and the availability of suitable dredged material. In-water construction work will adhere to the timing restrictions specified by the Oregon Department of Fish and Wildlife (ODFW; 2000) for the Lower Willamette River, specifically, the late summer and fall in-water work window from July 1 to October 31. After the berm is built and Slip 1 is isolated from the river, work in the CDF will not be bound by these in-water construction windows.

2.3.1 Stage 1 – CDF Preparation and Containment Berm Construction

This stage of the project will occur over a 2-year period and includes the following construction elements:

Slip 1 Preparation. In order to create a CDF in Slip 1, a number of structures need to be demolished and/or relocated. The Slip 1 piers, including Berths 405 and 408, will be demolished using predominantly water-based equipment, with some support from upland equipment. Because work will be conducted from the water, the construction of the

containment berm cannot begin until the demolition is completed. Berth 405 will be replaced with a replacement berth near the containment berm. The footprint of the new pier is offset from the berm footprint, so work on the two structures can occur concurrently.

Stormwater Outfall Rerouting. Another element of preparing Slip 1 for filling is the relocation of the stormwater outfalls. Four Port outfalls and one City of Portland (City) outfall are known to discharge into Slip 1. The majority of the work will occur out of water, so it can be completed outside the in-water work window. However, the daylighting of the outfalls into the Willamette River is in-water work that must be completed during the in-water work window.

Containment Berm Construction. The first task related to containment berm construction is overexcavation of the soft sediments below the berm. Removal of approximately 25,000 cubic yards (cy) of sediment will be completed with an 8-cy clamshell bucket and bottom-dump barge; the overexcavated material will be placed in the head of Slip 1. The overexcavation will then be backfilled with select fill. Once the overexcavation is filled to grade, the contractor will start placement of training terraces using either an 8-cy clamshell bucket or a skip box. Once the terraces are constructed on each side of the berm, select fill will be placed in between using a bottom-dump barge. The containment berm will require approximately 290,000 tons of select fill and 95,000 tons of rock for training terraces. The lower portion of the berm will be constructed from the water during the in-water work window; however, after the berm breaches the water surface, the upper portion will be finished in the dry with upland-based equipment.

2.3.2 Stage 2 – Filling the CDF with Portland Harbor Sediments

The CDF can confine an estimated 670,000 cy of contaminated sediments. Additional material (200,000 to 300,000 cy) beyond that volume may also be placed in confinement depending on the amount of settlement that occurs. The offloading facility is expected to be located at the replacement berth, and would likely be sized to offload 2,000 to 4,000 cy per day assuming a 10- to 12-inch-diameter hydraulic dredge pump, respectively. Assuming there are 100 working days per in-water work season (6 days per week between July 1 and

October 31), the maximum quantity of material that could reasonably be offloaded would be 200,000 to 400,000 cy. As a result, the filling process is estimated to take up to 4 years to complete, although it could take longer or shorter depending on the schedule of the Harbor-wide remedial actions and the availability of suitable dredged material.

2.3.3 Stage 3 – Placement of the CDF Cover

The CDF cover consists of two layers. The lower layer, located directly above the confined dredged sediment, is the import fill layer. The volume of this layer is approximately 464,000 cy. The majority of this material is anticipated to be suitable dredged material brought to the site on haul barges, and offloaded as described in the previous section. As with the contaminated sediment, the rate of placement of the import fill layer will be a function of the supply rate. At a minimum, the filling would require one to two seasons to complete.

The top of the CDF is the CDF cover layer. This layer consists of approximately 272,000 tons of aggregate. This material will be from an upland source, brought to the site by truck and/or barge, and offloaded. It is anticipated that offloading by barge would be done mechanically. The fastest rate that this material could be placed is estimated at 2,000 tons per day. The filling could be completed at any time during the year since it does not involve in-water work. This layer would require 6 to 12 months to construct. In all, placement of the CDF cover material is expected to take 1 to 2 years to complete.

2.4 Overview of CDF Monitoring Activities

Throughout this document and the appendices there are numerous sampling and monitoring requirements both for short-term activities associated with CDF construction and filling, and long-term activities associated with the operation and maintenance of the CDF after it has been filled and closed. Short-term monitoring activities will be used to verify that construction measures are in compliance with CDF design specifications, short-term performance objectives, and water quality ARARs, and are protective of archeologically sensitive areas. Long-term monitoring activities will be used to verify that the T4 CDF is performing as intended, and that the long-term performance objectives and water quality

ARARs are being met. Table 2-1 summarizes the various CDF monitoring requirements, with references to other parts of the CDF design documents where more details can be found.

2.5 Project Performance Standards

The performance standards used to guide the design of the T4 CDF and develop the attendant construction verification and monitoring plans are described in Section 4 (Dredge Plan) and Section 5 (Confined Disposal Facility Design). The current status of ARARs related to the construction and operation of the CDF are summarized in Section 8. However, the final ARARs will be established for the Portland Harbor Superfund Site in the ROD. As a result, the CDF performance standards may be modified by USEPA during the FS and ROD processes. Any such modifications would be accommodated in the later phases of design after the ROD is issued.

3 EXISTING CONDITIONS

Existing conditions in the vicinity of T4, and specifically in Slip 1, were used to inform the CDF design. The primary information describing the existing conditions is the data collected as part of the *Terminal 4 Early Action Engineering Evaluation/Cost Analysis* (BBL 2005), as summarized in the T4 Characterization Report (BBL 2004a), supplemented with additional pre-construction data (see Section 3.6). This information includes data on site use; physical, hydrodynamic, wind, and geotechnical conditions; sediment quality; and other design considerations. The information on existing site conditions, along with how the site is currently used by the Port and its tenants, are important considerations that were factored into the CDF design.

It should be noted that the design and implementation of the Port's Phase I Removal Action in 2008 represents a changed condition at T4 since the EE/CA (BBL 2005) and the Action Memo (USEPA 2006a) were issued. During the Phase I Removal Action, dredging and off-site disposal of contaminated sediment occurred at three areas exhibiting some of the highest chemical concentrations at T4 (including areas adjacent to Berth 411 and Pier 5 in Slip 3, and an area north of Berth 414 near the mouth of Slip 3), and a fourth area was dredged for navigational purposes (adjacent to Berth 410 in Slip 3) (see Section 1.1). In all, nearly 13,000 cy of sediments were removed (Anchor QEA 2009). As a result, the volume and average concentration of contaminated dredged material from T4 that would be placed in the CDF has been reduced, providing additional capacity for dredged material from other sites in Portland Harbor.

3.1 Terminal 4 Physical Characteristics

The T4 uplands comprise about 283 acres (Port of Portland 2002), including the Toyota lease areas, and are generally flat in grade in proximity to the slips. The surface covering is primarily asphalt, with minor areas of gravel and/or ballast associated with the rail lines. The submerged portion of T4 is approximately 38 acres, of which Slip 1, Slip 3, and Wheeler Bay make up about 28 acres; and the area from the mouths of the slips to the Harbor Line comprises an additional 10 acres.

The elevation of T4 generally ranges from 30 to 35 feet mean sea level (MSL) in proximity to the slips (see Figure 1-3). The river stage (i.e., elevation) is typically between 3.7 and 11.7 feet NGVD (also MSL), although higher levels occur during seasonal peak discharges. This range is based on information from the U.S. Geological Survey (USGS) gage at the Morrison Street Bridge at RM 12.8, approximately 8.5 miles upstream from T4. The gage readings at the Morrison Street Bridge are considered representative of the river levels at T4 because the minor tributary inputs between the gage and the site, primarily small seasonal creeks and municipal stormwater outfalls, are negligible compared to the flow in the river (BES 2008), and the Columbia River Datum is only 0.2 feet higher at the upstream gage compared to T4. The diurnal tidal range in the St. Johns area is 2.2 feet at low river stages, and becomes progressively less with higher river stages (USGS 2006).

To the northeast of T4, the topography is slightly sloping, but somewhat variable, rising gradually to about 50 feet MSL. Southeast of T4, the ground surface rises at 5 horizontal to 1 vertical (5H:1V) or shallower to an elevation of about 100 feet MSL, corresponding to the St. Johns area of Portland. To the west of T4, on the opposite bank of the Willamette River channel, are the Tualatin Mountains (Portland Hills), rising relatively steeply at about 1.5H:1V to 3.5H:1V to an elevation of about 1,000 feet MSL.

3.1.1 Slip 1 Physical Characteristics

Slip 1 is approximately 13 acres and is currently underutilized. The mudline elevation in Slip 1 ranges from about -32.3 to -36.3 feet NGVD according to the most recent annual bathymetric condition survey by the Port (see Figure 1-3).

Two large piers exist within Slip 1, from the head of the slip to about the midpoint, on the north and south sides, forming Berths 405 and 408, respectively. The piers are timber-pile supported with concrete columns and interconnecting concrete framework built from about the shoreline and above as the support structure for the pier deck and associated structures. The former grain elevator is located to the north of Slip 1.

Where it is not covered by the pier structures described above, the shoreline conditions in most of the Slip 1 area are either steeply sloped or armored with large riprap. The embankment slope west of the existing pier at Berth 408 does not have slope protection and is showing signs of erosion in the form of scarps and surficial sloughing. Factors that contribute to the erosion of this bank likely include undercutting associated with propeller wash during former uses of the pier, impacts from surface currents and wind waves, and possibly cycles of soil wetting and drying associated with tidal and seasonal variations in river stage combined with the relatively steep slope.

Underpier slopes generally range from 2H:1V to 3H:1V, with the exception of slopes near Berth 408, which range up to 1H:1V (Port of Portland 2002).

3.2 Terminal 4 Hydrodynamic Characteristics

This section summarizes the hydrodynamic characteristics of T4. These characteristics will be used for sizing armor material to prevent erosion of the berm face, and for evaluating potential water quality impacts during dredging of the berm key. The hydrodynamic characteristics of T4 were measured during the EE/CA and summarized in BBL (2004b). It should be noted that data gathered during the EE/CA are mainly representative of seasonal low-flow and low-rainfall conditions. The general hydrodynamic conditions are as follows:

- Hydrodynamics within Slip 1 are affected by variations in river flow, river stage, ship-induced currents, and, to a lesser extent, localized currents from stormwater discharges. In general, given the orientation of the slip relative to the river, river-induced currents in the slip are attenuated (i.e., reduced velocity) compared to the currents in the mainstem of the river.
- Although river-induced currents have an influence on the hydrodynamics at T4, current velocities in a many areas, especially Slip 3, are dominated by propeller-induced currents. In response to the higher current velocities, propeller-induced currents may cause increased turbidity levels and more active sediment transport.
- Ongoing river-induced sedimentation occurs throughout much of the T4 area. Sedimentation rates in areas of the terminal that are removed from active ship traffic

range from 0.6 centimeters per year (cm/yr) in Wheeler Bay to 2.5 cm/yr in Slip 1 (Formation Environmental 2010). In Slip 3, propwash from marine vessels creates localized areas of erosion beneath the active berths, causing resuspension and redistribution of sediment.

Appendices F and G provide more information on hydrodynamic conditions.

3.3 Wind Conditions

Wind data was obtained for the Portland International Airport from the National Climatic Data Center (1976 to 2004) and the Meteorological Resource Center (Webmet.com; 1961 to 1975). Appendix G provides more information on wind data, which was used to determine the appropriate size of material to use as protective armor on the CDF berm.

3.4 Slip 1 Geotechnical Conditions

Geotechnical information was used for various components of the CDF design, in particular, to assess the short-term and long-term stability of the berm, and the stability of shoreline structures near to which dredging will occur.

Subsurface geotechnical conditions in Slip 1 are important to the design process because the CDF berm must be geotechnically stable (i.e., will not subside, slough, or fail under ambient and or earthquake conditions). Therefore, the contents of 24 geotechnical reports prepared for past projects within T4 were reviewed. These data were screened for applicability to the project relative to proximity and exploration methodology. Over 80 borings and 10 cone penetrometer tests (CPTs) were included in this review. Of the borings reviewed, 11 were found to have been advanced within the general CDF area and completed with modern drilling equipment. The most significant data available from the borings consisted of standard penetration test (SPT) blowcounts. The SPT test results were summarized and corrected for rod length, overburden pressure, and hammer efficiency. For all corrections, mid-range values as recommended by the Federal Highway Administration were utilized. SPT results provide a measure of the density or strength of the sediment.

The following soil units were encountered in the geotechnical explorations:

- **Loose to Medium Dense Sand Fill.** In general, the upland areas adjacent to the CDF were constructed of loose to medium dense sand fills. The thickness of the fill layer ranges from approximately 17 to 35 feet. Gradation testing of the sand fills indicates fines content ranging from approximately 5 to 15 percent.
- **Soft Surface Sediments.** The floor of Slip 1 is covered by soft clayey, silty, and sandy sediments. Based on the sediment cores completed for the EE/CA (BBL 2005), the soft sediment layer generally ranges from about 0 to 3 feet in thickness.
- **Sand.** The majority of Slip 1 is underlain by a dark grey, medium dense to dense, medium to coarse sand. This sand is consistent with Willamette River alluvium. Based on past laboratory testing, the fines content of this sand ranges from 3 to 8 percent. The upper 5 to 10 feet of this formation can be disturbed and loose, likely owing to ongoing alluvial processes. Below this disturbed material, the density of the sand is relatively uniform. Based on a review of 138 corrected SPT values, the average blowcount value in this formation was 21 blows per foot (bpf) with a standard deviation of 9.3 bpf. The distribution of blowcounts indicates little to no variation with depth. Only one SPT sample had a measured blowcount of less than 10 (indicative of loose sand), and seven samples had blowcounts of more than 30 (indicative of dense sand). With little variation, this formation can be modeled as a medium dense, relatively clean sand.
- **Troutdale Gravel.** Dense, partially cemented deposits of gravel and sand were encountered at depth below the alluvial sands. This deposit likely consists of the Troutdale Formation.

Soil unit information was used to develop site models for both geotechnical stability of the berm and groundwater contaminant transport through the CDF.

3.5 Slip 1 Hydrogeologic Conditions

A summary of hydrogeologic conditions in Slip 1 is provided below. This information was used as the basis for the groundwater contaminant transport analysis of the CDF (see Appendix A).

After the CDF is constructed and filled, groundwater will flow through and around the facility toward the Willamette River. The groundwater pathway must be characterized to determine whether any of the contaminants in the contained dredged material will be transported to the Willamette River at levels of concern. A conceptual site model of the groundwater flow system was developed based on the hydrogeologic conditions at T4, and this formed the basis of the of groundwater contaminant transport model (see Appendix A).

The hydrogeology of T4 is summarized in Appendix D of the EE/CA report (BBL 2005), and presented in greater detail in the T4 Characterization Report (BBL 2004a). BBL (2005) summarized the geologic stratigraphy adjacent to and beneath the proposed CDF. The stratigraphy consists of the following:

- **Upland Fill Material**, consisting of medium to fine sand ranging in thickness from about 5 to 40 feet.
- **Unconsolidated Alluvial Deposits**, consisting of fine sand west of the former shoreline and interbedded layers of gravel, sand, silt, and clay to the east of the former shoreline, ranging in thickness from 120 to 160 feet
- **Troutdale Gravel**, encountered at an elevation of approximately -112 to -166 feet NGVD.

The groundwater flow direction is toward the Willamette River. In nearshore locations, groundwater in the upland fill material, unconsolidated alluvial deposits, and Troutdale Gravel is in direct hydraulic connection with the river. As a result, groundwater elevations respond rapidly to changes in river stage.

3.5.1 Boring and Well Inventory in Site Vicinity

A records review was conducted to inventory groundwater wells within a half mile of the CDF and water supply wells within one mile of the CDF. The results are compiled in Table 3-1 and Figure 3-1. No municipal water supply wells were identified in the search radius.

Well records were reviewed on the Oregon Water Resources Department web page at http://apps.wrd.state.or.us/apps/gw/well_log/ for wells located in Township 1N, Range 1W, Sections 1 and 2 and Township 2N, Range 1W, Sections 35 and 36. The resulting well list was reduced by all wells with records of abandonment, locations listed as geotechnical borings, wells located across the Willamette River, and wells outside the search radius described above. A total of 164 wells were identified. Most wells are monitoring wells associated with industrial properties, including records of 71 wells at T4. Four wells listed as "domestic/irrigation" wells were identified within a 1-mile radius; however, these wells were installed in 1944 when the property was agricultural. The property has since been redeveloped as industrial. Although there is no record of abandonment, these wells are likely no longer in use. The use of the remaining industrial supply wells is unknown.

3.5.2 Upgradient Groundwater Quality

Groundwater quality upgradient of the CDF was evaluated to determine whether existing site contamination could affect the quality of groundwater migrating through the CDF. A comprehensive investigation of groundwater quality was conducted as part of the Terminal 4 Slip 1 Remediation Investigation (ACA and NewFields 2007; Formation Environmental 2010). Chemical analytical results from seven monitoring wells surrounding Slip 1 and within 200 feet of the slip shoreline were reviewed (including wells MW-03, -08, -09, -10, -11, -12, and -26; see ACA and NewFields 2007). The wells were analyzed for metals, polycyclic aromatic hydrocarbons (PAHs), and PCBs, and screened against the water quality criteria in Table 6-1. Four rounds of data were collected at most wells.

In general, no groundwater plumes were identified on the uplands. No PCBs were detected in any of the Slip 1 monitoring wells at any time. PAHs were infrequently detected in Slip 1

shoreline wells at estimated concentrations below the laboratory reporting limit (0.02 micrograms per liter [μg/L]). All of the detected PAH concentrations were below fish consumption, drinking water, and aquatic life criteria. Total concentrations of CDF target metals (cadmium, copper, lead, and zinc) were at or near background concentrations and below drinking water MCLs, as appropriate. All dissolved metals concentrations were well below their respective aquatic life criteria.

Based on these data, upgradient groundwater is not expected to significantly affect the quality of groundwater in the T4 CDF. The Terminal 4 Sediment Recontamination Analysis Approach reached a similar conclusion: "*The groundwater monitoring results, screening evaluation of the data obtained, and a "weight of evidence" evaluation support that there are no COI at the Facility at concentrations that could cause significant, if any, degradation of water in the river or slips or pose unacceptable risk to human health from fish consumption*" (Formation Environmental 2010).

3.6 Slip 1 Sediment Chemistry and Physical Properties Data

A number of sources of sediment chemistry data for T4 are available from previous investigations. The Port has been investigating the nature and extent of sediment contamination at T4 since before 1988. Other organizations, including the U.S. Army Corps of Engineers (USACE), USEPA, and ODEQ, have investigated the nature and extent of sediment contamination in the Willamette River and have collected sediment samples in the vicinity of T4 as part of their investigations (BBL 2004a). More recently, sediment chemistry data were collected as part of the T4 EE/CA (BBL 2005).

The EE/CA is the primary source of sediment chemistry data for the CDF design (BBL 2005). Other historical reports containing sediment chemistry data with acceptable quality and documentation in the Slip 1 area include:

- USEPA Portland Harbor Sediment Investigation Report (Weston 1998)
- Willamette River Channel Maintenance Characterization Study (USACE 1999)

Sediment quality data as it pertains to construction of the T4 CDF is evaluated in Section 6.2.1, and a brief summary of that data is presented here. Refer to Table 6-3 for a statistical summary of sediment analytical results in the berm key dredge area and in the Slip 3 removal areas (including the Phase I removal area, which was dredged and disposed offsite in 2008, and the Phase II removal area, which is proposed for placement in the T4 CDF).

In Table 6-3, the average concentrations in the various remediation areas are compared to threshold effects concentrations (TEC values) and probable effects concentrations (PEC values) from MacDonald et al. (2000). In the berm key dredge area, metals, DDx, and PCB concentrations are near or below the TEC values, and PAHs are between the TEC and PEC values, indicating this to be a relatively low risk area. In the Slip 3 removal areas, the average lead and PAH concentrations are above the PEC values, and the other metals, pesticides, and PCB concentrations are between the TEC and PEC values. This material is suitable for placement in the T4 CDF, as discussed in Appendix A, Attachment 1 to the Groundwater Model Input Parameter Memorandum.

3.7 Site Uses

3.7.1 Terminal 4 Tenants and Adjacent Properties

The history of the T4 area and historical tenant operations are described in detail in the EE/CA Work Plan (BBL 2004b) and in Appendix A of the EE/CA (BBL 2005). Appendix A of the EE/CA provides a chronology of facility development between 1906 and 1999, a chronology of dredging and filling activity between 1917 and 2003, and a detailed description of T4 operations beginning in 1917.

Current tenants at T4 near Slip 1 and Slip 3 are Cereal Food Processors, International Raw Materials (IRM), Rogers Terminal, Kinder Morgan Bulk Terminals (KMBT), and Union Pacific Railroad. Adjacent property owners include Schnitzer Steel Industries, Northwest Pipe and Casing, and Burgard Industrial Park (housing both Boydstun Metal Works and Western Machine Works), all of which are under Voluntary Cleanup Program Agreements

with ODEQ for remedial investigations of those properties. Toyota leases land from the Port on the southern portion of T4 facility adjacent to Berth 414.

At this time, the only active tenant operating within Slip 1 is IRM. Currently, IRM imports liquid bulk materials at Berth 408. Both barges and ships call on the berth. Vessel calls are very infrequent, typically less than once per month.

Berth 401 is currently inactive; however, IRM is planning to relocate its operations to that berth, allowing Berth 408 to be shut down prior to CDF construction. Potentially, other tenants may also start operating at Berth 401 during the timeframe of this project.

It is important to consider site uses during the design process to ensure that the impact of CDF construction activities on existing tenants will be minimized, and the CDF construction will not be compromised by other ongoing site operations.

3.7.2 Typical Vessels that Call at Terminal 4

Local pilots were contacted to determine typical operational conditions at T4. Commercial vessels that call on Berth 411 in Slip 3 are "Panamax" size, deep-draft Bulk Carrier (primarily grain) ships. While Berth 401 is not currently in operation, future operations at the berth are likely to include similar vessels that call on Berth 411 in Slip 3. These vessels are assisted in and out of port by large, privately-owned tractor tugs. Appendix G provides more information on vessels that call on the site and their characteristics.

4 DREDGE PLAN

Dredging is the physical removal of sediments from a specific area. As part of the CDF construction, dredging is required beneath the containment berm to remove soft sediment that may compromise the stability of the berm if it was left in place. The depth of removal beneath the berm is governed by geotechnical conditions rather than sediment concentrations.

4.1 Basis of Design

The dredge design objectives were developed in consideration of the dredging performance standards described below.

4.1.1 Dredging Performance Standards

The performance standards for dredging include:

- Performing the dredging in a manner that minimizes, to the extent practicable, water quality exceedances of field parameters (turbidity, dissolved oxygen [DO], pH, and temperature), and contingent chemical parameters outside the compliance boundary.
- Dredging and disposing of sediments in a manner that minimizes dredging residuals and prevents recontamination of adjacent sediments.
- Dredging to a depth that provides a competent foundation to support construction of a stable CDF berm.

4.1.2 Dredge Design Objectives

The following dredge design objectives were used to develop the dredge plan:

- **Minimize water quality impacts outside of the construction zone.** The need to meet water quality standards and compliance criteria factored into the selection of dredging methods. Water quality monitoring activities, standards, and criteria for dredging are described in detail in the WQMP (Appendix E). The dredging of material in the berm key area must meet, to the extent practicable, the water quality standards and criteria defined in the WQMP and the forthcoming USEPA Water

Quality Monitoring and Compliance Conditions Plan (WQMCCP) that will be issued for this work.

- **Provide a competent substrate to support a stable CDF berm.** Dredging beneath the CDF containment berm must be performed to remove soft and loose surficial sediment that might otherwise compromise the stability of the berm. The dredging will expose more competent subsurface material that provides a stronger foundation on which to build the berm.

4.1.3 Additional Considerations

Additional considerations that helped guide the development of the dredge plan included the following:

- Physical characteristics of the site, including dredging in 30- to greater than 50-foot water depths
- The need to minimize disruption to the Port's tenant operations at T4
- The need for dredging technology to be compatible with the CDF such that dredged material removed from the berm key can be placed into the head of Slip 1 prior to filling the CDF with other material from Portland Harbor

The remainder of this section describes the detailed development of the dredge prism.

4.2 Dredge Design

The berm key dredge plan (as shown on Figure 4-1) was developed to remove soft sediment that may compromise the stability of the berm. The target dredge depths were developed to remove these soft sediments and, after factoring in engineering considerations and overdredge allowance, the dredge target depth includes a majority of the soft sediments.

4.2.1 Volume

The neatline dredge prism volume was calculated. Because of dredging limitations, the actual volume dredged will be somewhat higher than this neatline volume. The allowable

overdredge volume was computed by taking the spatial footprint of the dredge prism and multiplying that area by a 12-inch allowable overdepth.

The neatline dredging volume for the area beneath the containment berm is approximately 33,000 cy. The 12-inch allowable overdepth volume is approximately 6,000 cy, for a total approximate dredging volume of 39,000 cy.

4.2.2 Equipment Selection

The selection of appropriate dredging equipment is necessary to balance effectiveness, engineering feasibility (given site constraints; e.g., material density, proximity to structures, and potential for encountering dredging obstructions such as debris, rock, logs, pilings, etc.), potential for environmental impacts, potential for impacts to Port/tenant operations, cost, and scheduling. Some of the primary issues considered when selecting appropriate equipment included:

- Availability and types of equipment
- Maximizing environmental effectiveness
- Production rate capability
- Maintaining navigation access
- Minimizing disruption of Port/tenant operations
- Water depths
- Thickness of dredge prism
- Geotechnical properties of sediment targeted for removal and underlying materials
- River currents and tides
- Presence of significant debris
- Minimizing short-term water quality impacts
- Proximity to structures
- Accessibility of equipment

Mechanical dredging will be used for the berm overexcavation. An 8-cy clamshell bucket is anticipated for mechanical dredging (input from the contractor is required before making the

final equipment selection). Use of an "open-dredge" clamshell bucket is supported by T4 dredging elutriate test (DRET) results, as well as the Phase I water quality monitoring results which indicate water quality effects from dredging the berm key are expected to be negligible (see also Section 6.2.1). Therefore, use of a "closed" environmental bucket is not expected to be necessary, although it is listed as a potential best management practice (BMP) in the WQMP (Appendix E). During the Phase I work, an environmental bucket had limited success dredging the more dense and sandy material due to its lighter weight.

Material from the excavation of the berm key will be placed at the head of Slip 1 (see Figure 4-1).

4.2.3 Overdredge Allowance

Depth control with dredging equipment has certain tolerances. To improve the reliability of achieving the design depths, an overdredge allowance is commonly given to the contractor. The contractor is paid for this allowance, but not for material removed below this allowance. A 1-foot overdredge allowance will be specified for berm overexcavation.

4.2.4 Construction Quality Control Related to Dredging

The CQAP (Appendix D) describes in detail the measures that will be implemented during construction to ensure that the design objectives of dredging are met and the performance standards are achieved. There are two specific QC measures that will be implemented to ensure that the dredge design is completed to meet the design objectives:

1. Achieving the specified dredging depths and lateral extents
2. Meeting water quality monitoring standards outside of the construction zone

Each of these measures is described in more detail below:

- **Achieve specified dredging depths and lateral extents.** Confirmation must be obtained that the sediments were removed to the target elevations and full lateral extents as depicted on the Drawings (Appendix B) and Construction Specifications (Appendix C). This will be accomplished by completing post-dredge hydrographic

surveys of the berm key area and comparing them to the dredge plan. Any high areas above the target elevations in the dredge plan will be re-dredged by the contractor.

- **Meet water quality monitoring standards outside of the construction zone.** To ensure compliance with water quality criteria outside of the construction zone, monitoring of conventional field parameters (turbidity, DO, pH, and temperature) and contingent laboratory parameters (total suspended solids [TSS] and target chemical analytes) will be performed during dredging activities as described in the WQMP (Appendix E). Exceedances of water quality standards and criteria will trigger the implementation of additional BMPs (e.g., operational or engineering controls) to mitigate the water quality impacts of the dredging activities.

4.3 Dredged Material Placement

Sediment dredged from the berm key will be placed in the head of Slip 1 prior to construction of the berm at the mouth of the slip. As described in Section 4.2, approximately 39,000 cy of material will be dredged and placed on bottom-dump barges. The capacity of the haul barges will be 1,000 to 2,000 cy. After the barge is loaded, it will then be moved to the head of the slip for open-water placement of this material. In consideration of sediment quality in the berm key dredge area, dredging elutriate testing of T4 sediments, and Phase I water quality monitoring results, it is expected that turbidity will be the primary water quality concern during open-water placement (see Section 6.2.1). Water quality monitoring of open-water placement activities will be conducted in accordance with the to-be-developed USEPA WQMCCP for this project.

5 CONFINED DISPOSAL FACILITY DESIGN

As described in the EE/CA (BBL 2005), a CDF is an engineered structure for permanently containing dredged material in a nearshore environment. Confinement berms or dikes enclose the disposal area below the surface of the adjacent surface waters, thereby isolating the dredged sediment from adjacent waters. Confined disposal in a CDF is a proven technology that isolates contaminants from the aquatic environment and ensures protection of human health and the environment. Over the last 20 years, CDFs have been successfully designed and constructed at many other Superfund sites around the country and within USEPA Region 10. The remainder of this section describes the design basis and specific design information for constructing a CDF in Slip 1 at T4.

5.1 Basis of Design

The EE/CA (BBL 2005) and Action Memo (USEPA 2006a) established the approach of building a CDF at T4 with a permeable berm, consistent with other operating CDF designs in USEPA Region 10. The CDF design was conducted according to guidance procedures contained in USACE's Confined Disposal of Dredged Material manual (USACE 1987) and procedures followed for the CDFs constructed in St. Paul Waterway (City of Tacoma 2003) and Port of Tacoma Slip 1 (Occidental Chemical and Port of Tacoma 2003), both located in USEPA Region 10. As described for the development of the dredge prism, the basis of the CDF design relates to performance standards and design objectives and related criteria. As described below, these elements were used to guide the design of the CDF. A layout of the CDF that will be constructed in Slip 1 is shown on Figure 5-1.

5.1.1 CDF Performance Standards

On February 18, 2010, USEPA provided the LWG and the Port with a set of performance standards to be used in evaluating all CDF alternatives in the Harbor-wide FS, including the T4 CDF (USEPA 2010a). The intent of the USEPA CDF performance standards and further details regarding their implementation were clarified in subsequent correspondence between the LWG and USEPA (LWG 2010a and 2010b), as well as in notes from the April 28, 2010

meeting of the Port, USEPA, and its partners. The complete list of USEPA CDF performance standards and all related clarifying documents are provided in Appendix A.

The USEPA-directed performance standards will be met with the T4 CDF design presented in this DAR. Table 5-1 provides a list of USEPA CDF performance standards with an index of references to specific sections of the DAR in which those standards are addressed. Some of the key requirements of the USEPA CDF performance standards are summarized below.

- The CDF shall be designed to contain the volume, level, and characteristics of contaminated sediment to be placed within it, using site-specific designs as needed to accommodate the specific contaminated materials proposed for disposal. The design should consider representative sediment contaminant concentrations and contaminant mobility data obtained from, or estimated for, sediments from Portland Harbor sites where dredging is a reasonably anticipated remedial action.
- The CDF shall be designed to minimize water flow into and out of the CDF, including preventing or restricting preferential flow paths of clean or contaminated groundwater into or out of the CDF.
- The CDF shall achieve confinement of all hazardous substances disposed of in the facility through the groundwater pathway so that the CDF does not contribute any long-term discharge and/or release of contaminants above ARARs under federal or state law for surface water in the Lower Willamette River.
- The CDF shall limit contaminant concentrations in groundwater exiting the CDF to levels below USEPA's national recommended chronic water quality criteria for both aquatic organisms and fish consumption by humans (17.5 grams per day [g/day]), more stringent Oregon water quality standards, and maximum contaminant levels (MCLs) without dilution in the water column. The base case analysis shall not consider biodegradation. Groundwater exit concentrations are to be met in the berm, immediately prior to entering the surface water, not including riprap. It was subsequently clarified that groundwater exit concentrations would be spatially averaged over the area of the CDF berm face to evaluate fish consumption criteria.

- The CDF berm shall be designed to:
  - Provide a static safety factor of 1.5 or greater and a seismic safety factor of 1.1 or greater. The design seismic event shall correspond to a 10 percent probability of exceedance in 50 years.
  - Be resistant to erosive forces by the largest of 100-year flood flow, 100-year waves, and vessel-induced waves from typical passing vessels as well as vessels that operate in the area.
  - Have an appropriate gradation to allow transport of groundwater while retaining (filtering) sediment during filling and after closure.
- The CDF shall not measurably increase the 100-year flooding stage or decrease flood storage of the Willamette River.
- The CDF shall minimize releases of 303(d) listed contaminants to the extent practicable.
- The CDF berm and related components shall be constructed in a manner that complies with water quality ARARs during construction and filling of the CDF.

5.1.2 CDF Design Objectives and Related Criteria

The CDF design objectives were developed in consideration of the CDF performance standards listed above. The following design objectives and related criteria were used to design the CDF:

- **Develop a containment berm that is stable and will contain the confined sediment under a design-level seismic event and withstand erosion-generating forces.** The configuration of the berm was designed to be a stable structure based on a static factor of safety of greater than 1.5. In addition, the structure was designed to have a seismic factor of safety of 1.1 or greater and to withstand erosion from river currents associated with a 100-year flood, wind-induced waves typical of the T4 site, and propeller wash generated by the size of vessels that typically transit into and out of T4.
- **Select berm materials with permeabilities that allow transport of groundwater through the berm structure while retaining solids.** The berm is designed to be permeable and to allow the transport of groundwater through the structure, while

containing the contaminated sediments in the CDF behind the berm and prevent them from "piping" into the berm material.

- **Design the berm such that its permeability, composition, and configuration result in groundwater exit concentrations that are protective of the beneficial uses in the Willamette River.** Modeling of groundwater moving through the CDF berm with specified permeability, composition, and geometry was used to predict chemical concentrations that would be transported to the Willamette River. The modeling was performed to confirm that chronic water quality criteria, fish consumption criteria, and drinking water MCLs (as directed by USEPA) are met in the porewater of the CDF berm (not including riprap) without dilution in the water column over the design life of the facility.
- **Minimize water quality impacts to the extent practicable outside of the construction zone.** The need to meet water quality criteria for both conventional parameters (e.g., turbidity, DO, pH, and temperature) and contingent chemical parameters (e.g., TSS and target laboratory analytes) factored into the selection of berm material placement methods and the operation of the CDF during filling. In particular, the filling operations will be managed to achieve zero direct discharge of effluent from the facility (i.e., no weir discharge). Water quality monitoring activities, standards and criteria for construction of the berm are described in the WQMP (Appendix E).

5.1.3 Additional Considerations

Additional considerations that were essential to the design of the CDF include the following:

- Consolidation and settlement characteristics of the dredged material placed within the CDF.
- The contaminated sediments behind the berm must remain saturated to minimize leachability. Groundwater modeling was used to determine the elevation at which material will be saturated at all times. This elevation was determined to be 9.5 feet NGVD, which is the upper elevation at which contaminated sediments will be placed into the CDF.

- Future plans for the use of the upland terminal area created by completion of the CDF.
- The assumption that, in the future, the navigation channel outside of the berm may be dredged to a maximum depth of -46 feet NGVD.
- The CDF must not impact the Willamette River flood stage.
- Slip 1 structures must be demolished prior to material placement in the CDF.
- Stormwater outfalls that currently enter Slip 1 should be re-located prior to placement of material into the CDF.
- A replacement berth for those demolished in Slip 1 will be constructed parallel to the berm face.

5.2 CDF Berm, Fill, and Surface Layer Design

This section describes the design of three different CDF components—the containment berm, dredged fill layers, and the surface layer. Each component is described in detail below.

5.2.1 Containment Berm Constructability

Contractors commonly build underwater berms using training terraces (sometimes called training dikes). The terraces are constructed of quarry spalls or smaller sized riprap. They are constructed at the edges of the berm and are used to contain the select fill placed in between them. Because the select fill cannot be compacted, as is done with traditional berm or embankment construction above water, the training terraces are used to contain the select fill. If the training terraces were not used, the select fill could not be placed at the specified 2H:1V side slope. The side slopes would likely be closer to 3H:1V or 4H:1V, which would require more aquatic area and reduce disposal capacity. The approach of using training terraces was similarly used for the construction of the Milwaukee Waterway, Eagle Harbor (West Harbor Operable Unit), Port of Tacoma Slip 1, and St. Paul Waterway containment berms in USEPA Region 10.

The optimal size of the training terraces is a function of rock costs and ease of construction. For instance, larger training terraces allow the select fill to be placed more efficiently at a

lower cost; however, because the training terraces are larger, they require more rock and are more costly. On the other hand, smaller training terraces use less rock and more select fill, so they have lower material costs. However, they require more time to construct, reducing productivity and increasing costs. Therefore, there is an optimal size that balances production and material costs. The CDF capacity for contaminated sediment and the potential for impacts to the Willamette River floodway are additional factors to be considered in the design of the training dikes and the berm.

There are two primary design elements that are impacted by the size of the training terraces: 1) seismic stability of the berm; and 2) contaminant transport through the berm. The Conceptual (30 Percent) Design evaluated the size of training terraces and found that the berm would contain the confined sediments during a design-level earthquake with training terraces ranging from 3 to 20 feet high. A review of the berm design by a regional contractor indicated that the use of larger training terraces would greatly improve constructability. During Conceptual Design, however, the berm design included a habitat bench near elevation 0 feet NGVD which increased the stability of the structure. Subsequently, at the request of USEPA and its partner agencies, the habitat bench was removed from the design. A geotechnical evaluation of the revised berm geometry indicates training terraces no smaller than 20 feet high should be used. In addition, the geotechnical evaluation indicates a toe buttress should be placed on the outward face of the berm from the base up to elevation 0 feet NGVD to achieve the required factors of safety (see Figure 5-2 and Appendix H). The toe buttress would be constructed of toe buttress material and Armor Material Type 5.

Contaminant transport modeling of the containment berm was performed using 20-foot-high training terraces (see Appendix A). Through the modeling analysis, it was determined that water quality criteria would be met in the porewater of the berm without dilution in the water column, as directed by USEPA (2010a), thereby protecting the beneficial uses of the Willamette River.

5.2.2 Containment Berm Stability

Appendix H presents a detailed summary of the CDF containment berm geotechnical design. Figure 5-2 shows a generalized cross section through the containment berm.

The conceptual berm configuration evaluated for stability was modeled after the containment berms used for the St. Paul and Port of Tacoma Slip 1 CDFs. The conceptual design of the berm incorporates 2H:1V inward and outward faces. Similar to the other Region 10 CDFs, the berm material will be constructed of sandy gravel or gravelly sand, and training terraces consisting of quarry spalls will be placed at both ends of the CDF to assist with construction. The training terraces will be 20 feet high, built with 2H:1V outer side slopes and 1.5H:1V inner side slopes.

In front of the berm, a toe buttress will be placed from elevation 0 feet NGVD to the toe of the berm. The width of the toe buttress will be 5 feet at elevation 0 feet NGVD tapering to 20 feet wide at the toe of the berm. The toe buttress will consist of toe buttress material and Armor Material Type 5 as shown on Figure 5-2.

Behind the berm, contaminated dredged sediments will be placed to elevation 9.5 feet NGVD or below so that they will remain in a saturated condition at all times. Fill material will be placed above the contaminated sediment. The upper portion of the CDF will be filled with imported granular materials (see Figure 5-2).

5.2.2.1 Methods of Stability Analysis

A number of typical cross sections through the berm were developed and analyzed for global stability, similar to the approach used to assess the stability of the St. Paul and Port of Tacoma Slip 1 CDFs in Puget Sound. Based on the preliminary analysis, the cross section through the middle of the berm was determined to be the critical section (i.e., possessing the lowest factors of safety).

Stability modeling was conducted with GeoSlope's software package SLOPE/W. The software employs a limit equilibrium methodology for calculating a factor of safety against sliding or sloughing. The analysis was completed using Spencer's method, which satisfies both moment and force equilibrium.

Soil parameters used in the analyses were developed based on the results of the geotechnical review. SPT blow counts, CPT values, laboratory strength testing, and gradation data were used in concert with published references to develop preliminary strengths and unit weights. Statistical distributions were applied to each value based on a subjective evaluation of the potential variability of assumed and measured data. The values assumed for non-native soils (dredged material) are comparable to assumed values used in designing the St. Paul and Port of Tacoma Slip 1 CDF facilities. A summary of soil parameters employed in the analyses is presented in Appendix H.

The berm section was evaluated for the following four cases:

- Short-term (during filling) static (Section 5.2.2.2)
- Long-term (post-filling) static (Section 5.2.2.3)
- Long-term (post-filling) seismic (Section 5.2.2.4)
- Long-term post-earthquake static (Section 5.2.2.5)

For each case, the slope stability factor based on the most critical circular slip planes was evaluated. The calculated slip planes that pass anywhere through the berm, as well as slip planes that pass through the contaminated dredged material, were also evaluated to determine which of these have the lowest factor of safety. These slip planes are referred to as the shallow slip plane and the deep slip plane, respectively. The deep slip plane represents a deep-seated stability failure that could potentially result in release of contaminated sediment. A graphical representation of the results of each of these analyses is shown in Appendix H.

5.2.2.2 Short-Term Static Stability

The critical section for the short-term static stability reflects the conditions present during filling of the CDF when the entire CDF may be used to decant hydraulically dredged sediments. The analysis was based on the most critical case for this condition, with the dredged sediment placed, the water in the CDF to within 2 feet of the crest of the containment berm, and the river at a low water stage. Since the CDF will not be filled hydraulically, this conservative condition is unlikely.

Based on these very conservative assumptions, the slope stability factor of safety relative to a shallow slope movement was 1.52. The factor of safety for slope stability for a deep slope movement that would intersect the decant water in the pond was 1.72. These values indicate that the berm would be stable during hydraulic filling. Note that the condition modeled is not anticipated to actually occur because mechanical dredging is the likely method of filling the CDF for most, if not all, of the AOPCs in Portland Harbor.

5.2.2.3 Long-Term Static Stability

The long-term static stability case reflects a finished condition for the CDF. For this case, it was assumed that the groundwater table within the CDF would approach current levels observed inland of Slip 1. The factor of safety for the long-term static stability analysis was 1.62. The factor of safety for deep slope movements was 2.00. These values indicate that the berm will be stable under normal operating conditions.

5.2.2.4 Seismic Stability

In accordance with the USEPA-approved EE/CA (BBL 2005) and the Action Memo (USEPA 2006a), the CDF and the containment berm were evaluated for stability against a contingency level seismic event. The contingency level event (CLE) represents an earthquake with a 10 percent probability of exceedance in 50 years (i.e., 475-year return period). During the CLE, waterfront facilities may suffer significant damage that would impair operations and major repair work would likely be required, but no catastrophic failure

would develop. Although design components, such as a CDF containment berm, may suffer deflections, containment of the contaminated sediments would not be jeopardized.

The Action Memo (USEPA 2006a) requires the following design-level geotechnical seismic analysis for assessing the stability of the CDF containment berm:

- Detailed characterization of seismic sources (known regional faults) in the vicinity of the T4 CDF for development of a site-specific seismic hazard analysis.
- Development of input ground motions from seismic sources considering site-specific geotechnical considerations.
- Evaluation of liquefaction potential for CDF containment berm, foundations soils, dredge sediment, and surrounding site soils potentially contributing to instability of the CDF during the design-level earthquake, including evaluation of liquefaction-induced deformations and lateral spreading.
- Evaluation of slope stability and deformation for both pseudo-static and post-earthquake conditions.
- Development of a contingency plan for post-earthquake inspection and repair.

The seismicity of the Portland Metropolitan area, and hence the potential for ground shaking, is controlled by three separate fault mechanisms. These are the Cascadia Subduction Zone (CSZ), the mid-depth intraplate zone, and the relatively shallow crustal zone. Descriptions of these potential earthquake sources are presented in Appendix H. These sources were used to determine a design peak ground acceleration (PGA) to be used for seismic stability assessment.

A Probabilistic Seismic Hazard Evaluation (PSHA) using the most up-to-date information from agencies such as the USGS, Department of Geology and Mineral Industries (DOGAMI), and the Oregon Department of Transportation (ODOT) was completed to determine the appropriate seismic acceleration to use with stability design. This information has been supplemented with seismic hazard data from numerous other technical resources. On the basis of the PSHA analyses, the two primary seismic sources considered for design purposes have been considered to include: 1) a magnitude 9.0 mega-thrust earthquake along the CSZ

having a source-to-site distance of roughly 96 kilometers (km); and 2) a magnitude 6.2 shallow, crustal event with a source-to-site distance of 12 km. The relative contributions of the two closest faults, the Portland Hills Fault and the East Bank Fault, to the cumulative seismic hazard are small for the return period of interest (475 years). In light of the low slip rates and corresponding low rates of seismicity estimated for these faults, and based on input from DOGAMI personnel who are actively studying these faults (Madin 2006), these two potential seismic sources have not been incorporated in the current analyses. The design team has selected the following scenarios for subsequent analysis of dynamic soil response, soil liquefaction, and design for the CDF berm:

- Magnitude 9.0 CSZ event resulting in bedrock ground motions of 0.14g beneath the T4 CDF.
- Magnitude 6.2 crustal source resulting in bedrock ground motions of 0.20g.
- The intraslab (or intraplate) source has been shown to contribute the least to bedrock peak acceleration and spectral accelerations (0.2 and 1.0 second), and was therefore omitted from further consideration in the analyses.

Appendix H presents the seismic hazard analysis. A dynamic soil response analysis was then performed to estimate the PGA at multiple locations in the berm for the different seismic events. Dynamic soil response analysis considers the amplification effects of site soils above the bedrock to estimate a PGA at the containment berm. The results of this analysis determined that a PGA of up to 0.33g for a 475-year return interval event was appropriate for the site (see Appendix H).

5.2.2.5 Pseudostatic Stability

The seismic case was developed based on the 475-year return interval event. In accordance with widely accepted analysis methods, a value equal to one-half of the peak horizontal acceleration developed from the seismic analysis was used to assess pseudostatic stability.

Results of the analysis show that the factor of safety relative to shallow, surface movement was 1.00. The factor of safety for deep shear surfaces that intersect the dredged sediments

was 1.10. This analysis indicates that the potential exists for displacement of the berm toe under a design-level earthquake event. However, the remaining berm possesses sufficient residual strength to contain the contaminated sediments within the CDF.

The impact of a progressive failure of the toe of the berm resulting from a design earthquake was evaluated. In order to evaluate this potential, it was assumed that the deepest failure surface with a pseudostatic factor of safety of less than 1.1 occurred. Further, it was conservatively assumed that all of the material within the slide block was removed by river currents. For strength values, the reduced strengths described in Section 5.2.2.6 were used. These values include strength reductions for excess pore pressures and liquefaction. Ultimately, these phenomena would be short-lived. Even with these conservative assumptions, the results of this analysis indicate that the factor of safety against a further shallow failure is in excess of 1.3.

5.2.2.6 Post-Earthquake Stability

For the post-earthquake stability scenario, the strength parameters of the berm and foundation materials used in the static case were modified to account for strength loss from the seismic event.

The potential for soil liquefaction during seismic ground shaking is generally associated with loose to medium dense, saturated, non-plastic sands, and some very soft, recently deposited silt soils. The soils present in the area of Slip 1 consist of medium dense sands overlying very dense gravels and cobbles. The medium dense sands invariably have some liquefaction potential during near field earthquakes. Appendix H presents a summary of the conceptual liquefaction analysis completed to date. This analysis indicates that some of the foundation sediments below the CDF containment berm are susceptible to liquefaction. The post-earthquake stability analysis considers the liquefaction under the berm.

The factor of safety relative to shallow, surface movement on the berm face was greater than 1.04. The factor of safety for the deep shear surfaces that potentially intersect the dredged

sediments was 1.35. These values indicate that the berm will be stable after a design-level earthquake.

5.2.2.7 Seismically-Induced Berm Deflection

The post-earthquake stability analyses provide the margin of safety against lateral ground deformation for conditions that exist immediately after the ground shaking has stopped. At this time, it is conservatively assumed that any excess pore pressures that may have been generated during the earthquake event still exist in the soil layers and possible degradation in soil strength is incorporated into the stability model. While this procedure provides a useful parameter (safety factor) for assessing the likelihood of permanent earthquake-induced deformations, it does not provide explicit estimates of the likely slope movement. As previously addressed, the CDF berm can undergo limited, tolerable deformations and continue to contain the contaminated soils in an acceptable manner. A deformation-based method of design, similar to that adopted for large earth dams, has been employed on this project.

As described in Appendix H, two methods were used to predict the amount of deflections (Dickenson et al. 2002; Jibson and Jibson 2003). Conservative input values were used for the modeling. The estimated total displacement ranged from 1 to 2 feet for large-scale, deep-seated movements. These small amounts of displacement will not compromise the integrity of the CDF.

5.2.2.8 Summary of Stability Results and Conclusions

Based upon the analysis, the CDF structure as proposed is protective of the contaminated sediment placed within the CDF. The structure will adequately protect and contain the dredged sediment. The berm design and corresponding safety factor reflect a number of modifications and improvements. The foundation of the berm will be overexcavated and backfilled with structural fill. For the majority of the berm structure, the removal of loose sediment will likely be less than 5 feet, but in some locations the removal thickness could be

10 feet. The current design assumes that 5 to 10 feet will be removed below the outer toe of the berm.

Static factors of safety in excess of 1.5 and seismic factors of safety in excess of 1.1 are broadly considered stable for earth structures in cases where nominal permanent deformations are acceptable. For all cases, the factors of safety against a deep slope movement were far in excess of these values. The berm as conceptually designed will prevent the physical release of contaminated sediment.

The analysis did indicate the potential for deformations of the berm face due to a design seismic event. The shallow slope movement is considered to be within tolerable ranges, although such deformations would require rebuilding the outer face of the berm—the analysis indicates that the contaminated sediment would not be impacted. The risks associated with shallow surface sloughing are comparable to the risks associated with most waterfront facilities in the Portland area.

For each case evaluated, the statistical evaluations indicate that the probability for a deep movement that would impact the dredged sediments was zero. This analysis indicates that the proposed design more than adequately addresses the potential for variability within the strength of the soils present and proposed for use in the construction of the berm.

5.2.3 Containment Berm Erosion Resistance

The outward face of the containment berm will be exposed to potential erosive forces including river currents, waves, and propeller wash. To resist this erosion, an armor layer will be placed on the face of the berm. This section presents the design approach and results for the armor sizing.

Appendix G presents the detailed analysis of propeller wash-, river current-, and wave-induced erosion potential on the berm face. Each of these conditions is summarized below:

- **River Current.** WEST Consultants, Inc. used the LWG's river-wide Environmental Fluid Dynamics Code model and refined the existing grid to provide increased resolution at the berm face. The predicted currents associated with the 100-year flood flow conditions along the face of the berm are presented in Appendix F. At the lower section of the berm (-35 to approximately -15 feet NGVD), the velocities range from 1.01 to 1.32 feet per second (fps) resulting in a medium sand needed for erosion protection. Along the upper section of the berm (elevation -15 to +25 feet NGVD), the velocities decrease to 0.42 to 1.14 fps, resulting in the need for a fine to medium sand. Therefore, at a minimum, a medium-sized sand is required to resist the river current velocities.
- **Waves.** For wind-induced waves, a medium sand is needed to resist the bottom shear stress due to the passing wave prior to breaking. As the water depth over the berm decreases to roughly 2.5 feet, a fine gravel is required. For vessel-induced waves, a coarse gravel is required to resist the orbital velocity of a passing wave. Breaking waves impart more erosive force on the berm than a passing wave. A riprap-sized material (median diameter [D_{50}] between 7 and 10 inches) will be necessary to protect the berm within the surf zone areas. The surf zone is assumed to be at elevation -3 feet NGVD, given a river level elevation of 0 feet NGVD up to ordinary high water (OHW), 16.6 feet NGVD. Therefore, at a minimum, a coarse gravel is required to resist the subsurface force of a wave approaching and a riprap-sized material is required to resist the force of a wave crashing in the surf zone.
- **Propeller Wash.** To assess the propeller wash potential imparted on the berm face, the new replacement berth and Berth 401 were assumed to be operational and supporting ship traffic. Both tugs and ocean-going vessels were evaluated at different river stages. The analysis indicates that riprap will be needed on the berm face; the gradation depends on the elevation. From elevation -25 feet NGVD to the toe of the berm, riprap with a D_{50} of 15 inches is required. From elevation -25 feet NGVD to -10 feet NGVD, riprap with a D_{50} of 7 inches is required. Above that elevation, riprap with a D_{50} of 4 inches is required. Therefore, at a minimum, a riprap is required to resist propeller wash from approaching vessels.

In summary, to properly design the face of the berm to resist the most critical erosional forces, the largest sized armor was selected. For the berm face, the armor layer is controlled by the propeller wash and crashing waves. In summary, the face of the containment berm adjacent to the river will require riprap with a D_{50} of 15 inches from elevation -25 feet NGVD to the berm toe, and D_{50} of 7 to 10 inches above -25 feet NGVD up to the OHW.

5.2.4 Containment Berm Consolidation

The weight of the berm will induce consolidation of the sediments beneath the berm, causing the berm to settle. Consolidation properties of the sediment below the berm were derived from the completed explorations. The settlement of the berm was estimated by applying the weight of the berm on the subgrade soils. Settlement properties of the subgrade soils were estimated from the CPT results completed in the berm footprint. The material under the berm is predominantly granular. The analysis predicts approximately 4 feet of settlement under the weight of the berm. The berm settlement will occur predominantly as the berm is constructed. That is, after the berm is constructed to grade, long-term settlement will be negligible.

5.2.5 Consolidation and Settlement of Contaminated Dredged Sediment

Similar to containment berm consolidation, the weight of the sediment placed within the CDF will also induce consolidation. This consolidation has been considered in order to determine the total amount of contaminated dredged sediment that can be placed into the CDF. The contaminant transport model of the CDF indicates that the top elevation of the confined contaminated sediment will be 9.5 feet NGVD. Not considering consolidation, the capacity of the CDF for contaminated dredged sediment up to 9.5 feet NGVD is approximately 670,000 cy. Contaminated dredged sediments will include material from T4 and other sites within the Portland Harbor Superfund Site. As this material consolidates to a denser condition than is found in situ and the foundation materials below the CDF consolidate, additional contaminated sediment will be able to be placed below elevation 9.5 feet NGVD. The remainder of this section details the expected consolidation and predicts

the additional capacity for the dredged contaminated sediments that can be accommodated within the CDF below elevation 9.5 feet NGVD.

The contaminated dredged sediment will settle due to two factors: 1) consolidation of the dredged sediment placed within the CDF; and 2) consolidation of the sediments below the CDF. The two factors are described in detail below.

5.2.5.1 Consolidation of the Confined Contaminated Sediment

As the contaminated sediment is placed, consolidation and settlement will occur, induced by the weight of the sediment itself and from the weight of the import fill and cover layers placed above.

Dredged material initially placed within a CDF is typically at a higher moisture content than is found in situ prior to dredging. This is because the dredging activity breaks down the sediment structure, entraining more water into the sediment matrix. As more and more sediment is placed in the CDF, the previously placed dredged sediment consolidates due to the additional weight. With time, this consolidation process will reduce the water content of the contaminated sediment within the CDF to below what is found in situ prior to dredging.

Geotechnical information on dredged sediment and subsurface soil samples was used with computer models to estimate the total amount of the settlement. Procedures outlined in USACE's Confined Disposal of Dredged Material (USACE 1987) were used along with constitutive models that use laboratory-derived relations to predict the amount and duration of sediment settlement (Stark 1996; Znidarcic et al. 1992). The computer program CONDES (Yao and Znidarcic 1997) is a constitutive model that was used to estimate the total amount of settlement of the confined contaminated sediments. This program estimates both the amount of settlement and the time rate of settlement assuming certain fill rates and material properties.

Consolidation properties of the fill material were obtained from laboratory tests on representative samples of the dredged material from T4 Slip 3 (Anchor 2006c; Pre-

Construction Sampling Data Report). Two composite samples were analyzed from Slip 3 (Comp-1 and Comp-2). For the analysis described in this section, the consolidation properties of dredged sediment from other AOPCs in Portland Harbor were assumed to be similar to the properties of the dredged sediment from Slip 3.

The computer program CONDES was used to estimate the amount of sediment settlement. Figure 5-3 illustrates the top elevation of the contaminated sediment within the CDF during the filling process. The line represents the elevation of the top of the placed material. The initial steep upward portion of the curve represents the filling process during the available 4-month fish window (July through October). The flat or downward segment after the filling period is the settlement that occurs during the 8-month fish closure period (November through June). The filling period and subsequent waiting period create a "step" on the graph.

Each step represents a season of placement of contaminated sediments from various AOPCs in Portland Harbor. The filling process is estimated to take up to 4 years to complete, although it could take longer or shorter depending on the schedule of the Harbor-wide remedial action and the availability of suitable dredged material. After the contaminated sediment is placed, the imported fill and surface layer comprised of structural fill would then be placed. On the graph these are represented by the period between years 4 and 6. Again, this filling process could take longer or shorter than the assumed 2 years, depending on the availability of materials.

As can be seen on Figure 5-3, if 670,000 cy of in situ contaminated sediment were placed within the CDF, the top of this layer would be between elevation 0 to -9 feet NGVD after the imported fill and structural fill are placed. This indicates that an additional 9 to 18 feet of contaminated sediment could be placed within the CDF and still be below elevation 9.5 feet NGVD. Much of this capacity would be gained within a few years of placing the imported cover material over the contaminated dredged sediment. Because the contaminated dredged sediment will be covered with more than 18 feet of imported fill material plus an additional 4.5 feet of select fill material, the contaminated dredged sediment would be fully confined by the elevation of the berm and the surrounding peninsulas even if it were temporarily

overfilled by 9 to 18 feet. Further details regarding the CDF fill design and capacity optimization will be provided in the T4 CDF 100 Percent Design.

5.2.5.2 Consolidation of Foundation Below the CDF

Consolidation properties of the foundation below the CDF were derived from the completed explorations. The material under the CDF is predominantly granular with some silts. The analysis predicts approximately 2 to 4 feet of settlement under the weight of the fill. Due to the relatively slow filling schedule for the CDF, the settlement is anticipated to occur during filling.

5.2.5.3 Total Estimated Settlement

The consolidation of the confined contaminated sediment within the CDF with the consolidation of the CDF foundation indicates that an additional 11 to 22 feet of contaminated sediment could be placed within the CDF. This equates to an additional 200,000 to 300,000 cy of capacity for the CDF.

The predicted amount of settlement will need to be monitored during filling to confirm the theoretical calculations presented above. As part of the 100 Percent Design, a settlement monitoring program will be developed to monitor the settlement. In addition, material proposed for confinement within the CDF will need to undergo consolidation testing so that the settlement model can be updated.

5.2.6 CDF Surface Layer

The last stage of the CDF construction is the placement of the CDF surface layer (see Figure 5-2). Approximately 146,000 cy of material will be placed as the surface layer. The surface of the CDF will have a layer suitable to support long-term site uses. This layer will be constructed of imported granular material. Figure 5-2 shows the thickness of the surface layer. This surface layer will be graded for drainage and site use.

As discussed in detail in Section 6.5, the surface of the CDF does not need an asphalt pavement in order to meet water quality criteria in groundwater exit concentrations—infiltration of surface water does not adversely impact the groundwater quality discharging at the berm face. The ultimate post-filling use of the CDF surface by the Port is currently not known. Therefore, given these two factors, the 60 Percent Design assumes a compacted crushed rock surface.

The surface layer will consist of 4 feet of compacted sandy gravel/gravelly sand. The material will be placed in 12-inch lifts and compacted to a required density. On top of the compacted select fill will be 6 inches of compacted crushed rock, with the upper 2 inches being a finer graded material. The crushed rock layers will also be compacted to a required density.

Figure 5-4 shows the conceptual grading plan for the CDF surface layer. The surface grading plan will be finalized as part of the 100 Percent Design. Once future development plans are identified, appropriate stormwater conveyance and treatment systems associated with the planned development will be implemented under a separate permit process unrelated to this action. The current surface of the CDF is being designed to be pervious and to minimize stormwater discharge to the Willamette River.

5.3 Fish Removal

In order to minimize take of listed fish species and to ensure compliance with ORS 509.585 regarding providing fish passage, an effort will be made to remove fish from Slip 1 prior to dredged material placement in the CDF. Fish removal will occur following initial berm construction just before and after the height of the berm isolates water in the CDF from the river, and prior to dredged sediment placement in the CDF. During the final design process, methods will be explored that could be implemented to encourage fish to leave the slip before the berm gets to a level that isolates the water in the CDF from the river. After the berm reaches a level that isolates the CDF from the river, an effort will be made to remove the remaining listed fish from the slip. Fish removal is expected to span 3 to 5 fishing days. This removal is intended to minimize impacts to listed fish, but will also have the effect of minimizing impacts to other fish species that are collected with the listed fish. Following

this work, the absence (or near absence) of fish from the CDF pond should minimize or eliminate the potential contact of piscivorous birds with potentially affected water, sediments, or prey from Slip 1 during filling.

Based upon typical juvenile salmonid behavior, fish removal efforts will be focused on shallow water habitat and the top portion of the water column (NMFS 2005). Methods were selected that should be reasonably effective for the areas where juvenile salmonids and other fish are expected to be located, and are consistent with the provisions in the National Marine Fisheries Service (NMFS) fish collection guidance (NMFS 2000), typical methods used for fish collection (Murphy and Willis 1996), and with previous successful methods used to capture salmonids and other fish in the T4 vicinity (Gasco Removal Action, Anchor 2006d; and Portland Harbor RI/FS, Striplin et al. 2003). These methods are listed in order of expected catch effectiveness, and this order will be used in sequencing the effort, as follows:

1. Boat electrofishing at the head and sides of Slip 1 (including Berths 405 and 408)
2. Beach seines (if possible) in the open shore of the shallow water at the head of Slip 1
3. Research-size purse seines deployed by boat on the sides of Slip 1
4. Fyke nets extending from shallow to deeper water on the sides of Slip 1

During sampling, the fishing methods may be re-prioritized, or concurrent use of two or more methods may occur depending on field conditions, observed effectiveness, and catch rates, in order to maximize the potential for catching and removing as many fish as practicable.

Coordination will be ongoing with NMFS during this effort regarding actual catch per unit effort efficiencies achieved during the work. As stated previously, this removal would be expected to span approximately 3 to 5 days.

Once fish are captured, water quality conditions within fish transport systems (e.g., buckets or tanks) will be maintained as sufficient to promote fish recovery, including using brief holding times; aerators; and clean, cold, circulated water. Collected fish will be released into the river as quickly as possible in shallow water near the shore on the opposite side of the

containment berm. The selection of release sites will be coordinated with NMFS prior to the fish removal effort. In the event of mortalities, federally listed fish will be transferred to the Services if requested.

All fish removal activity will be conducted in close coordination with NMFS to determine the removal effort duration and to evaluate the effectiveness of the activity. The entire collect-and-release operation will be conducted by the Port's consultant team of experienced fishery biologists to ensure the safe and appropriate capture and handling of fish. During the entire process, the substantive requirements of ODFW Scientific Taking Permits will be met. Collection and release information will be reported to USEPA and NMFS in a brief memorandum following the fish removal effort, including the means of fish removal, the number and species of fish removed, the condition of all fish released, and any incidence of observed injury or mortality.

5.4 CDF Filling Methods

Following construction of the containment berm, the CDF will be filled with dredged sediments. The filling of the CDF will occur by offloading barges with sediments dredged by clamshell. There is a potential that dredged material from Portland Harbor Superfund Site locations could be dredged hydraulically and pumped directly to the Slip 1 CDF. However, there are only a limited number of AOPCs for which hydraulic dredging would be feasible, most being too far removed and/or on the opposite bank of the river. If hydraulic dredging is performed, it will be managed such that there will be no direct discharge of effluent to the river.

Filling the CDF from the land side using mechanical equipment is another possible option. Such an option might be preferred if contaminated sediments from Portland Harbor were dredged and then taken to one or more centrally located dewatering and rehandling facilities, and from there hauled over land via rail or truck to their final repository. If such a scenario is selected for the Portland Harbor remedial action, further details regarding land-side filling of the CDF would be provided in the T4 CDF 100 Percent Design.

5.4.1 Mechanically Dredged Sediments

Mechanically dredged sediment brought from Portland Harbor Superfund Site locations will most likely be brought to the CDF via a haul barge—this material will need to be transferred into the CDF with a pumping system.

The contractor will be required to design the offloading system for material brought to the site by barge. It is anticipated that material will be transferred from the barge to the CDF using a dredge pump. The offload facility will be located at the new replacement berth. The Contractor will be required to design a system that includes the following requirements:

- Includes spillage containment systems and methods to monitor for any spillage
- Draws any make up water used to slurry the dredged material for pumping from within the CDF
- Has sufficient capacity to handle the anticipated supply rates
- Has the ability to place materials to all locations of the CDF

The offloading system would connect to a diffuser barge system similar to that described in Section 5.4.2. By using CDF pond water as the make-up water for the pump slurry, there will be very little change in the water level between the pond and the river and, as a result, minimal groundwater advection through the berm.

5.4.2 Hydraulically Dredged Sediments

For any potential hydraulic dredging, the sediment will be pumped hydraulically to a diffuser barge located within the CDF. The alignment of the dredge pipeline between the dredge and the CDF will either be in the water or over the upland. It should be noted that the current design assumes that hydraulic dredging will not be used to fill the T4 CDF. If circumstances change such that hydraulic dredging becomes a preferred filling option, additional analysis of weir overflow conditions, water quality effects, and other potential impacts, both short-term and long-term, would need to be assessed in either the 100 Percent Design or in the AOPC-specific design process.

The diffuser barge will reduce the energy of the dredge slurry, allowing the dredged sediment to settle out. The contractor will design the diffuser barge. The specifications will require that the diffuser barge meets the following requirements:

- Reduces the energy of the slurry material
- Is capable of delivering the slurry to any elevation within the water column
- Can be moved around the CDF to varying discharge locations

If filling progresses at a relatively fast rate, the water level within the CDF will rise. Most CDFs are designed with a weir structure, and if the water rises high enough, it is discharged over the weir and through a pipeline and outfall to river. If hydraulic dredging is used to fill the T4 CDF, the dredging rates, schedules, and resultant water levels in the CDF will be managed such that there will be no over-the-weir discharge of dredging effluent. If it becomes necessary to design a hydraulic dredging scenario with an effluent discharge to the river, the weir, pipeline, and outfall structure will be designed, and water quality modeling will be performed as part of the AOPC-specific design process.

Figure 5-5 shows the cumulative capacity of the CDF for different elevations within the CDF. Before filling, the water level within the CDF will likely be near elevation 0 feet NGVD. Up to elevations +15 to +25 feet NGVD, there is approximately 300,000 to 550,000 cy of storage capacity. As the CDF is filled, water will gradually seep through the surrounding ground and containment berm providing more storage capacity. However, if the berm becomes gradually plugged with fine-grained sediment, its seepage rate may decrease, thereby slowing the recovery of water elevations in the CDF pond and placing constraints on the hydraulic filling rate. It is expected that berm plugging should be minimized at T4 because of the well-controlled placement procedures, including use of CDF pond water as make-up water to slurry the dredged material over the berm, and use of a diffuser barge, which provides accurate placement control within the CDF, both spatially and vertically in the water column. If hydraulic dredging is selected as a preferred disposal method for one or more sites in the Harbor, a contingency option would be developed for decanting ponded water in case the berm plugs and the berm seepage rate cannot keep up with the dredge inflow rate.

5.5 Construction Quality Control During CDF Construction

A number of QC measures will be implemented by the contractor during construction of the different elements of the CDF. The CQAP (Appendix D) presents the details of these different elements. QC measures for each element are presented below:

- **Containment Berm Construction.** Construction performance standards and criteria associated with the construction of the containment berm include the following:
  - Achieve Specified Grades and Extents. Berm construction materials must be placed at the specified grades within 1 foot of the extents shown on the Drawings (Appendix B) and Construction Specifications (Appendix C). Surveys will be completed to confirm grades.
  - Achieve Proper Stability of the Containment Berm. Berm slopes must be constructed to the grades shown on the Drawings (Appendix B), and need to be monitored for stability throughout construction. Surveys and visual observations will be completed to confirm berm stability.
  - Verify Import Material Quality. Import material must meet specified physical properties, as outlined in the Construction Specifications (Appendix C), and chemical acceptance criteria, to be developed during T4 CDF 100 Percent Design, prior to the use of any imported material. Sampling and analysis of materials before and during construction, coupled with visual inspections of import materials, will be completed to verify suitability. Gravel (ASTM #10 sieve) will be excluded from chemical testing.
  - Minimize Short-term Water Quality Impacts. Water quality monitoring activities are required to ensure compliance with federal and state water quality standards. Water quality criteria for berm construction are described in detail in the WQMP (Appendix E).
  - Minimize Potential Impacts to Cultural Resources. Archeological monitoring activities are required in the Construction Specifications (Appendix C) to ensure no impacts to cultural resources or historic structures.

- **CDF Filling.** Construction performance standards and criteria associated with the filling of the CDF include the following:
  - Verify Fill Material Quality. Dredged material being evaluated for placement in the CDF will be subjected to physical, chemical, and leachate testing to determine whether the material is acceptable for placement, and to ensure that it will not cause adverse water quality effects. Bulk sediment and leachate test results for 12 AOPCs in the Portland Harbor are presented in the Groundwater Model Input Parameter Memorandum, Attachment 1 (Appendix A). Groundwater contaminant transport modeling results indicate that 10 of the 12 AOPCs would be suitable for placement in the T4 CDF without causing adverse water quality effects, as presented in the Long-Term Groundwater Modeling Results Memorandum (Appendix A).
  - Prevent Release of Dredged Material (Mechanical Transport). Action must be taken to minimize the potential for, and prevent releases of, dredged material during the filling of the CDF. Releases outside the CDF could also occur during transport. The specifications will require certain types of haul barges and BMPs for transport.
  - Minimize Spillage of Material at the Transfer/Offload Facility. Action must be taken to minimize the potential for releases of dredged material during the transfer or offloading into the CDF. The Construction Specifications (Appendix C) require certain measures be implemented to minimize spillage during offloading. In addition, sampling of the sediments at the offloading facility will be completed after offloading to confirm no spillage occurred. If spillage is indicated, remedial measures will be implemented to clean up the area.
  - Achieve Specified Placement Elevations. Materials must be placed to the specified grades within the specified extents as shown on the Drawings (Appendix B) and as determined by the acceptance criteria and approval process described in the Confined Disposal Facility Sediment Management Plan (Appendix J). Surveying requirements are defined in the Construction Specifications (Appendix C) for vertical and lateral confirmation during placement.

- Achieve Expected CDF Consolidation. Confirmation that settlement and consolidation of placed material are occurring as predicted in the design is necessary. The contractor will be required to install settlement plates within the cover material to monitor settlement of the dredged fill as a result of cover placement and self-weight consolidation.
- Minimize Short-term Water Quality Impacts. Water quality monitoring activities are required to ensure compliance with federal and state water quality standards during filling of the CDF. Water quality criteria for CDF filling activities are described in the WQMP (Appendix E).

- **CDF Covering.** Construction performance standards and criteria associated with the covering of the CDF include the following:
  - Verify Import Material Quality. Import material must meet specified physical and chemical properties prior to use. Physical and chemical acceptance criteria for the import fill layer, which will likely include suitable dredged material, will be developed during T4 CDF 100 Percent Design. Sampling and analysis of materials before and during construction, coupled with visual inspections of import materials, will be completed to verify suitability. Gravel (ASTM #10 sieve) will be excluded from chemical testing.
  - Achieve Specified Cover, Thickness, and Extent. Topographic surveys by the contractor will be required to confirm accurate placement of materials. The contractor will also be required to have a location control system appropriate to meet the construction tolerances.

5.6 Assessment of CDF Impacts on Willamette River Flood Stage

An assessment of potential impacts to the Willamette River as part of the EE/CA (BBL 2005) demonstrated that no rise in the base flood elevations would result from the CDF, and the action would comply with Federal Emergency Management Agency (FEMA) regulations. Compliance with the FEMA "no rise" criteria, completed and approved as part of Appendix K of the EE/CA (BBL 2005), has been confirmed with the existing CDF configuration as part of the 60 Percent Design using the same models and process (see Appendix I).

5.7 Demolition of Slip 1 Structures

A number of structures within Slip 1 will need to be demolished prior to filling. Removing the structures will allow more uniform filling of the slip. In addition, removal of the structures will eliminate subsurface obstructions that could potentially impact future foundation constructions. The structures and piling will be removed with a combination of land- and water-based equipment. Because of this, most demolition work needs to occur prior to topping of the containment berm across the mouth of the CDF.

Slip 1 currently contains two piers, one on each side of the slip. Berth 405 is located on the north side, while Berth 408 is located on the south side of the slip. These piers are wooden and concrete structures with asphalt or concrete topping that support storage and crane loads above. A system of wood piling and some steel piling is used as the fendering system at each pier.

The two existing open pier structures located in Slip 1, Berth 405 and Berth 408, will be demolished and removed as part of this project. The piles at Berth 405 are to be cut or broken off at the mudline. The piles at Berth 408 are to be pulled and removed to the extent practicable. Figure 5-6 shows the extent of demolition in Slip 1 required for the CDF construction.

Construction QC procedures to confirm that demolition meets the intent of the design are presented in the CQAP (Appendix D). Briefly, construction performance objectives for pile/structure demolition include the following:

- **Remove Specified Structures and Piles and Protect Remaining Structures.** It is necessary to confirm that the piles and structures identified in the Drawings (Appendix B) and Construction Specifications (Appendix C) have been adequately removed, and that structures not requiring removal are not damaged during the demolition operation. Performance criteria include total removal of specified structures and piles, and less than 1 inch of movement of protected structures (i.e.,

structures not identified for removal). Settlement monitoring of adjacent structures will be required of the contractor.

- **Appropriate Disposal/Recycling of Demolition Materials.** Demolition material removed from the Slip 1 area must be properly disposed of or recycled. The performance criterion is disposal or recycling of demolition materials at the appropriate facility as detailed in the Construction Specifications (Appendix C). The contractor will be required to track and document all loads of material leaving the site for disposal or recycling.
- **Achieve No Off-site Tracking of Contaminants During Transport of Disposal Materials.** It is necessary to confirm that there is no spreading of contamination during transit to the off-site disposal facility. The performance criterion is no statistical difference in the quality of soil/sediment samples collected before and after transit activities. The specifications will present requirements to minimize off-site tracking of contaminants. In addition, sampling will be completed to confirm no off-site tracking. An important component of the investigation will be to adequately sample pre-transport conditions to be able to distinguish whether or not the presence of contaminated soil/sediment in the post-transport condition can be reliably attributed to CDF construction activities.
- **Minimize Short-term Water Quality Impacts.** Water quality monitoring activities are required to ensure compliance with federal and state water quality criteria. Performance criteria are specified in the WQMP (Appendix E).
- **Minimize Potential Impacts to Cultural Resources and Historical Structures.** Archeological monitoring activities are required to ensure that construction activities do not impact cultural resources and historical structures.

5.8 Outfall and Stormwater Rerouting

The goal of the stormwater reroute is to relocate multiple existing discharge outfalls currently used by the Port and the City out of Slip 1. The reroute minimizes the number of trunk lines, as well as impacts to existing utilities and site surface features. Design and layout of the stormwater reroute system was based on estimated flow rates of adjacent basin areas, current outfall and utility locations, and location of new construction at Berth 401 and Pier 2

rail yard. Consideration was also given to minimizing the depth of excavation for installation and providing the shortest run possible.

Currently, five storm drain mains are known to outfall into the most inward (eastern) portion of Slip 1 at T4. Four of these are Port-owned and operated storm lines, while the fifth outfall is owned by the City. When Slip 1 is filled, these discharge points will be buried; therefore, these pipes will be relocated to provide suitable points of discharge into the Willamette River. Figure 5-7 shows the location of the new lines and outfalls. Three new lines will be run:

- Storm main A is the City's line. The line will run north of Slip 1.
- Storm main B is a Port line also running north of Slip 1.
- Storm main C is a Port line running to the south of Slip 1.

Computations indicate that a 36-inch-diameter main is required for all three relocated trunk lines. The Port-owned 36-inch-diameter main will pick up the four existing outfalls in a collection pipe. Due to the long runs to the Willamette River, a slope of 0.4 percent is used in the design for storm main A; 0.6 percent for storm main B; and 0.35 percent for storm main C. Pipe sizing was calculated using Manning's equation. With the assumptions of a minimum flow velocity (V) of 3 fps, Manning's coefficient (n) of 0.013, and a hydraulic radius (R) of 0.75 feet, a slope (s) of 0.001 feet/feet was calculated. At this slope, a 36-inch-diameter pipe will meet the assumed minimum velocity of 3 fps. Also, the flow capacity of this size pipe exceeds the flow rate maximums of the adjacent basin areas, calculated by the Rational Method. Storm drain manholes will be provided at all changes in direction and at a maximum spacing of 400 feet.

Because the contaminated dredged material in the CDF will be placed below elevation 9.5 feet NGVD, below the perennial water table elevation, and beneath more than 18 feet of imported fill plus 4.5 feet of select fill, it is unlikely that the storm drain utilities described above will be placed at or below the contaminated sediment elevation. Utility locations and elevations will be evaluated further during 100 Percent Design and, if necessary, design

modifications may be made to prevent preferential flow of groundwater into or out of the CDF along the storm drain utility corridors.

5.9 Waterfront Structure(s) and Berth(s) Replacement

The new berth replacement pier is intended to provide a new berth for grain-carrying river barges, and act as a platform to support a grain offloading facility to be used by the Port's tenants. The dock is also intended to provide flexibility for future tenant use and is designed to support vessels up to the size of ocean-going barges. The dock has been designed to carry loads up to 1,000 pounds per square foot (psf) uniform load to support future uses of the dock structure, and will have vehicle access that is also designed for 1,000 psf to more easily accommodate future expansion. Additionally, this berth will be used to offload barges of mechanically dredged sediments from T4 and other Portland Harbor Superfund Site cleanup projects to fill the CDF. Figure 5-8 shows the location of the replacement berth.

The dock platform will be a precast, prestressed concrete platform supported by steel pipe piling. The concrete platform will provide an adequate base for the relocated grain unloading tower, and also provide maximum flexibility for the future use of the platform. Steel pipe piles were chosen due to geotechnical considerations in the berthing area and their ease of installation. The piles will be driven to sufficient depth to support the design loads.

The platform will be connected to the shore by a precast, prestressed concrete one-lane vehicle access trestle structure supported by steel pipe piles that are capable of supporting an American Association of State Highway and Transportation Officials (AASHTO)-rated H25 truck, large fork-lifts, container-handling top-picks, and a 1,000-psf uniform load. In addition, four ship berthing dolphins will be installed with catwalk access from the main platform. These dolphins will be spaced to accommodate ocean-going barges, as well as local river barges.

The structures associated with this new barge berth will require in-water work involving pile-driving operations, overwater concrete placement for the precast concrete pile bents, and installation of steel or aluminum walkways. It is anticipated that precast concrete deck

panels will be placed by a crane-loaded barge, as will prefabricated steel or aluminum access catwalks.

5.10 Management of CDF Filling Activities

The CDF will be filled with contaminated sediment dredged from various AOPCs in Portland Harbor, as well as sediment from the Phase II Removal Action at T4. A layer of cover material will then be placed over the contaminated sediments. This section describes the criteria to be used to evaluate the suitability of dredged material for placement in the CDF, and how the CDF will be managed during filling events and between filling seasons (see also the Confined Disposal Facility Sediment Management Plan [Appendix J]).

5.10.1 CDF Acceptance Criteria

Dredged sediments proposed for placement in the CDF will need to meet certain physical and chemical acceptance criteria, as per the Action Memo (USEPA 2006a). These criteria include the following:

- **No Hazardous Waste.** Sediments designated as hazardous waste, whether listed waste or characteristic waste, are not eligible for placement in the CDF without adequate treatment.
- **No Free Oil.** Sediments containing "free oil" are not eligible for placement in the CDF without adequate treatment.
- **Suitable Geotechnical Properties.** The geotechnical properties of the fill materials must be of an acceptable quality such that they do not impact the long-term performance of the CDF, e.g., they must be free of debris and significant organics (i.e., wood chips), which could cause unacceptable obstructions, settlement, or gas generation.
- **Suitable Geochemical Properties.** The geochemical properties of the contaminated dredged sediments, primarily their leaching characteristics, must be shown to provide long-term protection of human health and the environment, and the beneficial uses of the Willamette River.

- **Other Considerations.** The Port and USEPA may consider other factors in determining acceptability of contaminated dredged material for placement in the CDF, including presence of principal threat compounds, physical nature of the material, form of the chemical contaminants, quantity of the material, long-term site liability, indemnification, and cost.

5.10.2 Portland Harbor Leaching Tests

The LWG conducted a series of leaching tests on contaminated sediments from 12 AOPCs in Portland Harbor, including most of the AOPCs considered a high priority for remedial action. Sequential batch leaching tests (SBLTs) were conducted, and the results of the leaching tests were input to the T4 CDF groundwater model to characterize long-term groundwater exit concentrations to the Willamette River. An evaluation of SBLT bulk sediment and leachate concentrations for Portland Harbor AOPCs is presented in Section 6.2.3 and Table 6-4, and in Appendix A, Attachment 1 of the Groundwater Model Input Parameter Memorandum. Model predictions of groundwater exit concentrations for five index chemicals are presented in Section 6.4.2 and Appendix A.

Groundwater model predictions indicate that ten of the 12 AOPCs evaluated would be suitable for placement in the CDF on the basis of their leaching characteristics. During the latter stages of design and during construction, when more is known about which AOPCs are being placed in the CDF and their respective volumes and sequencing, more detailed placement scenarios may be evaluated using the T4 CDF groundwater model to verify that water quality goals will be met.

5.10.3 Dredged Material Suitability Determination

An applicant representing an AOPC in Portland Harbor will need to submit data on its dredged material characteristics to be considered for placement in the T4 CDF. The data will be submitted for review and approval by the Port and USEPA and, if appropriate, a suitability determination will be issued for the proposed dredged material. The testing requirements needed to support a suitability determination will include the following:

- **Bulk Sediment Chemistry.** Bulk sediments will be analyzed for metals, semivolatile organic compounds (SVOCs), PCBs, chlorinated pesticides, and total petroleum hydrocarbons (TPH).
- **Bulk Physical Properties.** Bulk sediments will be analyzed for total organic carbon (TOC), grain size, and Atterberg limits. Consolidation tests may also be required for some sites.
- **Toxic Characteristic Leaching Procedure (TCLP).** TCLP testing for hazardous waste designation will be conducted for TCLP metals. Other TCLP parameters (TCLP volatile organic compounds [VOCs], SVOCs, and/or pesticides) will be determined on a case-by-case basis.
- **SBLT or Pancake Column Leaching Test (PCLT).** Sediment leachate testing (SBLT or PCLT) will be conducted for metals, SVOCs, PCBs, chlorinated pesticides, and possibly other parameters as determined on a case-by-case basis.
- **Other Testing Requirements.** If material will be placed in the CDF is such a manner that a weir overflow is expected, causing an effluent discharge to the Willamette River, a Modified Elutriate Test (MET) and Column Settling Test (CST) may be required.

Existing data collected as part of the Portland Harbor RI/FS may satisfy some or all of these data requirements. To the extent that additional field sampling and laboratory analysis may be required, a Sampling and Analysis Plan (SAP) must first be submitted to the Port and USEPA for review and approval prior to conducting the work.

5.10.4 Management of Filling Events

The requirements for management of CDF filling events are described in the Confined Disposal Facility Sediment Management Plan (Appendix J). The following management activities are described in the plan:

- **Port and USEPA Administration.** Responsibilities for administration of CDF filling activities, agency contact information, application requirements, and scheduling constraints for filling operations.

- **Management of Offloading.** Description of docking facilities, acceptable offloading methods, spill prevention requirements, and equipment necessary to properly place the material within the CDF to the elevations and extents identified on the Drawings (Appendix B).
- **Water Quality Monitoring.** Water quality monitoring requirements during filling events.
- **Environmental Controls.** Environmental controls for surface water management, dust control, and erosion control.

The performance of the CDF may be improved if sediment with relatively higher COC concentrations is placed near the upper head of the CDF (i.e., farther from the berm and underlying aquifer). Sediment with lower COC concentrations would be placed in the outer portion of the CDF, in particular, on the inside wall of the berm and along the bottom of the CDF. These areas have the shortest travel times to the river, which are measured in decades, whereas travel times in the upper head of the CDF may be 200 years or more (see Appendix A). It is expected that segregation of sediment will complicate construction sequencing by requiring tighter scheduling and coordination of disposal actions from various AOPCs in Portland Harbor, and as a result, increasing the cost and the time required to fill the CDF. The cost and schedule implications of dredged material segregation will not be fully understood until further progress is made with AOPC-specific remedial designs.

5.10.5 Management Between Filling Seasons

The following CDF inspection and QC measures will be implemented between filling seasons, as described in the Confined Disposal Facility Sediment Management Plan (Appendix J):

- **Physical Inspections of the Berm.** The containment berm will be inspected at the end of each filling season until the CDF is completed.
- **Physical Inspections of the Placed Material.** Bathymetric surveys will be completed at defined intervals to track the elevations of placed materials.

- **Interim Wildlife Protection.** Interim wildlife protection measures will be implemented during the latter stages of filling when the water depth above the contaminated sediments is shallow enough to pose a potential risk to wildlife, primarily piscivorous birds. When the water depth in the CDF is sufficiently shallow, a thin layer of clean sand will be placed over the contaminated sediment between filling seasons. During the initial part of the filling operation, such measures will not be necessary due to the significant water depths over the sediment and the initial removal of fish from the CDF following berm closure. Further details on placement of interim covers will be provided in the 100 Percent Design submittal.

It should be noted that the use of thin (approximately 6-inch-thick) sand layers for interim wildlife protection between filling seasons is not expected to create preferential groundwater flow pathways through the CDF. This expectation is based on the limited thickness of the sand layers, the likelihood that they will be mixed with underlying and overlying fine-grained sediment during placement, and that layers may be deformed and separated into discontinuous lenses during consolidation. The potential for preferential transport along such thin sand layers will be evaluated further during 100 Percent Design when the filling sequence is better defined.

5.10.6 Long-Term (Post-Construction) Management

Long-term management activities will be addressed in the Long-term Monitoring and Reporting Plan (LTMRP) that will be included as part of the 100 Percent Design. An outline of the LTMRP is presented in Appendix K. Long-term monitoring activities will include:

- **Visual Monitoring**
  - Armor Layer Stability, which will be assessed though a visual survey of the portion of the CDF armor layer that is above the water line. Transects will be walked at low water levels to complete the visual surveys.

- **Physical Monitoring**
  - Armor Layer Stability, which will be assessed through a bathymetric survey of the portion of the CDF armor layer that is below the water line.
  - Consolidation and Settlement Monitoring, which will be assessed though a survey of eight monuments located on the CDF berm and CDF surface.
  - Groundwater Level Monitoring within the CDF, which will be assessed through water level measurements at five monitoring well locations within the extent of the contaminant fill area of the CDF.
- **Chemical Monitoring**
  - Groundwater Quality Monitoring in the CDF Berm, which will be assessed through collection of groundwater samples at three downgradient monitoring wells in the CDF berm, one upgradient location, and two lateral locations (six monitoring wells total). Long-term groundwater quality parameters and criteria are provided in Table 6-1.

Long-term monitoring activities will be performed at the completion of construction (Year 0), as well as during eight post-construction events (Years 2, 5, 7, 10, 15, 20, 25, and 30).

5.11 Contingency Planning Measures

Contingency planning measures in the form of management and engineering controls could be implemented to enhance the performance of the CDF (if warranted) during CDF construction or in the future as a facility retrofit. Possible management and engineering control measures for the CDF are discussed in this section, including a brief review of their effectiveness, cost, and implementability. The effectiveness of the contingency options at reducing contaminant loads from the CDF is based on long-term groundwater model predictions (see Section 6.4 for a description of the T4 CDF long-term groundwater model). Unless otherwise stated, the addition of the contingency measures described below could likely be implemented within the +50/-30 percent level of accuracy of a feasibility-level cost estimate for the CDF.

The contingency options that were evaluated include the following:

- Restrictions on sediment acceptance
- Amending berm select fill
- Reducing the size of training dikes
- Amending dredged sediment during placement
- Paving the CDF surface
- Installing a permeable reactive wall in the berm

5.11.1 Restrictions on Sediment Acceptance

One possible control measure to reduce contaminant loadings from the CDF is to place restrictions on the acceptance criteria for sediment and leachate quality in the incoming dredged material. For example, it may be possible to reduce PCB leachate concentrations in the CDF by 83 percent by excluding the three most contaminated AOPCs. Based on the Portland Harbor leachate data, as compiled in Appendix A (Attachment 1of the Groundwater Model Input Parameter Memorandum, Table 1-1), the arithmetic mean Total PCB leachate concentration for the ten candidate AOPCs is 0.87 µg/L; however, if the Schnitzer, Gunderson, and Fireboat Cove AOPCs were excluded, then the arithmetic mean leachate concentration for the remaining seven AOPCs would be reduced to 0.15 µg/L (see also Section 6.2.3).

The opportunity cost of excluding certain AOPCs in Portland Harbor from placing their dredged material in the T4 CDF cannot be estimated with certainty, but it would nevertheless have an impact on the CDF being a cost-effective option. If there are fewer potential users of the CDF, then there is less revenue and the total cost of the CDF will increase. However, the magnitude of the cost increase is unknown at this time.

5.11.2 Engineering Control Measures –Construction

5.11.2.1 Amending Berm Select Fill

The select fill used to construct the CDF berm could be amended with an adsorptive material that helps to sequester COCs in groundwater. The performance of the CDF would be

improved because the berm would have greater adsorbtive capacity and provide greater attenuation of COCs during groundwater transport. The adsorptive material used to amend the berm select fill would be based on the groundwater COCs that are targeted for reduction. For example, granular activated carbon (GAC) would be effective at sequestering most hydrophobic organic compounds (e.g., PCBs, DDx, and PAHs) (Barth and Reible 2008). Bauxite, apatite, and zeolites may have the ability to sequester certain inorganic compounds (Reible et al. 2006; Gavaskar et al. 2005; Jacobs and Forstner 1999).

One concept is to amend the berm select fill with GAC prior to placement between the training dikes. Due to the large volume of material that would need to be re-handled and processed, however, amendment of select fill material prior to placement would incur unnecessary costs and logistical complexity during berm construction. The preferred option for amending the berm is to install a permeable reactive wall in the berm after the CDF is constructed. The reactive berm wall is described in Section 5.11.3.2.

5.11.2.2 Reducing the Size of Training Dikes

Because of their enhanced permeability compared to the select fill, training dikes can create preferential flow pathways through the berm. Groundwater transport could be retarded, and the performance of the CDF could be enhanced if the size of the training dikes were reduced. The training dikes in the groundwater model were assumed to be 20 feet high. With the removal of the habitat bench from the face of the berm, the minimum height of the training dikes needed to provide long-term seismic stability is 20 feet. If the berm was keyed more deeply into the existing sediments, by over-excavating approximately 25 to 30 feet (the current design anticipates over-excavation of 5 to 10 feet), it may be possible to use smaller dikes on the upper tiers of the berm. However, such a design would involve over-excavation of a large amount of sediment (estimated at approximately 100,000 cy), as well as additional material costs for dike material and select fill to backfill the key excavation. The excavated material would require placement in the CDF, lowering the capacity of the CDF and increasing the per-cubic-yard disposal rate. For example, if the CDF capacity was reduced by 100,000 cy as a result of over-excavation needed to support smaller training dikes, the per-cubic-yard disposal cost would increase by 18 percent. As a result, this option is more

difficult to implement and will incur significant additional cost, potentially exceeding the +50 percent level of accuracy required for the FS. Therefore, it is not considered further.

5.11.2.3 Amending Dredged Sediment during Placement

Dredged sediment placed within the CDF could be amended with an adsorptive material during placement. The performance of the CDF as currently designed would be improved as a result of the increased binding and decreased leachability of COCs within the amended sediment. The adsorptive material used to amend the dredged sediment would be selected based on the COCs that are targeted for reduction, for example GAC to control hydrophobic organic compounds (see Section 5.11.2.1). Adsorptive material could be added prior to or during pumping of mechanically dredged sediment from barges with high-solids pumps. Alternatively, adsorptive material could be introduced in-line with sediment that is being hydraulically pumped into the CDF. Due to the large volume of material that would need to be processed, and the variability in physical and chemical properties of the incoming material, amendment of dredged sediment prior to placement will incur additional costs and logistical complexity during CDF construction. In terms of implementability, this option is more difficult.

For costing purposes, it is assumed that the dredged sediment will be amended with 0.1 percent GAC. The estimated concept-level cost to amend the incoming dredged sediment with 0.1 percent GAC is approximately $16 million.

5.11.3 Engineering Control Measures – Post-Construction

The engineering measures described in this section carry a distinct advantage in that they could be implemented after CDF construction as a facility retrofit, for example, if post-construction monitoring results indicate unanticipated water quality issues are developing. With post-construction measures, CDF performance data can be reviewed and evaluated to better design an appropriate engineering solution.

5.11.3.1 Paving the CDF Surface

The addition of a paved surface on top of the CDF is expected to improve CDF performance by reducing the infiltration of incident rainfall, and likely causing a slight reduction in the groundwater gradient and flow velocity through the dredged sediments. The CDF groundwater model predictions are currently based on an unpaved (i.e., pervious) surface, in accordance with the current design consisting of 4 feet of select fill topped with 6 inches of crushed rock. The CDF cost will increase with the inclusion of a paved surface. However, the paved surface may be beneficial with respect to future use of the terminal. A particular implementability concern is that the paved surface will generate greater volumes of stormwater runoff that would need to be managed in terms of quantity and quality. Special challenges would be associated with stormwater management on the surface of the CDF due to the need to avoid siting engineered infiltration facilities over the contaminated dredged material, and to avoid creating preferential flow paths or accelerating groundwater transport through the CDF.

Without consideration of the cost of stormwater management, the cost to pave the surface of the CDF with a pavement section typical for truck traffic is approximately $2.4 to 4.0 million. Costs for pavement sections necessary to support heavier traffic (such as mobile container cranes) could be up to 10 times as expensive. The Port currently does not know the long-term use of the area.

5.11.3.2 Installation of a Permeable Reactive Wall in the Berm

The addition of a permeable reactive wall in the berm would improve CDF performance by sequestering COCs in groundwater, similar to amending the berm with adsorptive material (see Section 5.11.2.1). The berm would have greater adsorbtive capacity and provide greater attenuation of COCs during groundwater transport. It is expected that the amount of contaminant attenuation will be proportional to the amount of GAC (or other adsorptive material) that is added to the permeable reactive wall. A wall could be added as a retrofit to the existing berm at any point in time after berm construction. The wall would likely be constructed by excavating a trench along the top centerline of the berm alignment and

introducing an amended slurry. The slurry would prevent the sidewalls from collapsing. Beyond the base cost of CDF construction, the additional cost of the wall will depend on the type (e.g., GAC, coke, etc.) and weight percent of adsorptive material that is added. Permeable reactive walls are implementable, having been successfully installed at numerous contaminated groundwater sites throughout the country, and at depths equal to or greater than the height of the CDF berm (USEPA 2002).

For costing purposes, it is assumed that the permeable reactive wall is 3 feet thick. Vertically, it spans the entire saturated zone of the berm, extending from above the water table to a footing in the underlying aquifer. The total wall length is approximately 1,050 linear feet, spanning the entire width of the berm and including several hundred feet of wing wall along the southern boundary of Slip 1 to protect Wheeler Bay from lateral migration from the CDF. Two scenarios are considered in which the reactive wall is amended with 0.1 percent and 1 percent GAC. The estimated concept-level cost to build a reactive wall in the berm with 0.1 percent and 1 percent GAC is $1.8 million and $2.0 million, respectively.

5.11.4 Cost-Effectiveness Comparison of Contingency Options

In this section, the cost-effectiveness of the different CDF contingency options is evaluated and compared. Estimated concept-level costs and underlying assumptions were described in the previous sections. The effectiveness of the different contingency options at reducing contaminant loads to the river was evaluated using the CDF long-term groundwater model. One metric that can be used to assess the effectiveness of the various contingency options is the duration of time over which the porewater at the berm face remains below the fish consumption criterion in the absence of biodegradation. This is referred to as the "travel time to the berm face." As discussed in Section 6.4.2, the fish consumption criterion is not likely to be exceeded with even a very small amount of biodegradation.

The estimated cost and environmental effectiveness (as measured in travel time to the berm face) of the various contingency options are summarized below:

Contingency Scenario	Control Type	Travel Time to Berm Face (years)	Conceptual Cost (millions)
Sediment Acceptance Restrictions	Management	700	Unknown
Paved Terminal Surface	Engineering	480	$2.4 to $4.0
Amended Dredge Fill, 0.1% GAC	Engineering	1,600	$16
Permeable Reactive Wall, 0.1% GAC	Engineering	1,900	$1.8
Permeable Reactive Wall, 1% GAC	Engineering	>>2,000	$2.0

Note:
GAC = granular activated carbon

The reactive berm wall appears to be the most cost-effective contingency option for reducing the contaminant load from the CDF, if further reduction is determined to be necessary. Also, an advantage of this option is that it can be implemented retroactively after the CDF has been built, and in consideration of post-construction groundwater monitoring data, thereby avoiding potentially unnecessary over-engineering during CDF construction.

6 WATER QUALITY

This section presents the water quality standards and guidelines that will be used to construct the T4 CDF, results of contaminant mobility testing, and predicted water quality conditions during construction (short-term effects) and after construction (long-term effects). These factors will be used to inform the basis of design for the CDF, contractor-required BMPs to protect water quality during construction, and to develop short-term and long-term water quality monitoring programs for the CDF.

6.1 Water Quality Criteria

Short-term and long-term water quality effects associated with the T4 CDF are evaluated in this section. Short-term effects are temporary and transient effects associated with construction activities over periods of days and weeks, including dredging of the berm key and demolition of the pier structures in Slip 1. Long-term effects are associated with continuous movement of groundwater through the CDF berm over periods of years and decades. Water quality criteria used to regulate these various activities will be consistent with the scale and duration of exposure.

Proposed water quality criteria for the T4 CDF are summarized in Table 6-1.

6.1.1 Short-Term Water Quality Standards and Criteria

Short-term water quality criteria will be used to regulate in-water construction activities when the CDF is open to the river (e.g., during berm key dredging, demolition, and berm construction). The water quality criteria to be complied with during CDF construction are listed in Table 6-1. Water quality criteria will be met at the points of compliance described in Section 6.1.2.

Water quality monitoring requirements during CDF construction activities will be specified in the WQMCCP, to be issued by USEPA for construction of the CDF, to regulate placement of T4 material in the CDF, and final placement of imported fill material to close the CDF. The WQMCCP is the substantive equivalent of a Clean Water Act (CWA) Section 401 Water

Quality Certification. Other responsible parties seeking to use the CDF will need to obtain a separate WQMCCP to cover their dredging, transport, and filling activities.

Three types of water quality standards will be employed during CDF construction:

- **Visual Standards.** Continuous visual monitoring of the construction site will be performed for evidence of construction-related impacts. Visual monitoring will be performed during all in-water activities.
- **Conventional Standards.** Turbidity, pH, temperature, and DO will be measured in real time using a field probe, and compared to the water quality standards listed in Table 6-1. Monitoring of conventional parameters will be performed during all in-water activities.
- **Acute Water Quality Criteria.** Laboratory analysis of target metals (i.e., cadmium, lead, and zinc) may be required during demolition of piers and pilings in Slip 1, and analysis of PAHs may be required in the CDF berm key area, if an exceedance of a conventional standard is observed and confirmed in the respective areas. TSS would also be analyzed. Analytical results for metals and PAHs will be compared to the acute water quality criteria listed in Table 6-1. While acute criteria will be used to evaluate compliance with water quality criteria, chronic criteria will be used to evaluate the effectiveness of construction BMPs, and whether additional BMPs should be implemented.

6.1.1.1 Visual Standards

Visual monitoring for water quality impacts during construction activities will take place whenever construction is underway. Visual monitoring will confirm that the construction site meets the following conditions:

- No oily sheen or other visible contamination in the water
- No distressed or dying fish
- No significant turbidity plume outside the compliance boundary

If any of these conditions are observed in the vicinity of construction operations, then a description of the size and probable source of impact must be recorded, and water quality measurements collected. USEPA must be notified to coordinate response decisions.

6.1.1.2 Conventional Standards

The conventional standards that will be used to monitor construction of the T4 CDF are listed below. These standards are consistent with the WQMCCP issued for the T4 Phase I Removal Action (USEPA 2008). Conventional parameters are measured in real time using a multi-parameter field instrument.

Turbidity. State water quality standards allow for limited turbidity exceedances for "dredging, construction, or other legitimate activities" [OAR 340-041-036(b)]. The following turbidity standards will apply at the point of compliance:

- Turbidity shall not exceed 5 Nephelometric Turbidity Units (NTU) above background if background is less than 50 NTU.
- Turbidity shall not exceed 10 percent above background if background is greater than 50 NTU.

At no time should turbidity exceed 50 NTU over background. Should this occur, then all in-water activities shall cease immediately, and USEPA shall be notified. Work shall not resume until turbidity levels have returned to compliant levels and approval has been given by USEPA.

Dissolved Oxygen. At the point of compliance, DO shall exceed 6.5 milligrams per liter (mg/L). At no time should DO drop below 6.0 mg/L at any station. Should this occur, all in-water activities shall cease immediately, and USEPA shall be notified. Work shall not resume until DO levels have returned to compliant levels and approval has been given by USEPA.

pH. At the point of compliance, pH will remain between 6.5 and 8.5 (standard units).

Temperature. At the point of compliance, the 7-day average temperature shall not exceed 18.0 degrees Celsius (°C). When ambient conditions exceed 18.0°C, no temperature increases will be allowed that will raise the receiving water temperature greater than 0.3°C. Should this occur, all in-water activities shall cease immediately, and USEPA shall be notified. Work shall not resume until temperatures have returned to compliant levels and approval has been given by USEPA.

6.1.1.3 Chemical Criteria

Water quality criteria for contingent chemical monitoring parameters are listed below. Laboratory analysis of chemical parameters will be performed in certain areas of the CDF if an exceedance of a conventional parameter is observed at the point of compliance and confirmed to be a result of construction activities. Laboratory analysis will be performed at an off-site analytical laboratory with an accelerated 72-hour turnaround from the time of sample delivery.

Total Suspended Solids (TSS). There are no formal water quality criteria for TSS. However, TSS is potentially a more direct indicator of construction-related sediment resuspension compared to turbidity. TSS is measured in concentration and is, therefore, more relevant for contaminant transport and mass balance calculations, whereas turbidity is a measure of light transmission through the water column.

Acute Metals Criteria. Contingent laboratory analysis of cadmium, lead, and zinc will be performed if an exceedance of one or more field parameters is observed during the demolition of piers in Slip 1. These index metals are associated with historical ore handling at T4. Acute water quality criteria for these metals are derived from Oregon Table 33A (ODEQ 2005) and the USEPA National Recommended Water Quality Criteria (USEPA 2010b). The criteria have been adjusted to a hardness value of 25 mg/L based on average measurements in the Lower Willamette River (USGS Station #14211720). Acute metals criteria will be used to evaluate compliance with water quality criteria, and chronic criteria will be used to evaluate the effectiveness of construction BMPs.

Polycyclic Aromatic Hydrocarbon (PAH) Guidance Values. Contingent laboratory analysis of PAHs will be performed if an exceedance of one or more field parameters is observed during dredging of the berm key. Aquatic life criteria for PAHs are not available in either federal or state standards. However, acute and chronic guidance values for PAHs have been developed by USEPA (USEPA 2003b and Table 6-1). Acute PAH values will be used to evaluate compliance with water quality criteria, and chronic values will be used to evaluate the effectiveness of construction BMPs.

6.1.1.4 Ambient Background Conditions

Ambient background values in the Willamette River for conventional and chemical parameters will be considered in the evaluation of construction monitoring data. No construction-related impacts are indicated if conventional measurements or analytical results are at or below background levels, even if these levels exceed water quality criteria (i.e., when background conditions exceed water quality criteria).

Background conditions in the Willamette River are determined using: 1) the USGS monitoring record at the Willamette River at Portland (Station #14211720); and 2) field measurements and laboratory analytical results at background monitoring stations during the T4 Phase I Removal Action, conducted in August through October 2008 (Anchor QEA 2009). The background values listed in Table 6-1 for conventional and chemical parameters are based on the 90th percentile values of the background dataset.

A background reference station will be established upstream of T4, and this station will be monitored concurrent with the monitoring of CDF construction activities. The background monitoring station will be placed in an area comparable to the compliance locations (e.g., at similar water depths and distances from the shoreline). Ongoing monitoring of this background station will be performed to detect any excursions of ambient river conditions (e.g., excessive turbidity caused by high flow events, etc.) that are not caused by the construction of the CDF, but which may nevertheless affect water quality in the vicinity of

the CDF. Ambient background statistics will be regularly updated with the background monitoring data collected during construction.

6.1.2 Short-Term Compliance Boundaries

Compliance boundaries will be established for construction activities. Inside the compliance boundaries, short duration exceedances of the water quality standards (visual, conventional, or chemical) are allowed provided that these exceedances are limited in distance, duration, and magnitude. Water quality standards and criteria as identified herein will be achieved at the compliance boundary. The compliance boundaries are established to allow the construction activities to be implemented while using appropriate BMPs to minimize any short-term impacts to water quality and/or the beneficial uses of the river.

The proposed compliance boundaries for the Slip 1 CDF are:

- Pier Demolition. 100 meters radially from the pier structures in Slip 1 during demolition activities
- Berm Key Excavation, Berm Construction. 100 meters radially from the berm key
- Sediment Offloading. 100 meters radially from the new Berth 405, which will be used to offload barges carrying dredged sediment from other sites in Portland Harbor
- Effluent from the CDF Pond. The CDF pond will be managed such that there will be no direct discharge of effluent into the river; as a result, no compliance boundary is needed.

The configurations of the compliance boundaries are shown in the WQMP (Appendix E).

The boundaries proposed for this project are consistent with those recently applied in other sediment remedial actions in Portland Harbor and in USEPA Region 10, including Phase I of the Removal Action at T4. The boundaries are consistent with state regulations, which allow for limited turbidity exceedances for "dredging, construction, or other legitimate activities" [OAR 340-041-0036(b)].

Dredging elutriate tests (see Section 6.2.1), which are used to evaluate the potential for contaminant releases during dredging, show that dissolved chemical concentrations in the vicinity of the dredge are expected to be undetected, below water quality criteria, or comparable to ambient background levels. Water quality modeling of dredging in the berm key area indicates elevated suspended sediment concentrations will be well controlled, remaining close to the dredge and within the compliance boundaries, and diminishing rapidly with distance from the dredge (see Section 6.3.1). The size of the compliance zones is small enough that the zones will not impede fish migration, given that approximately 80 percent of the width of the river will be unaffected. Very few juvenile salmonids are expected to be in the vicinity of Slip 1 during the construction window, and the few that may travel through the area are not expected to remain near the site for more than 1 day, and more likely a few hours, considering that typical outmigration rates for juvenile salmonids are 8 to 18 kilometers per day (km/day) (ODFW 2005; Knutsen and Ward 1994).

6.1.3 Long-Term Water Quality Criteria

This section provides a review of the long-term water quality criteria that will be used to evaluate groundwater transport through the CDF. A more detailed description of long-term monitoring requirements and activities will be presented in the LTMRP to be submitted as part of the 100 Percent Design.

Final application of ARARs related to surface water will be established by USEPA for the Portland Harbor Superfund Site in the ROD, currently estimated in December 2012. As a result, how the water quality standards and associated performance standards are applied to the CDF will be finalized at that time. For the purposes of this 60 Percent DAR, the long-term water quality numeric criteria and associated performance standards outlined in USEPA's letter to the LWG, dated February 18, 2010, are used (USEPA 2010a). As directed by USEPA, the numeric criteria are applied without dilution in the water column; i.e., at an observation point inside the berm (not including the riprap face). These criteria are summarized below. Although the 60 Percent CDF DAR is based on the USEPA-directed performance standards, other information on how numeric water quality criteria are applied for implementing all water quality standards is provided for additional context.

6.1.3.1 Chronic Ambient Water Quality Criteria

Chronic ambient water quality criteria provide a surface water concentration considered safe for aquatic organisms over a 4-day exposure period. The chronic criteria for copper, DDx, and Total PCBs are from Oregon Table 33A (ODEQ 2005) and the USEPA National Recommended Water Quality Criteria (USEPA 2010b). The chronic guideline values for naphthalene and benzo(a)pyrene are from USEPA guidance (USEPA 2003b).

6.1.3.2 Fish Consumption Criteria

A key exposure pathway for the Portland Harbor Site is the potential for contaminants to bioaccumulate in fish and shellfish at levels that could pose a risk to humans that consume fish and shellfish from the harbor. Human health criteria for fish consumption used for the T4 CDF design are the National Recommended Water Quality Criteria (USEPA 2010b). Fish consumption criteria for dioxin-like PCB congeners are derived from the criteria for 2,3,7,8-TCDD (dioxin) and USEPA's recommended toxicity equivalency factors (USEPA 2009b).

During USEPA and LWG clarifications of the USEPA CDF performance standards (LWG 2010a and 2010b), it was agreed that spatial averaging of concentrations over the area of the berm face would be appropriate for evaluating fish consumption criteria in groundwater exiting the CDF. This is a conservative approach because considerably larger exposure scales, consistent with the home range of the fish and the harvesting area of the fishers, are likely appropriate (USEPA 2006b). It is also appropriate to temporally average fish consumption exposures over the human lifetime (i.e., 70 years) (USEPA 1991; ODEQ 2007; LWG 2008a).

6.1.3.3 Drinking Water Criteria

The Safe Drinking Water Act has been determined by USEPA to be potentially relevant and appropriate to the CDF. The USEPA CDF performance standards include a comparison of groundwater concentrations exiting the CDF to drinking water MCLs (USEPA 2009b). The exact application of drinking water criteria as an ARAR for a CDF will be determined by the Portland Harbor ROD.

6.1.3.4 Ambient Background Concentrations

Characterization of upstream background concentrations in the Willamette River should be considered in long-term water quality evaluations because it is impracticable to control CDF groundwater concentrations to levels below ambient background concentrations in the river. Similarly, it is impracticable to impose water quality compliance criteria lower than ambient background concentrations in the river. High-volume surface water samples collected at upstream locations in Portland Harbor were used to define ambient background concentrations of Portland Harbor COCs, especially bioaccumulative COCs (LWG 2009; Table 7.4-4).

6.1.3.5 Limits of Analytical Technology

Compliance decisions cannot reliably be made at concentrations below the limits of analytical technology. In the USEPA letter dated November 15, 2007, regarding Resolution of 60 Percent Design Disputed Comments on the T4 Removal Action (T4 Dispute Resolution Agreements), the Port and USEPA agreed that *"…currently available laboratory quantification limits and their ability to achieve all standards (especially human health criteria) is an issue that needs to be resolved as part of the 100% Design."* To that end, analytical reporting limits were considered in the evaluation of groundwater quality exiting the CDF. Analytical reporting limits were taken from the Quality Assurance Project Plan for the LWG Round 3A stormwater sampling event, based on low-level analytical methods and standard sample volumes (LWG 2007).

6.1.3.6 Total Maximum Daily Loads

Currently, there are four total maximum daily loads (TMDLs) in effect in the Lower Willamette River:

- Temperature
- Bacteria
- Mercury

- Dioxin

None of these TMDLs are relevant to groundwater quality in the CDF. Groundwater exiting the CDF is not a source of elevated temperature or bacteria. The dioxin TMDL, approved in 1991 for implementation in the Columbia River Basin including the Lower Willamette River, is primarily directed at chlorine-bleaching pulp and paper mills, none of which are present in Portland Harbor. Significant secondary dioxin sources, such as non-chlorine bleaching pulp and paper mills and municipal wastewater treatment plants, are also absent from the Harbor, and the historical pentachlorophenol-based wood treating site in the Harbor (McCormick and Baxter site) was the subject of a separate ROD and cleanup action.

Mercury is not a significant COC in dredged material being placed in the CDF, considering that mercury was detected in only one out of 40 leachate cycles from high-priority AOPCs in Portland Harbor. Nevertheless, the potential mercury load from the CDF was evaluated in the previous T4 design submittal to ensure that the CDF is protective and will comply with the Portland Harbor ROD (Anchor 2006b). ODEQ adopted an interim TMDL for mercury in September 2006. The interim TMDL determined that an overall loading reduction of 27 percent from all source categories (point source and nonpoint source) would reduce annual mercury inputs to an acceptable guidance level of 94.6 kilograms per year (kg/yr). ODEQ's implementation strategy for the interim mercury TMDL includes point and nonpoint source reductions focused on wastewater discharges, air emissions, and minimizing soil erosion in areas that contain naturally occurring mercury. ODEQ does not plan to establish waste load allocations or load allocations for mercury until approximately 2011.

For the purpose of this analysis, it was assumed that mercury is present in dredged material leachate at the laboratory reporting limit (0.1 μg/L), given that mercury was undetected in 39 out of 40 leachate analyses. The reporting limit was used as the initial concentration in groundwater modeling predictions. At the time when peak mercury concentrations are reached, which would not be for several centuries, the estimated annual mercury load in groundwater exiting the CDF was estimated to be less than 0.0002 kg/yr. This load is nearly a million times less than the acceptable guidance level of 94.6 kg/yr; i.e., it is negligible and,

therefore, will not adversely impact the mercury TMDL and the associated source reduction plan.

6.1.3.7 303(d) Listings

In addition to the TMDLs discussed above, several other chemicals have been placed on the State 303(d) list. The following 303(d)-listed chemicals were specifically evaluated in the T4 CDF groundwater model (see Appendix A):

- DDT/DDE (as DDx)
- PCBs
- PAHs

In addition, the T4 CDF groundwater model also addresses the intent of the "Biological Criteria" listing, which is based on "fish exceeding EPA's human health screening values," given that compliance with fish consumption criteria is an integral part of the CDF evaluation. The remaining chemicals on the State 303(d) list are of secondary importance in Portland Harbor (i.e., DO, aldrin, dieldrin, and pentachlorophenol), or are dominated by background contributions from native basaltic rock (i.e., iron, manganese, and arsenic). Other parameters listed for potential concern include hexavalent chromium, lead, copper, nickel, zinc, malathion, parathion, DDD, and certain specific PAHs (i.e., fluoranthene, chrysene, benzo[a]pyrene, and benzo[a]anthracene).

6.1.4 Long-Term Points of Compliance

The USEPA CDF performance standards require that groundwater exiting the CDF be compared to surface water criteria in the porewater of the berm, without dilution in the water column (USEPA 2010a). USEPA is allowing the LWG and the Port to propose alternative groundwater discharge performance standards and points of compliance to better understand the implications (including cost and effectiveness) of the USEPA CDF performance standards.

6.2 Contaminant Mobility Testing

Contaminant mobility testing results are described in this section. DRETs were performed to assess short-term water quality effects during dredging, and SBLTs were performed to assess long-term effects on CDF groundwater quality.

6.2.1 Dredging Elutriate Tests

DRETs were performed on two representative composite samples at T4. One composite sample (T4-CM1) includes sediment from Slip 1 and Berth 401, and the other composite sample (T4-CM2) includes sediment from Slip 3, Berth 414, and Wheeler Bay.

The DRET results for the composite samples T4-CM1 and T4-CM2 show that water quality effects from sediments resuspended during dredging will be negligible (Table 6-2 and BBL 2005). All metals results were well below their respective acute water quality criteria, with the exception of copper. One of the two DRET copper concentrations (5.1 and 4.3 µg/L in composite samples T4-CM1 and T4-CM2, respectively) was slightly above the acute copper criterion (4.4 µg/L) [Note: the acute and chronic copper criteria were calculated using the Biotic Ligand Model and major element chemistry in the Willamette River based on the USGS monitoring record at Portland Oregon, Station #14211720]. However, similar concentrations have been reported in ambient background surveys in the Willamette River (ODEQ 2002), and the copper concentrations in the bulk sediment samples (23 and 26 milligrams per kilogram [mg/kg], respectively) are within the range of background soil concentrations in the Pacific Northwest (WDOE 1994). Only a few PAHs were detected, and the few detected PAHs were two or more orders of magnitude below their acute water quality guidance values (USEPA 2003b). No DDT isomers or PCBs were detected.

Dredging of the berm key will be performed during construction of the CDF. The average sediment concentrations in the berm key overexcavation area (comprised of the 0 to 5-foot intervals in four cores in the berm footprint) are compiled in Table 6-3. The quality of the sediment in the berm key area is very consistent with the quality of sediment used in DRET

tests T4-CM1 and T4-CM2; therefore, the results of the DRET tests, as summarized above, should be representative of berm key dredging activities.

The results of the construction water quality monitoring program implemented during the Phase I Removal Action at T4, Slip 3 (Anchor QEA 2009) provide further evidence that no adverse water quality effects are expected during berm key dredging. The entire Phase I Removal Action in Slip 3 was implemented with only one exceedance of a conventional standard (turbidity) related to dredging at Berth 414, and no exceedances of chemical water quality criteria (including metals, PAHs, PCBs, and DDTs). As shown in Table 6-3, sediments in the Phase I Removal Action area, which were safely dredged with no significant exceedances of water quality criteria, are much more contaminated than sediments in the berm key area. Metals, DDx, and PCB concentrations in Slip 3 are several times higher than those in the berm key area, and lead and PAH concentrations are more than ten times higher than the berm key area.

6.2.2 Modified Elutriate Tests and Column Settling Tests

METs are designed to predict the chemical quality of dredging elutriate water flowing over the weir of the CDF during hydraulic filling. CSTs are designed to predict the amount of turbidity and suspended solids that discharge over the weir of the CDF during hydraulic dredging and filling. If hydraulic dredging is determined to be a practicable and cost-effective alternative for a particular AOPC, and weir overflow is predicted to occur, METs and CSTs will be conducted on a site-specific basis during later stages of design. However, this is not anticipated to be a pathway of concern for this project (see Section 6.3.1).

6.2.3 Sequential Batch Leaching Tests

SBLTs are laboratory tests designed by USACE to simulate chemical leaching characteristics of sediments in a CDF (USACE 2003) and, in this case, the leachability of COCs in Portland Harbor dredged sediments after placement in the T4 CDF. These data are used to initialize the source concentrations in the CDF groundwater model. The groundwater model then

describes the attenuation processes that occur as the COCs migrate through the CDF toward the river.

The LWG performed SBLT testing on composite sediment samples from 11 AOPCs within Portland Harbor (LWG 2009). An SBLT test was also performed by the Port using composited sediment from T4. In all, bulk sediment and leachate data are available for 12 AOPCs, which are among the sites most likely to be addressed with active remediation, including dredging. These AOPCs provide a representative cross-section of contaminated sediments throughout Portland Harbor, extending from RM 2.2 to RM 9.7 on both the east and west banks of the river, and including a wide spectrum of waterfront industries and COCs.

Four sequential leachate cycles were extracted and analyzed for each AOPC. A summary of bulk sediment and mean leachate quality for CDF index contaminants (copper, naphthalene, benzo[a]pyrene, DDx, and Total PCBs) in each of the 12 AOPCs is provided in Table 6-4. The organic contaminants are sufficiently hydrophobic that there is negligible change in the bulk sediment concentration between leachate cycles; therefore, decreasing concentrations were not normally observed across the four leaching cycles. Further discussion of SBLT results is provided in Appendix A, Attachment 1 of the Groundwater Model Input Parameter Memorandum.

The SBLT tests are also used to develop partitioning coefficients for contaminated sediments from Portland Harbor, as described in Section 6.4. The partitioning coefficients describe how readily contaminants are desorbed from the sediments, dissolved in groundwater, and transported through the CDF.

Ten of the AOPCs were evaluated for placement in the T4 CDF. Statistical distributions of leachate concentrations and partitioning coefficients were compiled on a Harbor-wide basis using the SBLT results from these ten AOPCs. The remaining two AOPCs (Sites 9 and 14, adjacent to Gasco and Arkema, respectively) were excluded from the Harbor-wide analysis because portions of these AOPCs may contain free product. Sediments containing free

product may require stabilization or some other form of treatment before they are considered suitable for placement in the CDF. Therefore, additional work at Sites 9 and 14 would be necessary to determine whether portions of these AOPCs could be placed in the CDF.

The groundwater modeling results indicate that dredged sediments from the ten AOPCs would be suitable for placement in the T4 CDF. The groundwater modeling results are discussed in Section 6.4 and Appendix A.

6.3 Short-Term Water Quality Effects

6.3.1 Water Quality during Dredging

A number of factors influence water quality conditions around the dredging operations. These factors include dredging equipment and methods, sediment characteristics, hydrodynamic conditions, water depth, and others. Mechanical dredging will be utilized to excavate the berm key.

The USACE model DREDGE was used to predict suspended sediment concentrations around the dredging operation (Kuo and Hayes 1991). DREDGE model input parameters are summarized in Table 6-5. A mechanical simulation was performed using input parameters representative of the berm key area (i.e., current velocity, water depth, and sediment gradation). The loss rates for mechanical dredging were estimated to range from 5 to 10 percent loss.

DREDGE model results are shown on Figure 6-1. The model-predicted TSS concentrations in the immediate vicinity of the dredge are as high as 26 to 54 mg/L. Concentrations drop off rapidly within a short distance from the dredge. The DREDGE model estimates TSS concentrations typical of ambient conditions in the Willamette River (22 mg/L; USGS 2006) will be reached within 10 meters.

Dredging BMPs to protect water quality and minimize turbidity are presented in the WQMP (Appendix E) and the Construction Specifications (Appendix C).

6.3.2 Water Quality during Berm Construction

The new containment berm will be created by placing material across the mouth of Slip 1 and parallel to the riverbanks, for a total distance of approximately 600 horizontal feet. The height of the berm will be equivalent to the height of the adjacent riverbanks at an elevation of approximately 30 to 35 feet NGVD. The berm will be approximately 300 feet wide at the base and 20 feet wide at the top.

Increased turbidity and suspended sediment concentrations may occur during placement of berm material through the water column, including placement of training terraces and select fill material. Water quality monitoring (i.e., visual, conventional, and contingent laboratory analysis) will occur at the mouth of Slip 1 during berm construction. Further details are provided in the WQMP (Appendix E). Appropriate construction BMPs are presented in the Construction Specifications (Appendix C).

6.3.3 Water Quality during Filling of the CDF

Hydraulic dredging and filling may not be a feasible option for most or all of the AOPCs in Portland Harbor, given that most of the AOPCs are located a long distance from T4, and many are on the opposite bank of the river. It is expected that a majority of the sediments AOPCs will be mechanically dredged and barged to the CDF. Mechanically dredged and barged sediments will then either be mechanically transferred over the berm, or hydraulically transferred with a high-solids pump using pond water as make-up water. In either case, there will be no significant rise in the pond level of the CDF, and no overflow or effluent discharge to the river. Therefore, this is not a pathway of concern for this project.

6.3.4 Water Quality during Sediment Transport

Dredged sediment will be transported by barge and/or hydraulically through a pipeline from the dredging location to the CDF. Sediment overexcavated beneath the containment berm

will be dredged mechanically and transported by barge to the head of Slip 1 for placement. It is expected that barge transport will be used for the majority of AOPCs in Portland Harbor that would potentially be using the CDF.

Water quality monitoring (visual, conventional, and contingent laboratory analysis) will occur at the transfer facility if the material is mechanically offloaded, and along the pipeline if the material is hydraulically dredged. Further details are provided in the WQMP (Appendix E). Appropriate construction BMPs are presented in the Construction Specifications (Appendix C).

6.3.5 Water Quality during Demolition and Pile Removal

Numerous structures and piling will be demolished and removed in Slip 1 as part of CDF construction. Possible water quality impacts during demolition and pile removal activities include generation of debris and dust, and disturbance of sediment. Water quality monitoring (visual, conventional, and contingent laboratory analysis) will occur at the demolition site. Further details are provided in the WQMP (Appendix E). Appropriate construction BMPs are presented in the Construction Specifications (Appendix C).

6.3.6 Water Quality during Marine Structures Construction

Piling will be driven and superstructure constructed as part of the installation of the new Berth 405. Water quality monitoring (visual, conventional, and contingent laboratory analysis) will occur at the construction site. Further details are provided in the WQMP (Appendix E). Appropriate construction BMPs are presented in the Construction Specifications (Appendix C).

6.4 Long-Term Groundwater Quality in the CDF

A CDF groundwater contaminant transport model was developed to simulate leaching of COCs from dredged sediment placed in the CDF, and subsequent transport of COCs through the berm and the underlying aquifer toward the Willamette River. A two-dimensional cross-sectional model was aligned with the critical groundwater flow path through the

center of the CDF. The following contaminant transport and attenuation processes are included in the model:

- Groundwater advection and dispersion
- Mixing of leachate with incident rainfall above and regional groundwater below
- Adsorption and desorption of contaminants onto berm and aquifer matrix materials
- Biodegradation of contaminants (in some scenarios)

Visual Modflow (Version 2010.1 Pro, Build 4.5.0.157, Waterloo Hydrogeologic, Inc.) was used for model construction, execution, and visualization. All groundwater flow simulations were performed with MODFLOW-2000 (Harbaugh et al. 2000). Contaminant transport simulations were performed with MT3DMS (Zheng and Wang 1999), which uses the flow solution provided by MODFLOW-2000.

Documentation of model input parameters, set up, calibration, results, and sensitivity analysis are provided in Appendix A, and described briefly below.

6.4.1 Groundwater Model Input Parameters

Physical and hydrogeologic input parameters are compiled in Table 6-6, including mean or central tendency values for use in base case model simulations, and a representative range of values (minimum and maximum values) for use in sensitivity and uncertainty analysis. Geochemical input parameters for T4 CDF COCs are compiled in Table 6-7. Data sources and rationale are also summarized in these tables. An overview of key model input parameters is provided below. A more detailed discussion is provided in Appendix A – Groundwater Model Input Parameter Memorandum.

6.4.1.1 Hydrogeologic Parameters

The material and hydraulic properties of the CDF building materials, including the contaminated sediment fill material, cover material (imported fill), regional aquifer, berm fill, and the training dikes are summarized in Table 6-6. Representative values for organic carbon content for contaminated sediment fill material were derived from bulk sediment

testing of Portland Harbor AOPCs (LWG 2009). Representative values for organic carbon content for import fill and berm fill material were derived from test results from local quarries (Anchor 2007b). Hydraulic conductivity values for contaminated sediment fill material were derived from consolidation tests conducted at T4 and other Region 10 sites; these tests simulate the reduction in porosity and permeability that result from the self-weight and overburden pressures in a CDF (Anchor 2007c). Hydraulic conductivity values for local aquifer materials were derived from T4 pumping tests (Hart Crowser 2000), and representative literature values were used to characterize import fill and berm fill material based on their grain size specifications (Freeze and Cherry 1979). Values for horizontal and vertical dispersion were obtained from dynamic model calibration, which is driven by daily and seasonal water level fluctuations in the river (NewFields 2007a).

6.4.1.2 Initial Source Concentrations

The initial source concentrations for the various groundwater COCs are compiled in Table 6-7. The geometric mean, arithmetic mean, and 90th percentile leachate concentrations from Portland Harbor SBLT results (excluding leachate results from AOPCs 9 and 14; see Section 6.2.3) were selected to represent the initial conditions in the groundwater model, including the base case (central value), as well as the range of concentrations (minimum and maximum values) to use in the sensitivity and uncertainty analysis. Because the CDF is comprised of a mixture of sediment and leachate from a variety of different AOPCs, an average concentration (i.e., arithmetic mean) is an appropriate statistic to characterize the source strength of this material. This does not suggest that the sediments will be homogeneously mixed during placement, but rather that CDF groundwater will be exposed to sediments from a variety of different AOPCs as it migrates through the CDF. In the future, more specific placement scenarios may be evaluated, which could consider volume-weighted averaging of AOPC leachate quality. However, information on the comparative removal volumes of the AOPCs and the sequencing of remediation actions in the Harbor is not currently available.

6.4.1.3 Partitioning Coefficients

The ratio of the bulk sediment concentration to the SBLT leachate concentration is used to develop site-specific partitioning coefficients for contaminated sediment placed in the CDF. The partitioning coefficient describes how readily contaminants are desorbed from the sediments, dissolved in groundwater, and made available for transport through the CDF. The derivation of partitioning coefficients from SBLT tests is presented in Appendix A, Attachment 1 of the Groundwater Model Input Parameter Memorandum. For most constituents, the geometric mean value of the partitioning coefficients from the ten Portland Harbor AOPC sites was used as the base case value; for Total PCBs, the coefficient was derived from a linear isotherm model (see Appendix A, Attachment 1 of the Groundwater Model Input Parameter Memorandum for further details). The initial source concentrations and the partitioning coefficients are dependent variables in that both are derived from the same SBLT leachate data; therefore, the model sensitivity analysis was focused on the variability in initial source concentrations, those being the more direct measurements, rather than the variability in partitioning coefficients.

The SBLT leachate results are applicable to the contaminated sediment material, but are not representative of the geochemical environment in the berm. The physical properties (sand and gravel) and source characteristics (regional quarries) of the berm material are fundamentally different, as are the geochemical conditions in the berm (i.e., dominated by adsorption processes rather than desorption). Applicable partitioning coefficients for metals in the berm material were established in NewFields (2007b). Partitioning coefficients for organic constituents were adopted from the LWG RI Report, Table E6 (LWG 2009). The minimum Koc value for DDD was revised based on site-specific Willamette River water column data.

6.4.1.4 Biodegradation Rates

Biodegradation rates used in the T4 CDF model (expressed as half-lives, in days) are presented in Table 6-7, along with supporting literature citations. It is expected that anaerobic degradation processes will prevail in the confined contaminated sediments,

whereas aerobic degradation processes will be more important in the berm. The T4 CDF model assumes zero degradation as a base case and worst-case scenario, and also provides alternative scenarios with conservatively protective biodegradation rates from the lower end of published literature values, (i.e., slower rates), with particular emphasis on field and regional studies.

PAHs. Anaerobic biodegradation rates for PAHs were compiled from the published literature based primarily on laboratory measurements on sediments and sediment slurries from freshwater, estuarine, and marine environments (Bach et al. 2005; Coates et al. 1996a, 1996b, and 1997; Chang et al. 2001; Heitkamp and Cerniglia 1987; and Rothermich et al. 2002). Rates measured in liquid media and tests inoculated with microorganisms were not included. Because chemical metabolism depends on bioavailability and, more specifically, solubility in porewater, the published biodegradation rates were normalized to the porosity and organic carbon content (1.5 percent) of the Portland Harbor dredged sediments. A regression model was developed which correlated the molecular weight of the PAH compounds to the normalized, published biodegradation rates, given that higher molecular weight PAHs degrade more slowly than lower molecular weight PAHs (Cerniglia 1992). The biodegradation rate defined by the 5 percent lower confidence level of the regression model was calculated, and this was further reduced by a factor of ten to provide an additional layer of conservatism and to account for possible overestimation of biodegradation rates in laboratory experiments. Based on this analysis, the biodegradation half lives for naphthalene and benzo(a)pyrene were conservatively estimated at 3 years and 40 years, respectively.

DDx. Biodegradation of DDx compounds, primarily DDE, has been extensively studied on the Palos Verdes shelf off southern California, which received contaminated effluent discharges from a nearby Montrose Chemical plant. In anaerobic sediments, DDE is the most resistant of the DDx isomers to biodegradation (Huang et al. 2001). Sediment investigations showed that the DDE mass inventory on the Palos Verdes shelf was reduced by approximately 50 percent in 10 to 15 years (Eganhouse et al. 2000a; Quensen et al. 2001), indicating significant transformation of DDE was occurring. Eganhouse et al. (2000a) estimated DDE biodegradation rates on the Palos Verdes shelf based on an analysis of parent

and degradation products in core profiles; their estimated half lives ranged from 30 to 300 years, with a geometric mean of 90 years. They suggested that physical-chemical processes, such as porewater diffusion, resuspension, and advection out of the study area, accounted for the much higher DDE loss rates that were observed in the field. In contrast, higher degradation rates were measured in laboratory studies of Palos Verdes shelf sediments, with DDE half lives ranging from about 1 to 10 years with a best estimate of 7 years (Quensen et al. 2001). In consideration of these studies, a conservative DDx half life of 90 years was selected for use in the T4 CDF model.

PCBs. A number of field studies have shown that PCBs undergo significant dechlorination in anaerobic environments over periods of a few decades, causing an overall reduction in the molecular weight of the PCB mixture and a shift toward simpler and less chlorinated homologs (Magar et al. 2005; van Dort et al. 1997). The dechlorination process is beneficial in several ways: it provides a direct reduction in PCB mass and concentration through the loss of chlorine atoms, a general detoxification of the mixture through transformation to less toxic congeners, and it leads to the formation of simpler and lighter PCB molecules that are more susceptible to aerobic degradation (i.e., destruction), which can occur in the CDF berm. Other studies have shown that highly toxic, dioxin-like PCB congeners are preferentially attacked during anaerobic dechlorination, leading to a substantial reduction in PCB toxicity in only a decade or two (Beurskens and Stortelder 1995; Sinkkonen and Paasivirta 2000). For example, the degradation half life of PCB-126, which accounts for about 86 percent of the dioxin-like toxicity in Portland Harbor leachate samples, was estimated at only 6.5 years in buried sediments from the Rhine River (Beurskens and Stortelder 1995). Long-term regional models for evaluating the environmental fate of PCBs in both San Francisco Bay and Lake Ontario used a PCB degradation half life in aquatic sediments of 56 years (Davis 2004; Gobas et al. 1995). In consideration of these studies, a PCB half life of 60 years was selected for use in the T4 CDF model.

6.4.2 Long-Term Groundwater Model Results

Figures 6-2A through 6-2E present the predicted CDF groundwater exit concentrations for a list of key Portland Harbor COCs, including copper, naphthalene, benzo(a)pyrene, DDx, and

Total PCBs, respectively. These charts show the model prediction curves for the 1,000-year simulation periods. By comparison, the longest applicable engineering design standard being applied to the CDF (the seismic design standard) has a return period of 475 years. Except for naphthalene, which peaked and decayed much more quickly than the other COCs, the model-predicted concentration trends were relatively stable at the end of the 1,000-year simulation period.

Model predictions are compared to various regulatory criteria, including chronic aquatic life criteria, fish consumption criteria, and drinking water MCLs, as required by the USEPA CDF performance standards (USEPA 2010a). Ambient upstream background concentrations in the Willamette River, and laboratory analytical limits (below which concentrations cannot be reliably quantitated) are also shown, as both must be considered in compliance evaluations. Prediction curves are presented for the peak centerline concentration, as well as the spatially averaged concentration over the interface between the berm and the river. Peak concentrations are appropriate for evaluating chronic risk to aquatic life, and spatially averaged concentrations are appropriate for evaluating fish consumption risk to humans. The region at or below analytical reporting limits is shaded in gray, and the region at or below ambient background concentrations is shaded in yellow. For organic constituents, model predictions are presented for a scenario with no biodegradation and an alternative scenario assuming a conservatively slow rate of biodegradation based on peer-reviewed literature studies (see Section 6.4.1.4).

Copper (Figure 6-2A). Centerline copper concentrations are below both chronic water quality criteria and upstream background concentrations during the 1,000-year model simulation period. Therefore, no adverse effects are predicted for copper.

Naphthalene (Figure 6-2B). Centerline naphthalene concentrations remain well below the chronic guideline indefinitely. This result was anticipated prior to conducting the model simulation since the initial leachate concentration was already below the chronic guideline. Naphthalene concentrations are also predicted to remain below the analytical reporting limit. Therefore, no adverse effects are predicted for naphthalene. Note that naphthalene

prediction curves were terminated early because concentrations had already reached their maximum value and were declining, due to naphthalene's low partitioning coefficient.

Benzo(a)pyrene (Figure 6-2C). The benzo(a)pyrene centerline concentration remains well below the chronic guideline, and the spatially averaged concentration remains well below the MCL and fish consumption criteria during the 1,000-year model simulation period. The model predicted concentrations are also below the analytical reporting limit. Therefore, no adverse effects are predicted for benzo(a)pyrene. For comparison, model predictions using a conservative biodegradation rate (41-year half life) are also presented; when biodegradation is considered, benzo(a)pyrene concentrations are many orders of magnitude below all water quality criteria.

DDx (Figure 6-2D). The DDx centerline concentration remains below the chronic water quality criteria, and the spatially averaged concentration remains below the fish consumption criteria during the entire 1,000-year simulation period. The model predicted concentrations are also below the analytical reporting limit. Therefore, no adverse effects are predicted for DDx. For comparison, model predictions using a conservative biodegradation rate (90-year half life) are also presented; when biodegradation is considered, DDx concentrations are many orders of magnitude below all water quality criteria.

Total PCBs (Figure 6-2E). Total PCB centerline concentrations remain well below the chronic water quality criteria, and spatially averaged concentrations remain well below the MCL during the entire 1,000-year simulation period. Spatially averaged PCB concentrations also remain below the fish consumption criterion for approximately 500 years, assuming zero biodegradation, and below the upstream background concentration and the analytical reporting limit for approximately 600 years. Model predictions using a conservatively slow biodegradation rate (60-year half life) indicate Total PCB concentrations are orders of magnitude below all water quality criteria at all times. With a biodegradation half life as long as 205 years (i.e., more than three times the recommended value of 60 years), the Total PCB concentrations in groundwater exiting the berm will meet water quality criteria indefinitely. Therefore, no adverse water quality effects are predicted for Total PCBs.

Contaminant Transport Pathways. The contaminant distributions and transport pathways for DDx and PCBs in groundwater migrating through the CDF berm at Year 475 are shown on Figure 6-3. Although the absolute concentrations and travel times will differ, the relative distributions and pathways will be similar for other COCs as well since they are fundamentally controlled by the same processes. In general, the fine-grained and compacted dredged sediment in the CDF serves as a plug, causing regional groundwater to flow around and under the facility, and then upwell into the more permeable berm. Contaminants diffuse out from the contaminated sediment along the base of the CDF and along the inner berm face, and they are then advected toward the river with the upwelling regional groundwater flow regime. The training dikes provide preferential transport pathways across the berm, being an order of magnitude more permeable than the berm fill. As a result, the leading edge of the groundwater plume, as well as the peak concentrations, occur within the upper training dike on the outer berm face. Long-term groundwater monitoring efforts should therefore be focused on characterizing this critical pathway.

6.4.3 Groundwater Model Sensitivity and Uncertainty

6.4.3.1 Model Sensitivity Analysis

Model sensitivity analysis was conducted to determine which input parameters have the greatest effects on model predictions. In some cases, model results were not particularly sensitive to the observed ranges in input parameter values. Model results were less than +2.4 times the base case concentration as a result of variability in sediment fill permeability, berm permeability, and berm foc. A moderate degree of sensitivity was observed for contaminated sediment source concentrations (i.e., leachate concentrations). Model predictions varied by up to +2.5 times and -4.1 times the base case concentration as a result of variability in the source strength of PCBs and DDx.

A higher degree of sensitivity was observed for berm Koc values; in particular, significantly higher concentrations were observed for Total PCBs (+ 35 times) and DDx (+ 300 times) at Year 475 when minimum Koc values were applied. However, other lines of evidence,

including Willamette River surface water data (i.e., analysis of particulate and dissolved fractions), indicate such low Koc values are not representative of Portland Harbor sediments, and the mean Koc values selected for the T4 CDF base case simulations are appropriate. The most sensitive input parameter is the biodegradation rate. By assuming zero biodegradation, predicted concentrations of Total PCBs and DDx may be overestimated by two to three orders of magnitude.

6.4.3.2 Model Uncertainty Analysis

An uncertainty analysis was conducted to assess the robustness of the CDF groundwater model predictions. The uncertainty analysis was focused on variability in source concentrations and berm Kd/Koc values because model results were shown to be highly sensitive to these input parameters. Relatively extreme observations were evaluated. Source concentrations were varied between the 50th and 90th percentiles of the Portland Harbor leachate data, and berm Kd/Koc values were varied between the minimum and maximum reported literature values (outliers removed), as compiled in the Portland Harbor RI Report, Table E6 (LWG 2009). Model predictions for copper, benzo(a)pyrene, DDx, and Total PCBs were evaluated. A conservatively slow biodegradation rate was assumed for organic COCs.

The results of the uncertainty analysis are shown in Figures 6-4A through 6-4D. For the organic COCs, the model results were much more sensitive to variability in Koc values compared to source concentrations. In all scenarios and for all COCs, the model-predicted peak concentrations were below all applicable water quality criteria. These results demonstrate that model predictions are robust to input parameter assumptions and provide further evidence that the CDF will be protective of water quality in the river.

6.4.3.3 Other Potential Uncertainty Factors

Conservative Exposure Assumptions. One of the most conservative model assumptions is the application of spatially averaged receiving water criteria, specifically fish consumption criteria, to the porewaters beneath the berm face. Rapid initial mixing in the receiving water will cause significant attenuation of contaminant concentrations; i.e., reductions of several

orders of magnitude immediately after groundwater exits the berm, because the groundwater seepage rate (8.9 E-7 meters per second [m/sec]) is approximately 50,000 times slower than the ambient river velocity (5 E-2 m/sec). The effect of CDF groundwater on receiving water quality at 10 cm from the berm face is unmeasurable. Mass balance calculations show no discernible change in the ambient background concentrations in the river as a result of groundwater discharge from the CDF. By applying receiving water standards to the berm porewater, groundwater model predictions are extremely protective of the receiving water, where the real aquatic exposures occur, by several orders of magnitude.

Turbid Leachate Samples. The SBLT leaching tests used to characterize the source strength of the porewaters of the contaminated dredge fill are susceptible to high biases. Fine clay particles and colloids have the ability to pass through the filtration step of the SBLT, especially the nonstandard 1-micron filter used for organic constituents. Laboratory observations of high turbidity levels in the filtered leachate support the interpretation that SBLT results may be biased high due to the inclusion of excessive particulate matter. Partitioning coefficients derived from turbid SBLT results are typically one to two orders of magnitude lower than corresponding literature values, indicating the magnitude of the bias may be significant. This provides a factor of conservatism in groundwater model predictions.

Porewater Release During Dredge Sediment Consolidation. A possible source of model uncertainty is the degree to which contaminant transport might be accelerated as a result of porewater being expelled during dredge sediment consolidation. If so, model predictions could underestimate the travel times of contaminants. The mean residence time of groundwater in the CDF is approximately 50 to 100 years (see Appendix A, Figure 5A). In other words, a pore volume in the CDF will turn over once every 50 to 100 years, on average. Even if an entire pore volume was expelled instantaneously, due to compaction, it would only accelerate the groundwater travel time by about 10 percent over the 500- to 1,000-year model simulation period. Therefore, the net effect of porewater expulsion during consolidation is not likely significant over the time scale of interest.

Preferential Transport along Thin Sand Layers. Thin (approximately 6-inch-thick) sand layers may be applied during the filling of the CDF to provide an interim cover over contaminated dredged material between filling seasons. A possible source of model uncertainty is the degree to which these sand layers might cause preferential flow paths through the CDF. Because of their limited thickness, the likelihood of being mixed with underlying and overlying fine-grained sediment during filling, and the likelihood that the layers will be broken into discontinuous lenses during consolidation, preferential flow seems unlikely. Further evaluation of potential thin sand layers will be conducted during 100 Percent Design when the use and configuration of such layers is better understood.

Competitive Sorption Effects. In laboratory studies, co-solutes have been observed to compete for available adsorption sites (Faria and Young 2010; Crittenden et al. 1985). The degree of competition depends on the nature of the organic substrate and the physical-chemical properties of the contaminants. Structurally similar molecules appear more likely to exhibit competition. DDx and PCBs have similar molecular weight (354 and 326 g/mol for DDT and Aroclor 1254, respectively) and similar partitioning behavior (log Koc values of 6.44 and 6.39, respectively; Table 6-7), and may therefore exhibit competitive adsorption in the T4 CDF berm.

Because the average PCB concentration in CDF leachate is about 15 times higher than the average DDx concentration, competitive sorption by DDx is likely to have an insignificant effect on the fate and transport of PCBs. On the other hand, the adsorption of DDx could potentially be reduced by as much as an order of magnitude due to the greater prevalence of PCB molecules on the adsorption sites, leading to faster travel times for DDx. Even considering such an effect, however, DDx would not exceed fish consumption criteria in porewater for well over 500 years, without assuming biodegradation.

6.5 Other Design Considerations Affecting CDF Groundwater Quality

6.5.1 Berm Material Permeability

In response to a USEPA request, further evaluation was conducted on the potential of using finer-grained material within the berm to reduce the permeability and further reduce groundwater concentrations exiting the berm, even though CDF model predictions indicate long-term groundwater quality will be in compliance with water quality standards. The selection of the berm material is a balance between finding the lowest permeable material that will not adversely affect the seismic stability of the berm. Finer-grained material will have a lower shear strength and, hence, is less resistant to failure during a seismic event.

A sensitivity analysis was completed on locally available fill materials. Ten different materials from four different suppliers were evaluated to estimate both their permeability and the seismic stability of the containment berm if it were constructed of those materials. Figure 6-5 plots the results of the sensitivity analysis. The y-axis of the graph represents the seismic safety factor for the material. For design purposes, a safety factor greater than 1.1 is acceptable. The x-axis represents the grain size of the material. Specifically, it represents the D_{10}, which corresponds to the grain size below which 10 percent of the material is finer by weight.

As shown on Figure 6-5, finer-grained materials provide a lower permeability, but at the expense of berm stability. Sources C-2 and B-4, with a D_{10} of 0.2 to 0.3 millimeter (mm), provide an optimal balance of material properties with the lowest possible permeability that will also meet the seismic stability requirements for the berm; in addition, these sources comply with the grain size specifications for select fill, as presented in the Construction Specifications (Appendix C). For comparison, a D_{10} of 0.3 mm was assumed for the groundwater modeling work described in Appendix A.

6.5.2 Solids Retention of Containment Berm

The select fill material specified for the construction of the containment berm will also serve to retain solids as water flows through the dredged material and into the berm. An analysis

was completed to assess the filtering function of the berm to retain the dredged material solids.

Composite samples from prospective removal areas in nine potential AOPCs in Portland Harbor were prepared for chemical mobility testing (LWG 2008b), as well two additional samples from T4 Slip 3. In total, ten AOPCs were evaluated for placement in the T4 CDF. These bulk composite samples were analyzed for grain size distribution. The overall description of these Portland Harbor sediments ranges from silty sand or clayey silty sand to sandy silt or clayey sandy silt. The D_{15} of these sediments ranges from 0.004 to 0.016 mm, averaging approximately 0.008 mm; and the D_{85} ranges from 0.13 to 0.50 mm, averaging approximately 0.25 mm. The specified gradation for the select fill has a D_{15} ranging from 0.18 to 0.70 mm.

Cedergren (1989) recommends the following ratios be met for proper design of a filter material to retain solids:

- [a] (D_{15} select fill)/(D_{85} dredged material) < 4 and
- [b] (D_{15} select fill)/(D_{15} dredged material) > 5

For the select fill specified and the dredged material being evaluated for placement in the T4 CDF, equation [a] ranges from 0.7 to 2.8, and equation [b] ranges from 23 to 88. This indicates that the select fill used to construct the berm should retain the dredged material placed within the CDF.

The use of a geotextile filter fabric was also evaluated for solids retention. The filter fabric would essentially serve the same function as the select fill. The filter fabric would be anchored towards the top of the berm and rolled down the slope to the toe. Panels would be overlapped 3 feet and not seamed. An underwater diver would likely be required to secure the panels in the portion placed beneath the water. Because the fabric does not improve the solids retention capabilities beyond those provided by the 200-foot-wide berm, which is an integral component of the CDF design, and because the cost is high relative to the expected benefit, the use of a filter fabric was not considered further in the design.

7 HABITAT MITIGATION

Construction of the CDF will require discharge of fill materials into Slip 1 to construct the containment berm, and discharge of dredged sediments into the CDF for final isolation of contaminated material. Discharge of fill materials during construction of the CDF triggers the need for compensatory mitigation due to the permanent loss of aquatic habitat as required by the CWA, Section 404(b)(1).

This 60 Percent CDF Design document is not proposing any specific habitat mitigation as the habitat mitigation components that will be conducted to offset losses of aquatic habitat in Slip 1 from construction of the CDF will be determined during the Phase II Removal Action design phases after the Portland Harbor ROD is issued. Habitat mitigation costs for all disposal options, including the T4 CDF, will be included in the alternatives screening evaluation in the Portland Harbor FS, and the T4 CDF will be included as part of the Harbor-wide CWA 404(b)(1) memorandum, which will be an attachment to the FS and will identify a process for determining mitigation requirements for remedial action activities. This document summarizes the activities that have occurred to date per the protocol for selecting a mitigation project that is outlined in the USEPA-approved EE/CA (BBL 2005) and acknowledges that the mitigation requirement would be determined post-ROD and would be consistent with agreements reached in the Harbor-wide FS on how to determine mitigation under Section 404 of the CWA.

As part of the full Removal Action 30 and 60 Percent Design phases, the Port completed and submitted a Conceptual Mitigation Plan Proposal (CMPP; Anchor 2006e), as well as a Draft Mitigation Plan (Anchor 2006f) to USEPA and its federal, state, and tribal partners. The CMPP represented the initial step in identification and documentation of compensatory mitigation activities proposed by the Port, and the Draft Mitigation Plan presented the proposed mitigation package, including on-site actions and the off-site project selected from the options presented in the CMPP. Additional details related to the mitigation activities the Port has completed to date related to Phase II are provided below.

7.1 Summary of Mitigation Activities through 60 Percent Design of Full Removal Action

The Port conducted mitigation activities through the 60 Percent Design phase of the full Removal Action project following the steps for identifying appropriate mitigation project(s) that were described in Appendix Q (Section Q-7.2.1) of the EE/CA (BBL 2005). The steps the Port followed, and the results, are described below:

1. **Conduct a habitat assessment of the Removal Action area.** This assessment was done to refine the characterization of affected habitat provided in Appendix Q of the EE/CA (BBL 2005) based on the design of the Removal Action by describing the biological and physical characteristics of the habitat in the Removal Action area. The results of the habitat assessment identified that 13.98 acres of aquatic habitat would be lost in Slip 1 from construction of the CDF. Of the 13.98 total acres of aquatic habitat, only 1.09 acres, or approximately 8 percent of the total aquatic habitat, would be in the less than 6-foot depth range, which is the most important depth stratum for juvenile salmonids. Within this 1.09 acres, over 85 percent is steep sloped, armored with large riprap, and/or covered with overwater structures. Additionally, a total of 2.19 acres would be within the 6- to 20-foot depth stratum, which represents about 16 percent of the total aquatic habitat impacted in Slip 1. Within this 2.19-acre area, there is a similar trend, whereby approximately 85 percent of the area is either steep sloped, armored with large riprap, and/or covered with overwater structures. A total of approximately 10.7 acres, or about 75 percent of the total aquatic habitat that could be impacted at T4 from construction of the CDF, is in the greater than 20-foot depth range, which is plentiful habitat in the Lower Willamette River.

   The Portland Harbor 404(b)(1) memorandum will consider the mitigation requirements for the T4 CDF. The results of that process will be applied to the Mitigation Plan that will be updated during the design of the Phase II Removal Action post-ROD.

2. **Identify options for proposed mitigation project(s) and determine feasibility of each option.** After meeting with USEPA and its federal, state, and tribal partners during the summer and fall of 2006, three projects were identified as potential compensatory mitigation projects, including Swan Island; Ramsey Lake Refugia, Phase II (financial contribution); and Miller Creek (mitigation bank). In addition to the off-site options, on-site mitigation actions were also selected for inclusion in the proposed mitigation package. On-site actions included creating a small amount of shallow water habitat through capping; placing a sand and gravel layer over the armor layer of the cap in Wheeler Bay; and vegetating the slope in Wheeler Bay and placing large woody debris. Additional on-site activities, including creation of a shallow water area on the CDF berm and removal of 1,800 piling, were initially included in the mitigation package, but were later removed due to discussions with USEPA and its federal, state, and tribal partners.

3. **Prepare a CMPP, which describes the identified off-site mitigation options listed above and evaluates the feasibility of each option.** The Port prepared and submitted a CMPP (Anchor 2006e) as part of the 30 Percent Design documents for the full Removal Action project.
4. **Identify the off-site mitigation project.** A project was selected based on a comparison of options that considered both habitat and programmatic details. As part of this step, the Port met with USEPA and its federal, state, and tribal partners. During the meeting, the Port presented conceptual details of the potential mitigation projects, including drawings and limited engineering characterization needed to support approval of a preferred project. Based on the results of the project comparison exercise, the stakeholder group discussed the scores and selected the Ramsey Refugia, Phase II project. This project will re-establish hydrologic connectivity to the Lower Columbia Slough over 5 acres to reclaim and improve floodplain wetland functions (forested wetland and soft bottom, mud backwater sloughs) and to increase the amount and quality of off-channel rearing and refuge habitat.

The Ramsey Refugia, Phase II project was selected based on the habitat and scale of the project relative to the habitat that would be lost from Slip 1; the implementability of the project; the demonstrated success of the Ramsey Refugia, Phase I project in attracting a variety of fish species, including juvenile salmonids; and the desired characteristics previously communicated by resource agency personnel, particularly NMFS and the U.S. Fish and Wildlife Service (USFWS). In addition, the group of stakeholders asked the Port to further evaluate the feasibility of a second project, Miller Creek, since some members of the group favored Miller Creek over the Ramsey Refugia, Phase II project. In response, the Port initiated discussions with the landowner, but the landowner was unwilling to use the land as a mitigation site.

5. **Prepare a Draft Mitigation Plan.** This document (Anchor 2006f) was prepared after the mitigation project had been identified and was submitted to USEPA as part of the 60 Percent Design documents for the full Removal Action project (Anchor 2006b). The plan identified the on-site and off-site proposed mitigation actions, the potential benefits to salmon and other aquatic species, project logistics, and timing. As the selected project involves the Port providing a certain amount of funding for the implementation of the project, no specific design details were provided in the Draft Mitigation Plan. As part of the submittal, the Port provided semi-quantitative documentation of how the proposed on-site and off-site mitigation options offset losses of habitat in Slip 1, as requested by USEPA.

   It is anticipated that the Draft Mitigation Plan will be updated post-ROD as the Phase II design progresses, and will reflect any Harbor-wide agreements reached during the FS process.

6. **Prepare a Final Mitigation Plan (100 Percent Design) once the Draft Mitigation Plan has been approved.** It is anticipated that the Final Mitigation Plan will be submitted along with the 100 Percent Design documents for Phase II of the Removal Action. The nature of this 100 Percent mitigation design submittal may vary depending on whether the mitigation action is a stand-alone Port project, or if the Port is

contributing to another project in the region, like the Ramsey Refugia, Phase II project.

The Port and USEPA and its federal, state, and tribal partners convened for a meeting in December 2006 to discuss the Draft Mitigation Plan (Anchor 2006f). Comments discussed during this meeting resulted in the removal of the on-site mitigation activities, except for the vegetation planting and placement of large woody debris in Wheeler Bay. In addition, the Port received comments on the Draft Mitigation Plan in January 2007 as part of USEPA's 60 Percent Design comments for the full Removal Action. The comments received in meetings and on the Draft Mitigation Plan are summarized below:

- Final agreement between the Port, USEPA, and a third party needs to be reached before USEPA can approve the Mitigation Plan. Additionally, the agreement details need to allow USEPA to comment on the design to ensure that ARARs are being met.
- Consider the timing of the habitat loss versus the timing of implementation of the mitigation project.
- Include complete plans and specifications for construction in the Final Mitigation Plan.
- Address the temporal loss of habitat in dredging and capping areas.
- Consider species other than salmon.
- Address the replacement of the berth structure.
- Eliminate piling removal and habitat bench along CDF berm from the mitigation package.
- Refine performance criteria related to the acreage created as part of the project, topography, and fish presence.
- Update monitoring timeframes beyond 5 years.

7.2 Next Steps

The Port is not proposing any specific mitigation in this document and acknowledges that determination of final mitigation requirements for the Phase II Removal Action, and construction of the CDF, are uncertain at this time and will be established in cooperation

with USEPA, consultation with NMFS, and coordination with other stakeholders post-ROD. The determination of the final mitigation requirements for Phase II will consider agreements reached through the FS process related to the determination of mitigation requirements, as well as any applicable information provided in the Draft Mitigation Plan developed during the full Removal Action 60 Percent Design phase, in which the Port prepared a quantitative analysis of a 5-acre area that creates and/or restores shallow water off-channel habitat as mitigation to offset impacts related to the full Removal Action, including construction of the CDF in Slip 1. The Port received initial feedback from NMFS on this document and was in the process of addressing those comments when the IDR process began.

8 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

USEPA identified location-, chemical-, and action-specific ARARs for CDF construction activities in the Action Memo (USEPA 2006a). Although these activities do not require federal, state, or local permits, they must comply with the substantive requirements of these permits, as detailed in Table 8-1. Federal, state, and local permits are required for any off-site actions.

Since issuance of the Action Memo, there have been some discussions between the LWG and USEPA related to ARARs that could impact activities related to the CDF construction. For example, on January 6, 2010, USEPA provided the LWG preliminary identification of ARARs for development of the Harbor-wide FS. The LWG and USEPA have been undergoing a series of technical discussions regarding application of the ARARs for FS evaluation purposes. Ongoing discussions between USEPA and the LWG regarding ARARs will be presented in the Harbor-wide FS. For this document, Table 8-1 has been reviewed and updated based on "EPA's Preliminary Identification of ARARs at the Portland Harbor Site for Development of the Feasibility Study," dated January 6, 2010, and subsequent letters between USEPA and the LWG dated February 1, 2010 and February 10, 2010. Note that subsequent conversations and emails occurred that are not reflected in Table 8-1, and the dialogue regarding Harbor-wide ARARs stopped without resolution as it was determined to first allow the FS process to progress. The Harbor-wide ARARs are not final and are subject to change through the FS process.

9 CONSTRUCTION SCHEDULE AND SEQUENCING

Construction of the T4 CDF will be completed in three main stages as summarized below:

- **Stage 1** – Construction of the CDF containment berm.
- **Stage 2** – Filling of the CDF with contaminated sediments from Portland Harbor AOPCs.
- **Stage 3** – Completion of the CDF cover.

In-water work for this project will comply with the timing restrictions specified in the in-water work window that have been determined by ODFW (2000), when salmonids are expected to be present in very low numbers. In the Lower Willamette River, the work window is in the summer and early fall, from July 1 through October 31, and in the winter, from December 1 through January 31. As an additional conservation measure, in-water work will be limited to the late summer and fall in-water work window, from July 1 to October 31. After the berm is built and Slip 1 is isolated from the river, work in the CDF will not be bound by these windows.

9.1 Stage 1 – CDF Containment Berm Construction

This stage of the project will occur over a 2-year period. The first year will be preparation of Slip 1 for filling, as well as constructing the containment berm at the mouth of the slip. The construction elements associated with Stage 1 include the following:

- Slip 1 Preparation
  - Demolition
  - Replacement berth construction
- Stormwater Outfall Rerouting
- Containment Berm Construction

Stage 1 work will take 1 year to complete. Figure 9-1 presents the anticipated duration and sequencing of the different Stage 1 events. The figure also shows the fish closure periods. Each of the elements is described in more detail below.

9.1.1 Slip 1 Preparation

In order to create a CDF in Slip 1, a number of structures need to be demolished and/or relocated. Berths 405 and 408 will be demolished to make room for the CDF (see Section 5.7). This work will be completed with predominantly water-based equipment, with some support from upland equipment. Because work will be conducted from the water, the construction of the containment berm cannot begin until the demolition is completed. Demolition of Slip 1 piers will begin immediately at the beginning of the in-water work window and will take 5 to 6 weeks. Due to the limited duration of in-water work windows, the contractor will work 6 days per week for these activities and for all of the water-based work.

Berth 405 will be replaced with a replacement berth near the containment berm (see Figure 5-9 and Section 5.9). This work is estimated to take 4 months to complete. The footprint of the new pier is offset from the berm footprint, so work on the two structures can occur concurrently without much schedule impact on the other.

Another element of preparing Slip 1 for filling is the relocation of the stormwater outfalls. As described in Section 5.8, four Port outfalls and one City outfall are known to discharge into Slip 1. The rerouting of the outfalls is estimated to take 6 months to complete. The majority of the work will occur out of water, so it can be completed outside the in-water work window. The daylighting of the outfalls into the Willamette River is in-water work that can only be completed during the in-water work window. The relocation needs to occur before the CDF berm breaks the water surface at the mouth of Slip 1 and breaks the hydraulic connection.

9.1.2 Containment Berm Construction

Section 5.2 describes the construction of the containment berm. The first task will be overexcavation of the soft sediments below the berm. Removal of this approximately 25,000 cy will be completed with an 8-cy clamshell bucket and bottom-dump barge. The

work will be completed in 5 to 9 days. The overexcavation will then be backfilled with select fill. Once the overexcavation is filled to grade, the contractor will start placement of training terraces. The training terraces will be constructed with an 8-cy clamshell bucket or with a skip box. A skip box is a bucket shaped like the bed of a dump truck. Material is placed by lifting one end of the box while moving it over the target area. Once the terraces are constructed on each side of the berm, select fill will be placed in between. The contractor will use a bottom-dump barge as much as possible to place the select fill. The containment berm will require approximately 290,000 tons of select fill and 95,000 tons of rock for training terraces.

The total duration of berm construction is anticipated to be 5.5 to 6 months. Because of this timeframe, the construction of the berm will be completed using two approaches. The lower portion of the berm will be constructed from the water until the closure of the in-water work window (October 31). The top elevation of the berm at this date is anticipated to be between 4 to 8 feet NGVD, which is expected to be above the water level. The berm will then be finished in the dry with upland-based equipment. This equipment will include trucks hauling in materials, dozers spreading the material, and equipment to compact the lifts.

Once the berm has sealed off the slip from the Willamette River, fish removal in Slip 1 will begin. This process is estimated to last 3 to 5 days.

9.2 Stage 2 – Filling of the CDF with Portland Harbor Superfund Site Sediments

The CDF can confine an estimated 670,000 cy of contaminated sediments. Additional material (200,000 to 300,000 cy) beyond that volume may also be placed in confinement depending on the amount of settlement that occurs. The speed at which the material is placed within the CDF is a function of two factors: 1) how fast the material can be physically offloaded from barges and pumped into the CDF; and 2) how available the material is. The offloading facility to be located at the replacement berth would likely be sized to offload 2,000 to 4,000 cy per day assuming a 10- to 12-inch-diameter hydraulic dredge pump,

respectively. Assuming there are 100 working days per in-water work season (6 days per week between July 1 and October 31), the maximum quantity of material that could reasonably be offloaded would be 200,000 to 400,000 cy.

The filling process is estimated to take up to 4 years to complete, although it could take longer or shorter depending on the schedule of the Harbor-wide remedial action and the availability of suitable dredged material. In particular, the filling process may be limited by the progress of remedial actions occurring elsewhere in Portland Harbor.

9.3 Stage 3 – Placement of the CDF Cover

The CDF cover consists of two layers (see Figure 5-2). The lower level, located directly above the confined dredged sediment, is the import fill layer. The volume of this layer is approximately 464,000 cy. The majority of this material is anticipated to be suitable dredged material brought to the site on haul barges. It will be necessary to coordinate with USACE and fulfill the substantive requirements of a CWA Section 404 permit to place suitable dredged material from maintenance dredging activities in the import fill layer. Acceptance criteria, including numeric chemical criteria, for the use of dredged material as part of the import fill layer will be developed during 100 Percent Design.

The offloading facility described in Section 5.4.1 will be used for offloading the material. As with the contaminated sediment, the rate of placement will be a function of the supply rate. At a minimum, the filling would require 1 to 2 seasons to complete.

The top of the CDF is the CDF cover layer. This layer consists of approximately 272,000 tons of aggregate. This material will be from an upland source, brought to the site by truck and/or barge and offloaded. It is anticipated that offloading by barge would be done mechanically. The fastest rate that this material could be placed is estimated at 2,000 tons per day. The filling could be completed at any time during the year since it does not involve in-water work. This layer would require 6 to 12 months to construct.

10 ENGINEERING COST ESTIMATE

The T4 CDF 60 Percent Design Engineering Cost Estimate details the anticipated costs necessary to implement the T4 CDF construction. The cost estimate includes direct and indirect construction costs.

Each of the main costs is summarized below by the different stages of construction. A more detailed account of the cost estimate basis and assumptions is provided in Appendix L.

Stage 1 Construction	**Cost in $Million**
Overwater structure and miscellaneous demolition	$5.7
Stormwater and outfall structures relocation	$2.0
Containment berm construction	$11.4
Replacement berth construction	$4.2
Stage 2 Construction	
Place contaminated sediment[1]	$0
Stage 3 Construction	
Place imported fill	$2.1 to $13.8
Place CDF cover layer	$5.4
Other costs associated with each of the stages:	
Mobilization/demobilization	$0.8
Water quality monitoring	$0.3
Habitat and other mitigation	$1.5 to $5.0
Indirect construction costs	$3.0 to $4.3
Long-term monitoring and maintenance	$1.5
Construction contingency (15%)	$5.7 to $8.2
Total Estimated Cost	**$43.6 to $62.6**

[1] It is assumed that the cost of dredging, hauling, and placement of contaminated sediment will be borne by the parties that generated the dredged sediment and, therefore, those costs are not included here.

11 ACCESS AND EASEMENT REQUIREMENTS

As stated in Section IX (Access and Institutional Controls) of the AOC (USEPA 2003a), the Port shall provide USEPA and its representatives, including contractors, with access at all reasonable times to the T4 area for the purpose of conducting any activity related to the AOC, including construction of the CDF. The AOC further states that if any portion of the T4 area, or any other riparian property where access is needed to implement the Order, is owned by or in the control of someone other than the Port, the Port shall use best efforts to obtain all necessary access for performing and overseeing the construction of the CDF.

The Port owns a majority of the uplands adjacent to the CDF and leases some areas to its tenants. As stated previously, current tenants at T4 near Slip 1 are Cereal Food Processors, IRM, Rogers Terminal, KMBT, and Union Pacific Railroad. As necessary, the Port will develop agreements with Port tenants to coordinate the work necessary for CDF construction.

Currently, both the Port and DSL own the submerged and submersible lands within T4. The Port is in the process of acquiring the land that would be necessary to site the CDF from the State of Oregon. The Port submitted a Land Sale Application Form to DSL in May 2005, which was presented and approved for negotiations at the June 2006 State Land Board. The Port has been, and will continue to be, in discussions with DSL as the CDF design progresses to acquire the remaining submersible land from DSL.

12 INSTITUTIONAL CONTROLS

Institutional controls will be required to ensure that the integrity of the CDF is maintained over the long term. Section IX (Access and Institutional Controls) of the AOC (USEPA 2003a) states that *"If after the Removal Action is complete* [including construction of the CDF]*, restrictions on the use of the Port's property, including the beds or banks of the slips or Willamette River, is necessary to maintain the Removal Action or avoid exposure to hazardous substances, pollutants, or contaminants, the Port shall take any and all actions to establish, implement, and maintain the necessary institutional controls."* In accordance with this requirement, this section describes the institutional controls that will be implemented after the CDF is built.

The overall protectiveness of the CDF will be further enhanced by implementation of institutional controls for areas where contaminated sediment is contained in place. The primary objectives for the institutional controls include protecting the integrity of the CDF berm and its ability to provide confinement of the contaminated sediments placed behind it, and protecting the integrity of the CDF such that the confined contaminated sediments, as well as groundwater in direct contact with these sediments, are not exposed through ingestion or contact with site workers or aquatic life, and do not re-enter the river.

Additional details regarding the institutional controls that will be implemented at the T4 CDF are provided below:

- **Regulated Navigation Area.** A request for a regulated navigation area (RNA) for the CDF berm will be submitted to the U.S. Coast Guard (USCG) and/or the National Oceanic and Atmospheric Administration after the berm is constructed. An RNA designation will prohibit such activities as anchoring, dragging, trawling, or other actions that may disrupt the function or affect the integrity of the CDF berm. The CDF berm will be designed to handle pile driving and removal within its footprint, and to accommodate ship berthing, tugs, and other marine traffic.
- **Update the T4 Base Map.** The footprint of the CDF and its containment berm will be placed on the T4 base map to alert personnel conducting future construction activities

that the integrity of the CDF berm must be maintained. Additionally, all development projects at the Port pass through multiple stages of internal stakeholder review during planning, design, and construction of a project. Specifically, the Port's management process for soliciting stakeholder feedback on a project is called a "Business Analysis Terms Sheet" (BATS). BATS requires solicitation of input from various departments within the Port, including environmental, and provides the opportunity to ensure coordination prior to conducting any invasive construction activities within the CDF footprint.

- **USEPA and Port Notification and Review of Construction Activities.** The confined contaminated sediments will be located 22 feet below the ground surface of the CDF. To ensure the integrity and protectiveness of the CDF, the following activities shall not be conducted on the CDF without adequate supporting technical analysis and USEPA and Port review and approval:
  - Installation of piles driven through the contaminated sediment zone
  - Installation of engineered stormwater infiltration facilities
  - Installation of utilities, storm drain lines, and other conduits under or within the contaminated sediment zone
  - Installation of groundwater extraction wells
  - Installation of foundations within 3 feet of the contaminated sediment zone
- **Tenant Lease Language.** Specific lease language will be provided to future tenants who may occupy the land above or adjacent to the CDF. The lease language will require that all below-grade excavation, construction, or other invasive activity that might potentially disturb the containment must be approved by the Port's Marine Environmental group and, if necessary, USEPA, prior to conducting such work. The lease will also include a groundwater use restriction that prohibits extraction of groundwater from the CDF for ingestion and dermal contact.
- **Restrictive Covenant/Easement and Property Record Notice.** A restrictive covenant or easement that runs with the land and is enforceable against future landowners will be recorded on the title of the property containing the CDF. The restrictive covenant or easement will institutionalize the land use, excavation, and groundwater use

restrictions described above for the property. In addition, a notice will be placed in the property record documenting the CDF location and the long-term monitoring and maintenance requirements as described in the LTMRP.

13 CONCLUSIONS

The T4 CDF, as designed, meets the intent of the USEPA CDF performance standards, as well as Portland Harbor RAOs and ARARs as they are currently known. Among the key CDF performance standards are those that address short-term and long-term water quality effects, berm stability, flood storage capacity, import material specifications, long-term monitoring requirements, habitat mitigation requirements, and institutional controls.

Short-Term Water Quality. Dredging, filling, and related sediment-disturbing CDF construction activities will be conducted in a manner that meets water quality criteria at specified points of compliance. Proposed monitoring methods, measurement parameters, locations, and frequencies are presented in the WQMP (Appendix E), and will be further detailed in the USEPA WQMCCP to be developed during 100 Percent Design. Based on the results of dredging elutriate tests, the favorable monitoring record during the T4 Phase I Removal Action, and the relatively low contaminant concentrations in the berm key area, adverse short-term water quality effects are not expected during T4 CDF construction.

Long-Term Water Quality. A long-term groundwater model of the CDF was developed to predict chemical concentrations exiting the CDF to the river for decades and centuries into the future. The model used leachate data from potential dredged material within the Willamette River. The following conclusions are supported by the groundwater modeling results (see Section 6.4 and Appendix A for further details):

- Groundwater transport pathways are dominated by downward vertical flow through the contaminated sediment toward the underlying aquifer and laterally into the berm.
- The groundwater residence time in the contaminated fill material varies from less than 20 years along the front and bottom of the CDF, to greater than 200 years at the upper rear of the CDF. Therefore, contaminated sediments in the rear and upper portion of the CDF are likely to have less effect on groundwater exit concentrations.
- During the model simulation period, the centerline and spatially averaged concentrations of all COCs remained below their respective evaluation criteria—including chronic water quality criteria, fish consumption criteria, and drinking

water MCLs—under the base case scenario of no biodegradation, except for Total PCBs, which reached its fish consumption criterion at approximately 500 years. Groundwater exit concentrations for copper, DDx, and Total PCBs remained below Portland Harbor upstream background concentrations, and all organic COCs remained below analytical reporting limits for at least 500 years.

- When conservatively slow rates of biodegradation are incorporated into model simulations for organic compounds, the maximum groundwater concentrations exiting the berm are reduced by two to three orders of magnitude.
- Model sensitivity and uncertainty analysis was conducted to assess the robustness of the model predictions to variations in sediment fill permeability, berm permeability, berm organic carbon content, dredged sediment leachate concentrations, berm Koc values, and biodegradation rates. Using a realistic range of input parameter values and a conservatively slow biodegradation rate, none of the sensitivity scenarios were predicted to exceed water quality criteria.
- The mass loading of contaminants in groundwater exiting the CDF constitute a negligible percentage of the upstream load to Portland Harbor, as well as a negligible percentage of the existing load from in situ contaminated sediments in the Harbor. Dredging the contaminated sediments in the Harbor and placing them in the CDF is expected to result in greater than 99.99 percent reduction in the mass loading of PCBs and DDx to the river (excluding consideration of sediment from AOPCs 9 and 14) compared to the contaminant loading that would occur through dissolution and resuspension if the sediments were allowed to remain in place in the river and were not remediated.

Berm Stability. The berm has been designed to provide a static safety factor of 1.5 or greater and a seismic safety factor of 1.1 or greater, based on a design seismic event corresponding to a 10 percent probability of exceedance in 50 years (see Section 5.2.2 and Appendix H). The berm has been designed to resist erosion from 100-year floods, 100-year waves, and propeller wash and waves from vessels maneuvering at or near the terminal (see Section 5.2.3 and Appendix G). The CQAP (Appendix D) provides QC measures that will be implemented

during construction to verify that the CDF is built in accordance with the project Drawings (Appendix B) and Construction Specifications (Appendix C).

Floodway Impacts. Based on hydraulic modeling of the Willamette River (using the USACE HEC-RAS model), it has been demonstrated that the CDF will not measurably increase the 100-year flood elevations or decrease the flood storage capacity of the river, in accordance with FEMA regulations (see Section 5.6 and Appendix I).

Import Material Specifications. The materials used to construct the CDF elements (including the berm, contaminated sediment fill, and cover layer) will meet acceptable physical and chemical characteristics to ensure the facility will be structurally stable and will not cause adverse water quality effects. Contaminated dredged material will be evaluated for placement in the CDF based on the bulk sediment and leachate quality of the candidate sediments. Contaminated sediments will be maintained in a saturated condition by placing them below elevation +9.5 feet NGVD. Numerical sediment acceptance criteria and import material goals will be presented in the Sediment Acceptance Criteria Memorandum to be developed during 100 Percent Design.

Long-Term Monitoring. A long-term monitoring program will be implemented after the CDF is built to ensure that the CDF is functioning as intended and meeting its performance standards well into the future. The long-term monitoring program will include routine visual surveys of the exposed portions of the berm and hydrographic surveys of the submerged portions of the berm for evidence of berm erosion and slope movement; surveying of monuments to assess CDF consolidation and settlement; and installation, monitoring, and sampling of a groundwater well network to assess saturation levels and groundwater quality in the CDF (see Section 6.4 and Appendix A). Details are outlined in the LTMRP (Appendix K), which will be further developed during 100 Percent Design.

Habitat Mitigation. The Port is not proposing any specific mitigation in this document, but acknowledges that the determination of final mitigation requirements for construction of the

CDF will be established in consultation with USEPA and its federal, state, and tribal partners after the ROD is issued.

Institutional Controls. The integrity of the CDF will be protected through the use of institutional controls such that the confined contaminated sediments, as well as groundwater in contact with those sediments, are not exposed to site workers or aquatic life (see Section 12). Institutional controls will include requesting a regulated navigation area designation from USCG, requiring construction notifications to the Port and USEPA, general restrictions regarding subsurface disturbances in the CDF (e.g., installation of utilities, piles, wells, foundations, etc.), tenant lease restrictions, and recording a restrictive covenant or easement that runs with the land on the title of the property.

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TABLES

Table 2-1
Summary of Monitoring Activities Associated with the Terminal 4 CDF

Construction Activity	Type of Sampling/Monitoring	Sampling/Monitoring Activity	Reference Document
Short-Term Monitoring (during construction)			
Pile/Structure Demolition	Water Quality Monitoring	Conventional Field Parameters	Section 3.1 of the Water Quality Monitoring Plan (WQMP)
		Laboratory Analytical Parameters	Section 3.1 of the WQMP
	Archeological Monitoring	Monitoring for activities occurring within the archeologically sensitive areas according to the Archeological Monitoring Protocol	Attachment 1 of the Construction Quality Assurance Plan (CQAP)
	Construction Performance Monitoring and Verification	Verify Removal of Specified Structure/Pile	Section 4.1.3.1 of the CQAP
		Settlement Monitoring to Verify Protection of Remaining Structures	Section 4.1.3.1 of the CQAP
		Waste-Tracking Program to Verify Appropriate Disposal/Recycling of Demolition Materials	Section 4.1.3.2 of the CQAP
		Soil Sampling to Verify No Off-site Tracking of Contaminants During Transport of Disposal Materials	Section 4.1.3.3 of the CQAP
Containment Berm Construction	Water Quality	Conventional Field Parameters	Section 3.3 of the WQMP
		Laboratory Analytical Parameters	Section 3.3 of the WQMP
	Archeological Monitoring	Monitoring for activities occurring within the archeologically sensitive areas according to the Archeological Monitoring Protocol	Attachment 1 of the CQAP
	Construction Performance Monitoring and Verification	Bathymetric/Topographic Surveys to Verify Specified Grades and Extents	Section 4.2.3.1 of the CQAP
		Verify Stability of the Containment Berm	Section 4.2.3.2 of the CQAP
		Verify Import Material Quality	Section 4.2.3.3 of the CQAP
Dredging of Berm Key	Water Quality	Conventional Field Parameters	Section 3.2 (Berm Key) of the WQMP
		Laboratory Analytical Parameters	Section 3.2 (Berm Key) of the WQMP
	Archeological Monitoring	Monitoring for activities occurring within the archeologically sensitive areas according to the Archeological Monitoring Protocol	Attachment 1 of the CQAP
	Construction Performance Monitoring and Verification	Hydrographic Surveys to Verify Dredging Depths and Extents	Section 4.3.3.1 of the CQAP
		Hydrographic Surveys to Verify Placement of Material at the Head of Slip 1	Section 4.3.3.3 of the CQAP
		Settlement Monitoring to Verify Protection of Structures	Section 4.3.3.4 of the CQAP
		Soil Sampling (pre and post) to Verify No Off-site Tracking of Contaminants During Transport of Disposal Materials for Demolition Activities	Section 4.3.3.5 of the CQAP
New Structure/Outfall/ Piping Construction	Water Quality	Conventional Field Parameters	Section 3.4 of the WQMP
		Laboratory Analytical Parameters	Section 3.4 of the WQMP
	Archeological Monitoring	Monitoring for activities occurring within the archeologically sensitive areas according to the Archeological Monitoring Protocol	Attachment 1 of the CQAP
	Construction Performance Monitoring and Verification	Verify Construction Material	Section 4.4.3.1 of the CQAP
		Surveys to Verify Specified Grades and Dimensions	Section 4.4.3.2 of the CQAP
		Hydrostatic and/or Air Testing to Verify Watertightness of Pipes	Section 4.4.3.3 of the CQAP
		Mandrel Tests to Verify Pipe Loading	Section 4.4.3.4 of the CQAP
		Field Nuclear Gage Testing (or equivalent) to Verify Compaction	Section 4.4.3.5 of the CQAP
CDF Filling With Contaminated Dredged Material	Water Quality	Field Monitoring and Laboratory Analysis of CDF Effluent	None required; CDF filling will be managed to zero effluent
		Field Monitoring and Laboratory Analysis of Ponded Water Release Through Berm Face	None required; hydraulic dredging not anticipated
		Field Monitoring and Laboratory Analysis During Transport of Dredged Material to CDF	AOPC-specific analysis (TBD)
	Sediment Characterization for Placement in CDF	Bulk Sediment Chemistry Testing	AOPC-specific analysis (TBD)
		Bulk Physical Properties (TOC, Grain Size, Atterberg Limits)	AOPC-specific analysis (TBD)
		TCLP (Hazardous Waste Designation)	AOPC-specific analysis (TBD)
		SBLT or PCLT (Sediment Leachability)	AOPC-specific analysis (TBD)
		Other Testing Requirements (Possible MET and CST Testing)	AOPC-specific analysis (TBD)
	Construction Performance Monitoring and Verification	Sediment Sampling (Pre and Post) to Confirm No Spillage of Material at the Transfer/Offload Facility	Section 4.5.3.4 of the CQAP
		Bathymetric Surveys to Verify Specified Material Placement Elevations	Section 4.5.3.5 of the CQAP
		Settlement Monitoring to Verify CDF Consolidation	Section 4.5.3.6 of the CQAP
	Interim Fill Monitoring	Bathymetric Surveys and Visual Inspections of Containment Berm After a Filling Season or Design-Level Flood or Earthquake	Section 2.1 of the Confined Disposal Facility Sediment Management Plan
		Bathymetric and/or Topographic Surveys of Placed Material	Section 2.2 of the Confined Disposal Facility Sediment Management Plan
CDF Covering	Construction Performance Monitoring and Verification	Laboratory Analysis to Verify Import Material Quality	Section 4.6.2.1 of the CQAP
		Surveys to Verify Specified Cover Thickness and Extent	Section 4.6.2.2 of the CQAP
Long-Term Monitoring (post-construction)			
CDF Long-Term Performance	Physical Monitoring	Details to be determined during 100% Design	Section 2.0 of the LTMRP
	Groundwater Quality Monitoring	Details to be determined during 100% Design	Section 3.0 of the LTMRP

Table 3-1
List of Groundwater Wells in Terminal 4 Vicinity

Company/ Owner	Use	Date	Count	TWN	RANGE	SEC	QTR	QTR40	Tax Lot ID[1]	Street Address
Monitoring Wells Within 0.5-mile of Slip 1 CDF										
BORDEN CHEMICAL		2000	1	1 N	1 W	1	NW	NW	1N1W02A-00100	10915 N LOMBARD ST
CHEMCENTRAL CORP.		1991-2002	6	1 N	1 W	1	NW	NW	1N1W01BB-00100	10821 N LOMBARD ST
INTERNATIONAL KNIFE AND SAW CO.		1995	3	1 N	1 W	1	NW	NW	1N1W01BB-00400	10707 N LOMBARD ST
MITCH, EUGENE		1999	1	1 N	1 W	1	NW	NW	1N1W01BB-00300	10761 N LOMBARD ST
PORT OF PORTLAND		1992-2009	71	1 N	1 W	2	NE	SW	1N1W02-00100	11040 N LOMBARD ST
PORT OF PORTLAND		1993	3	1 N	1 W	2	NE	SW	1N1W02A-00500	11040 N LOMBARD ST
PORT OF PORTLAND		1996	3	1 N	1 W	2	NE	SE	1N1W02A-02200	10400 N LOMBARD ST
PORT OF PORTLAND		2004	16	1 N	1 W	2	NW	NW	1N1W02A-02700	11040 N LOMBARD ST
PORT OF PORTLAND		2002	4	1 N	1 W	2	SE	NW	1N1W02D-01000	11020 N LOMBARD ST
SCHNITZER STEEL INDUSTRIES INC. AND OTHERS		1979-2011	18	2 N	1 W	35	SW	SE	2N1W35-00500	12005 N BURGARD ST
SCHNITZER INVESTMENT CORP.		2002	1	2 N	1 W	35	SE	SE	2N1W35D-00800	12005 N BURGARD ST
UNION PACIFIC RAILROAD		2001	4	1 N	1 W	2	NE	SE	1N1W02A-02300	6908 N ROBERTS AVE
W M R LLC AND OTHERS		2000-2005	20	2 N	1 W	36	NW	SW	2N1W35D-01200	11920 N BURGARD ST
Water Supply Wells Within 1 mile of Slip 1 CDF										
BEALL PIPE AND TANK CORP.	Industrial	1973	1	2 N	1 W	35	SE	NW	2N1W35D-01000	12005 N BURGARD ST
TOYOTA VEHICLE PROCESSING		1985	4	1 N	1 W	2	NE	SE	1N1W02-00301	11020 N LOMBARD ST
UNION CARBIDE	Industrial	12/31/1952	1	2 N	1 W	35	SE	NE	1640 N, 929 W	11920 N BURGARD ST
UNION CARBIDE	Industrial	12/31/1941	1	2 N	1 W	35	SE	NE	1887 N, 495 W	11920 N BURGARD ST
UNION CARBIDE	Industrial	12/31/1941	1	2 N	1 W	35	SE	NE	1758 N, 768 W	11920 N BURGARD ST
WILLIAM SHENKER CO.	Domest/Irrig[2]	12/31/1944	1	2 N	1 W	35	SE	SE	450 N, 760 W	11920 N BURGARD ST
WILLIAM SHENKER CO.	Domest/Irrig[2]	12/31/1944	1	2 N	1 W	35	SE	SE	780 N, 820 W	11920 N BURGARD ST
WILLIAM SHENKER CO.	Domest/Irrig[2]	12/31/1944	2	2 N	1 W	35	SE	SE	1200 N, 1040 W	12005 N BURGARD ST
WILLIAM SHENKER CO.	Domest/Irrig[2]	12/31/1944	1	2 N	1 W	35	SE	SE	980 N, 930 W	12005 N BURGARD ST

Notes:

Well data obtained from the Oregon Water Resources Department (OWRD) Well Log Database. http://apps.wrd.state.or.us/apps/gw/well_log/

[1] Bearing and distance from section corner listed if Tax Lot ID not provided in the OWRD database or inferred from well records.

[2] These wells were installed in 1944 when the property was agricultural. The property has since been redeveloped as industrial. Although there is no record of abandonment, these wells are likely no longer in use.

Table 5-1

Design Analysis Report Index for USEPA CDF Performance Standards

Performance Standard	Design Analysis Task	Pertinent Section
Design – *The CDF shall be designed to:*		
Contain the volume, level, and characteristics of contaminated sediment to be placed within it, using site-specific designs as needed to accommodate the specific contaminated materials proposed for disposal. The CDF shall be designed to achieve these performance standards when filled with the specified design volume of contaminated sediment meeting CDF sediment acceptance criteria that will be established, considering representative sediment contaminant concentrations and contaminant mobility data obtained from, or estimated for, sediments from Portland Harbor sites where dredging is a reasonably anticipated remedial action that would generate sediments requiring confinement.	CDF Berm, Fill, and Surface Layer Design CDF Acceptance Criteria Contaminant Mobility Testing Long-Term Water Quality Analysis and Contaminant Transport Modeling	Section 5.2 Section 5.10.1 and Sediment Acceptance Criteria Memorandum (to be developed) Section 6.2 Section 6.4; Appendix A
Minimize physical intrusion into waters of the US.	Navigation and Site Use Evaluation	Section 3.7
Minimize water flow into and out of the CDF, including preventing or restricting preferential flow paths of clean or contaminated groundwater into or out of the CDF. The evaluation should include identifying, removing or modifying utilities trenches, storm drain lines, wells, and other conduits within 500 feet of the CDF (or other distance as determined to be appropriate). Utilities, storm drain lines and other conduits are not allowed under or within the contaminated sediment fill prism.	Outfall and Stormwater Rerouting	Section 5.8 (Note: Further work will be done during 100 Percent Design)
Achieve confinement of all hazardous substances disposed of in the facility through the groundwater pathway so that the CDF does not contribute any long- term discharge and/or release of contaminants above applicable and relevant and appropriate requirements under federal or state law for surface water in the lower Willamette River.	Long-Term Water Quality Analysis and Contaminant Transport Modeling	Section 6.4; Appendix A
Limit contaminant concentrations in groundwater (including berm pore water) exiting the CDF to levels below EPA's national recommended chronic water quality criteria for both aquatic organisms and fish consumption by humans (17.5 g/day), more stringent Oregon water quality standards, and MCLs without dilution in the water column. This should include dormant periods between CDF filling, and after closure. Analyses for meeting these criteria shall not consider biodegradation of contaminants within the CDF.	Long-Term Water Quality Analysis and Contaminant Transport Modeling	Section 6.4; Appendix A
CDFs shall be designed in a manner that is consistent with the Remedial Action Objectives and Management Goals that have been established for the Feasibility Study. Habitat mitigation and land acquisition assumptions for individual CDFs shall be developed for cost estimating purposes in the FS.	Habitat Mitigation Evaluation	Section 7
CDF Berms shall be designed to: • Provide a static safety factor of 1.5 or greater and a seismic safety factor of 1.1 or greater. The design seismic event shall correspond to a 10 percent probability of exceedance in 50 years. • Be resistant to erosive forces by the largest of 100-year flood flow, 100-year waves, vessel-induced waves from typical passing vessels, and anticipated propeller wash from vessels that operate in the area. • Have an appropriate gradation to allow transport of groundwater while retaining (filtering) sediment during filling and after closure.	Stability Analysis Erosion Resistance Analysis Gradation Analysis	Section 5.2.2; Appendix H Section 5.2.3; Appendix G Section 5.2
Construction of any CDF shall not measurably increase the 100-year flooding stage or decrease flood storage of the Willamette River. The FS shall consider cumulative effects of multiple sites and related remedial actions including sediment capping.	Flood Storage Evaluation	Section 5.6; Appendix I
Maintain saturated or unsaturated conditions (as appropriate) within the confined contaminated sediments prism, considering reasonably anticipated seasonal and long-term cyclical groundwater levels, and considering site infiltration or zero recharge (as appropriate) from the overlying ground surface, to eliminate or reduce potential mobility of chemicals of concern.	Long-Term Water Quality Analysis and Contaminant Transport Modeling	Section 6.3; Appendix A

Table 5-1

Design Analysis Report Index for USEPA CDF Performance Standards

Performance Standard	Design Analysis Task	Pertinent Section
Minimize releases of 303(d) listed contaminants to the extent practicable.	Long-Term Water Quality Analysis and Contaminant Transport Modeling	Section 6.3; Appendix A
Unless modified by EPA, all CDFs shall be designed to meet these performance standards, ARARs and the final Portland Harbor ROD requirements in perpetuity.	ARARs Analysis	Section 8
Construction and Filling:		
Construct the CDF berm and related components in a manner that minimizes to the extent practicable water quality exceedances within the construction zone and achieves compliance with water quality criteria/standards at and beyond the specified point of compliance.	Short-Term Water Quality Analysis	Section 6.1.1
Construct the CDF in a manner that minimizes impacts to fisheries and wildlife by removing fish to the extent practicable from the CDF area before and during berm construction.	Fish Removal Plan	Section 5.3
Construct the CDF berm with acceptable material. For cost estimating purposes, acceptable material should be based on requirements established in the December 2003 Technical Plans and Specifications (Ecology and the Environment 2003) for the McCormick & Baxter sediment cap located within the Willamette River. Materials will generally be imported clean granular material, but typically all materials shall be free of roots, inappropriate organic material, contaminants, and all other deleterious and objectionable material. However, CDF berm construction material shall have an organic fraction meeting minimum specified values consistent with contaminant transport modeling.	Import Material Goals	Section 5.5
Accept only sediments meeting final sediment acceptance criteria. EPA shall approve all sediment to be disposed of in any CDF.	Sediment Acceptance Criteria	Section 5.10.1 and Sediment Acceptance Criteria Memorandum (to be developed)
Plan and manage the CDF filling to avoid any short-term overflow(s), or minimize the overflows to the extent possible. If a CDF overflow during filling cannot be avoided, complete an analysis of overflow discharge rates and duration, contaminant concentrations, and ability to meet water quality criteria at end of pipe. Evaluate BMPs and treatment options needed to meet water quality criteria at the end of the pipe. If EPA agrees that criteria cannot be met at the end of the pipe then a dilution zone modeling analysis of the discharge impacts shall be completed to demonstrate compliance with water quality criteria. Overflows must meet acute water quality criteria. Chronic water criteria will be used to guide implementation of BMPs to minimize contaminant loadings to the river. The design shall consider engineering controls and treatment options needed to meet chronic discharge criteria at end of pipe.	Short-Term Water Quality Analysis	Section 6.1.1
During CDF filling, concentrations in groundwater (berm pore water) exiting the CDF must meet acute water quality criteria. Chronic water criteria will be used to guide implementation of BMPs to minimize contaminant loadings to the river. For the CDF, short-term water quality impacts are defined as the period from the beginning of the fill activity until the water level in the CDF reduces to within 0.1 foot of the water level in the river.	Short-Term Contaminant Transport Modeling	Section 6.3.3; Appendix A
Physically close any hydraulic connection between river and the CDF (except through groundwater) except during periods of actual approved overflow.	CDF Berm Design	Section 5.2
Prior to final closure of any CDFs, the facility shall be managed in a manner that minimizes impacts to fisheries and wildlife. Potential and short-term exposures of fish and wildlife to contaminated sediments and/or water within a CDF shall be fully assessed and disclosed.	Management Plan for Time Between Filling Seasons	Section 5.10.5
Cap contaminated sediments with clean soils/sediment, or soils/sediments that meet specific acceptance criteria that are established by EPA.	Import Material Goals	Section 5.5
Stormwater discharges or infiltration of stormwater into the CDF is not allowed.	Outfall and Stormwater Rerouting CDF Surface Layer Design	Section 5.8 Section 5.2.6

Table 5-1

Design Analysis Report Index for USEPA CDF Performance Standards

Performance Standard	Design Analysis Task	Pertinent Section
Long-Term:		
Monitor CDF(s) in perpetuity, or until reduced monitoring is approved by EPA, to document that the CDF(s) achieves confinement of all hazardous substances placed in it so that the facility does not contribute any discharge and/or release of contaminants above performance standards/ROD criteria for surface water or sediment in the lower Willamette River.	Long-Term Management and Monitoring	Section 5.10.6; Appendix K
Provide appropriate financial assurance for project development, closure, long- term monitoring, mitigation as needed, and contingency actions.	Engineering Cost Estimate	Section 10
Implement appropriate institutional controls: • Prevent disturbance of the sediment • Prevent stormwater infiltration into the CDF or the CDF buffer zone. • Prevent installation of groundwater extraction wells for any purpose with the CDF or the CDF buffer zone. • Restrict development on the CDF. Structures may be constructed over the CDF; however, foundations must remain at least 3 feet above the upper surface of the contaminated sediment zone. Installation of piles driven through the contaminated sediment zone is not allowed. However, EPA is willing to consider proposals for jet grouted piles or other technologies that will not disturb the contaminated sediments.	Institutional Control Plan	Section 12

Table 6-1
Short-Term and Long-Term Water Quality Criteria and Background Criteria

Parameter	Units	Background Criteria			Short-Term Criteria			Long-Term Criteria				Analytical Reporting Limit[9]
		USGS Station 14211720[1]	T4 Phase I (2008)[2]	LWG Upstream (2009)[3]	Narrative Standard[4]	Acute WQC[5]	Acute Guidance Value[6]	Chronic WQC[5]	Chronic Guidance Value[6]	Fish Consumption Criteria[7]	Drinking Water MCL[8]	
Field Parameters												
Turbidity	NTU	32	9.8	--	BG <50 ntu: BG + 5 ntu BG >50 ntu: BG + 5%	--	--	--	--	--	--	--
Temperature	deg C	22	22	--	<18°C (7-day avg); if BG >18°C: BG+0.3°C	--	--	--	--	--	--	--
Dissolved Oxygen	mg/L	--	7.0	--	> 6.5	--	--	--	--	--	--	--
pH	s.u.	--	7.5	--	6.5 to 8.5	--	--	--	--	--	--	--
Laboratory Conventionals												
Total Suspended Solids	mg/L	22	7.6	--	--	--	--	--	--	--	--	--
Metals												
Cadmium (Total)	µg/L	--	--	--	--	--	--	--	--	--	5	--
Cadmium (Dissolved)	µg/L	0.05	< 0.2	--	--	0.5	--	0.09	--	--	--	--
Copper (Total)	µg/L	--	--	3.1	--	--	--	--	--	--	1,300	--
Copper (Dissolved)	µg/L	1.5	--	--	--	4.4	--	2.7	--	--	--	--
Lead (Total)	µg/L	--	--	0.74	--	--	--	--	--	--	15	--
Lead (Dissolved)	µg/L	0.14	~1	0.032	--	14	--	0.54	--	--	--	--
Zinc (Total)	µg/L	--	--	6.1	--	--	--	--	--	--	--	--
Zinc (Dissolved)	µg/L	--	12	1.9	--	36	--	36	--	--	--	--
Polycyclic Aromatic Hydrocarbons (PAHs)												
Naphthalene	µg/L	--	< 0.1	0.024	--	--	807	--	194	--	--	0.02
Acenaphthylene	µg/L	--	< 0.1	--	--	--	1277	--	307	--	--	0.02
Acenaphthene	µg/L	--	< 0.1	--	--	--	233	--	56	--	--	0.02
Fluorene	µg/L	--	< 0.1	--	--	--	162	--	39	--	--	0.02
Phenanthrene	µg/L	--	< 0.1	--	--	--	79	--	19	--	--	0.02
Anthracene	µg/L	--	< 0.1	--	--	--	87	--	21	--	--	0.02

Table 6-1
Short-Term and Long-Term Water Quality Criteria and Background Criteria

Parameter	Units	Background Criteria			Short-Term Criteria			Long-Term Criteria				Analytical Reporting Limit[9]
		USGS Station 14211720[1]	T4 Phase I (2008)[2]	LWG Upstream (2009)[3]	Narrative Standard[4]	Acute WQC[5]	Acute Guidance Value[6]	Chronic WQC[5]	Chronic Guidance Value[6]	Fish Consumption Criteria[7]	Drinking Water MCL[8]	
Fluoranthene	µg/L	--	< 0.1	--	--	--	30	--	7.1	--	--	0.02
Pyrene	µg/L	--	< 0.1	--	--	--	42	--	10	--	--	0.02
Benzo(a)anthracene	µg/L	--	< 0.1	0.00034	--	--	9.2	--	2.2	0.018	--	0.02
Chrysene	µg/L	--	< 0.1	0.00088	--	--	8.3	--	2.0	0.018	--	0.02
Benzo(b)fluoranthene	µg/L	--	< 0.1	0.00059	--	--	2.8	--	0.68	0.018	--	0.02
Benzo(k)fluoranthene	µg/L	--	< 0.1	0.00047	--	--	2.7	--	0.64	0.018	--	0.02
Benzo(a)pyrene	µg/L	--	< 0.1	0.00050	--	--	4.0	--	0.96	0.018	0.2	0.02
Indeno(1,2,3-cd)pyrene	µg/L	--	< 0.1	0.00033	--	--	1.2	--	0.28	0.018	--	0.02
Dibenzo(a,h)anthracene	µg/L	--	< 0.1	0.00011	--	--	1.2	--	0.28	0.018	--	0.02
Benzo(g,h,i)perylene	µg/L	--	< 0.1	--	--	--	1.8	--	0.44	--	--	0.02
Chlorinated Organic Compounds												
4,4'-DDT	µg/L	--	--	0.00027	--	1.1	--	0.001	--	0.00022	--	0.0005
4,4'-DDE	µg/L	--	--	0.00019	--	--	--	--	--	0.00022	--	0.0005
4,4'-DDD	µg/L	--	--	0.00008	--	--	--	--	--	0.00031	--	0.0005
Total DDx	µg/L	--	--	0.00059	--	1.1	--	0.001	--	--	--	0.0005
Total PCBs	µg/L	--	--	3.9E-04	--	--	--	0.014	--	6.4E-05	0.5	2.0E-04

Notes:

[1] 90th percentile values; USGS Morrison Street Bridge gage; field parameters record from 1998-2008; metals record from 2004-2005.

[2] 90th percentile values (except DO = 10th percentile); combined pre-construction and construction background stations, June - October 2008; see T4 Phase I Removal Action Completion Report (Anchor QEA 2009).

[3] LWG Remedial Investigation Report 2009, Table 7.4-4; Upper Prediction Levels (UPLs) with outliers removed; also LWG unpublished (PAHs and metals)

[4] As per Water Quality Monitoring and Compliance Conditions Plan (WQMCCP) for T4 Phase I Removal Action (USEPA 2008).

[5] ODEQ 2005, Table 33A; and USEPA 2010, National Recommended Water Quality Criteria; copper based on Biotic Ligand Model; all other metals based on Willamette River hardness of 25 mg/L.

[6] USEPA 2003b, aquatic life guidance values.

[7] USEPA 2010b, National Recommended Water Quality Criteria (organisms only).

[8] USEPA 2009b, National Primary Drinking Water Standards, Maximum Contaminant Level (MCL) or Treatment Technique (TT).

[9] LWG 2007, Round 2 QAPP, Addendum 8, Table 3-2; except Total PCBs which is based on 90th percentile laboratory blank contamination levels in RI data.

Table 6-2
DRET Elutriate Chemistry Results

Sample ID Lab ID Date Sampled	Acute Water Quality Value	T4-CM1-Dret K2402978-004 04/20/2004	T4-CM2-Dret K2403382-001 05/05/2004
Metals (µg/L)			
Arsenic	340	0.9	0.8
Cadmium	0.5	0.02 U	0.04 U
Chromium	183	1.11	1.77
Copper	4.4	5.08	4.25
Lead	14	1.63	1.86
Mercury	1.4	0.2 U	0.2 U
Nickel	145	1.3	1.65
Selenium	--	0.7 U	0.4 B
Silver	0.3	0.03 U	0.03
Zinc	36	5.62	6.7
Semivolatile Organics (µg/L)			
Naphthalene	807	0.40 U	0.39 U
2-Methylnaphthalene	300	0.40 U	0.39 U
1-Methylnaphthalene	312	0.40 U	0.39 U
Biphenyl	--	0.40 U	0.39 U
2,6-Dimethylnaphthalene	108	0.40 U	0.39 U
Acenaphthylene	1,277	0.40 U	0.099 J
Acenaphthene	233	0.40 U	0.19 J
2,3,5-Trimethylnaphthalene	41	0.40 U	0.027 J
Fluorene	162	0.40 U	0.096 J
Phenanthrene	79	0.40 U	0.13 J
Anthracene	87	0.40 U	0.39 U
1-Methylphenanthrene	31	0.40 U	0.39 U
Fluoranthene	30	0.40 U	0.092 J
Pyrene	42	0.075 J	0.13 J
Benz(a)anthracene	9.2	0.40 U	0.39 U
Chrysene	8.3	0.40 U	0.39 U
Benzo(b)fluoranthene	2.8	0.40 U	0.39 U
Benzo(k)fluoranthene	2.7	0.40 U	0.39 U
Benzo(e)pyrene	3.7	0.40 U	0.39 U
Benzo(a)pyrene	4.0	0.40 U	0.39 U
Perylene	3.7	0.40 U	0.39 U
Indeno(1,2,3-cd)pyrene	1.2	0.40 U	0.39 U
Dibenz(a,h)anthracene	1.2	0.40 U	0.39 U
Benzo(g,h,i)perylene	1.8	0.40 U	0.39 U
Dimethyl phthalate	--	9.9 U	9.6 UJ
Diethyl phthalate	--	9.9 U	9.6 U
Di-n-butyl phthalate	--	9.9 U	9.6 U
Butylbenzyl phthalate	--	9.9 U	9.6 U
Bis(2-ethylhexyl) phthalate	--	9.9 U	9.6 U
Di-n-octyl phthalate	--	9.9 U	9.6 U
Total PAHs (a,b)	--	0.075 J	0.737 J

Table 6-2
DRET Elutriate Chemistry Results

Sample ID Lab ID Date Sampled	Acute Water Quality Value	T4-CM1-Dret K2402978-004 04/20/2004	T4-CM2-Dret K2403382-001 05/05/2004
Pesticides (µg/L)			
4,4'-DDE	--	0.099 U	0.097 U
4,4'-DDD	--	0.099 U	0.097 U
4,4'-DDT	1.1	0.099 U	0.097 U
2,4'-DDE	--	0.099 U	0.097 U
2,4'-DDD	--	0.099 U	0.097 U
2,4'-DDT	--	0.099 U	0.097 U
Total DDD	--	0.099 U	0.097 U
Total DDE	--	0.099 U	0.097 U
Total DDT	--	0.099 U	0.097 U
ΣDDTs (a)	--	0.099 U	0.097 U
PCBs (µg/L)			
Aroclor 1016	--	0.099 U	0.097 U
Aroclor 1221	--	0.099 U	0.097 U
Aroclor 1232	--	0.099 U	0.097 U
Aroclor 1242	--	0.099 U	0.097 U
Aroclor 1248	--	0.099 U	0.097 U
Aroclor 1254	--	0.099 U	0.097 U
Aroclor 1260	--	0.099 U	0.097 U
Aroclor 1262	--	0.099 U	0.097 U
Aroclor 1268	--	0.099 U	0.097 U
Total PCBs (a)	2	0.099 U	0.097 U
Petroleum Hydrocarbons (µg/L)			
Diesel Range Organics (DRO)	--	250 U	250 U
Residual Range Organics (RRO)	--	57 J	500 U
Conventionals (mg/L)			
Total suspended solids	--	5 U	5 U
Ammonia as Nitrogen	--	0.57	0.68
Total Sulfide	--	0.05 U	0.05 U

Notes:

U = Analyte not detected above the reporting limit.
J = Analyte was positively identified; associated concentration is an estimated value.
UJ = Analyte not detected above the reporting limit. Reporting limit is approximate.
B = Analyte was also detected in method blank.
a. Summations performed using detected concentrations of individual constituents.
Shaded cell indicates elutriate concentration above acute water quality criteria

Table 6-3
Comparison of Sediment Quality in Berm Key, Slip 1, and Slip 3 Removal Action Areas

	MacDonald et al. (2000) Sediment Quality Guidelines		[1] Contaminant Mobility Testing Composite Bulk Sediment		[2]	[3]	[4]
	TEC	PEC	Slip 1, Berth 401 (CM1)	Slip 3, Wheeler Bay, Berth 411 (CM2)	Berm Key Over-excavation Area	Slip 3 Removal Action Area	Slip 3 Phase I Removal Action Area
Metals (mg/kg)							
Cadmium	1.0	5.0	0.3	0.3	0.3	1.6	2.3
Copper	32	149	26 J	23 J	27	43	--
Lead	36	128	30	23	18	184	302
Zinc	121	459	94	79	82	250	386
PAHs (µg/kg)							
Naphthalene	176	561	56	97	61	312	--
Phenanthrene	204	1,170	230	590	608	4,259	--
Chrysene	166	1,290	240	690	538	5,656	--
Benzo(a)pyrene	150	1,450	230	750	662	6,148	--
Total PAHs	1,610	22,800	2,311	6,440	5,766	50,850	172,750
Pesticides (µg/kg)							
4,4-DDE	3.2	31	1.7	2.1	3.6	3.7	--
4,4-DDD	4.9	28	1.4	1.9	2.5	6.8	--
4,4-DDT	4.2	63	2.0	2.5	2.5	9.8	--
4,4-DDX	5.3	572	5.1	6.5	8.5	16.3	--
PCBs (µg/kg)							
Total PCBs	60	676	67	25	32	92	--

References:

[1] BBL 2005, Appendix F, Table F-1

[2] BBL 2005, Appendix E, Table E-1, Cores VC-03, -04, -11, and -12 (mean from 0 to 5 feet subsurface)

[3] Anchor 2007a

[4] Anchor QEA 2009, Table 5 (area-weighted)

Table 6-4
AOPC Bulk Sediment and Leachate Quality

	Copper			Benzo(a)pyrene			Naphthalene			Total PCBs			Total DDx		
	Bulk Sediment Conc.	Mean Leachate Conc.	Mean Log Kd	Bulk Sediment Conc.	Mean Leachate Conc.	Mean Log Koc	Bulk Sediment Conc.	Mean Leachate Conc.	Mean Log Koc	Bulk Sediment Conc.	Mean Leachate Conc.	Mean Log Koc	Bulk Sediment Conc.	Mean Leachate Conc.	Mean Log Koc
Portland Harbor AOPC	**mg/kg**	**mg/L**	**Log(L/kg)**	**µg/kg**	**µg/L**	**Log(L/kg)**	**µg/kg**	**µg/L**	**Log(L/kg)**	**µg/kg**	**µg/L**	**Log(L/kg)**	**µg/kg**	**µg/L**	**Log(L/kg)**
Site 1: Evraz Oregon Steel	16.6 J	0.0062	3.42	100	0.051	5.24	11	0.048	4.29	109	0.366	4.40	6.1 U	0.005	ND
Site 3: Schnitzer	33.6 J	0.0085	3.60	460	0.286	5.03	150	0.015	5.81	4,520	3.763	4.90	10.0 U	0.011	ND
Site 6: Terminal 4	48.9	0.0086	3.75	7,900	0.050	7.01	250	0.050	5.50	46	0.089	4.51	23.0 U	0.011	ND
Site 8: BP-Arco	121.0 J	0.0033	4.56	450	0.572	5.04	27	0.011	5.53	10 U	0.009	ND	2.0 U	0.005	ND
Site 11: Mar Com Marine	20.8 J	0.0018	4.06	240 J	0.310	4.75	73	0.228	4.27	10 U	0.070	ND	6.1	0.024	4.23
Site 13: Willamette Cove	67.6 J	0.0066	4.01	200 J	0.253	4.42	240 J	0.121	4.83	77	0.095	4.44	16.8	0.017	4.53
Site 17: Cascade General	67.8 J	0.0037	4.27	70	0.039	5.17	6	0.029	4.22	50	0.088	4.66	2.0 U	0.005	ND
Site 17: Swan Is. Lagoon	14.5 J	0.0034	3.62	74	0.050	4.94	35	0.022	NC	69	0.163	4.39	1.9 U	0.005	ND
Site 19: Gunderson	50.6	0.0033	4.19	72 J	0.049	4.93	36	0.027	4.89	1,358	1.315	4.78	238.0	0.302	4.66
Site 20: Fireboat Cove	28.7 T	0.0025	4.06	290	0.138	5.31	65	0.025	5.40	281	1.192	4.32	264.5	0.023	6.06
Site 9: Gasco	33.6 J	0.0039	3.94	200,000	54.391	4.54	3,200,000	6,567.530	3.65	120 U	0.044	ND	99.0 U	0.023	ND
Site 14: Arkema	70.4	0.0036	4.29	800 J	0.221	5.26	190	1.337	3.79	990 U	2.549	ND	46,000	40.662	4.75

Notes:
- J = Estimated value
- ND = Koc not calculated because constituent is undetected in bulk sediment
- U = Undetected at indicated reporting limit
- Mean leachate concentration is geometric mean of four leachate cycles; nondetects included at 1/2 reporting limit value
- Sites 9 and 14 are excluded from Terminal 4 CDF model input values
- Total DDx is defined as the sum of 4,4'-DDT, 4,4'-DDD, and 4,4'-DDE

Table 6-5
DREDGE Model Input Parameters

	Typical	Units	Data Sources/References
Dredging Parameters			
Open Bucket Size	6.2	m^3	Source: Manson
Cycle Time	150	sec	Source: Manson (average cycle time)
(Average) Settling Velocity	0.00423	m/sec	Calculated by model based on particle sizes
In-situ dry density	700	kg/m^3	Source: Typical for recently deposited sediments
Near-field TSS Model			
User Estimate (Mechanical)	5 to 10	% loss	Hayes and Wu 2001; Anchor 2003
Far-field TSS Models			
Kuo's Model			
Lateral diffusion coefficient	100000	cm^2/s	Model default value
Vertical diffusion coefficent	10	cm^2/s	Model default value
(Average) settling velocity	0.00423	m/s	Calculated by model based on particle sizes
Downstream locations (for output)	150	m	Defined by user
Downstream step	5	m	Defined by user
Lateral locations (for output)	100	m	Defined by user
Lateral step	5	m	Defined by user
Site Characteristics			
Water depth (Mechanical dredge area)	11	m	Typical dredge depth, mouth of Slip 1
Ambient Water Velocity	0.15	m/s	Source: BBL 2005, EE/CA Figure G-1; typical at Harbor Line
Mean particle size	74	um	Source: Review of geotech data
Specific gravity of sediment	2.64	g/cm^3	Source: Review of geotech data
Fraction of particles < 74um	0.70	%	Source: BBL 2004a, Table E-1
Fraction of particles < 5um	0.28	%	Source: BBL 2004a, Table E-1

Table 6-6
Physical and Hydraulic Properties of CDF Materials

Material	Units	Model Input Values for Base Case and Sensitivity Analysis			Data Source/Rationale
		Min.	Central	Max.	
Sediment Fill					
Fraction organic carbon	-	0.010	0.015	0.018	LWG (2009), Measured pH bulk sediment: 10% / Average / 90%
Porosity	-	-	0.35	-	Anchor (2006b)
Hydraulic conductivity	ft/d	0.00017	0.00085	0.0028	Anchor (2007c); Consolidation tests from T4 and Region 10
Bulk density	g/cm^3	-	1.3	-	BBL (2005; Table 4-4); Consolidation tests from T4
Imported Fill					
Fraction organic carbon	-	0.0005	0.0006	0.0007	Anchor (2007b), Measured import from local quarries
Porosity	-	-	0.30	-	Anchor (2006b)
Hydraulic conductivity	ft/d	-	28	-	Freeze and Cherry (1979; Table 2.2); clean sand
Bulk density	g/cm^3	-	2.0	-	Holz and Kovacs (1981; Table 2-1)
Berm Fill					
Fraction organic carbon	-	0.0005	0.0006	0.0007	Anchor (2007b), Measured import from local quarries
Porosity	-	-	0.30	-	Anchor (2006b)
Hydraulic conductivity	ft/d	30	280	450	Hazen's approximation based on gradation specification for Select Fill
Bulk density	g/cm^3	-	2.0	-	Holz and Kovacs (1981; Table 2-1)
Dispersion - Horizontal	-	-	40	-	Anchor (2006b); NewFields (2007a): Dynamic model calibration
Dispersion - Vertical	-	-	0.4	-	Anchor (2006b); NewFields (2007a): Dynamic model calibration
Training Dikes					
Fraction organic carbon	-	-	0.00006	-	Assumed 10 percent of Berm Fill value
Porosity	-	-	0.30	-	Anchor (2006b)
Hydraulic conductivity	ft/d	-	2,800	-	Freeze and Cherry (1979; Table 2.2); clean gravel
Bulk density	g/cm^3	-	2.2	-	Holz and Kovacs (1981; Table 2-1)
Aquifer					
Fraction organic carbon	-	-	0.003	-	BBL (2005); Average measured value in Slip 1 aquifer material
Porosity	-	-	0.30	-	Anchor (2006b)
Hydraulic conductivity (K)	ft/d	-	65	-	Hart Crowser (2000); Pumping test results, as reported in BBL (2005)
Bulk Density	g/cm^3	-	2.0	-	Holz and Kovacs (1981; Table 2-1)

"Base case" input values used in Figures 6-2A through 6-2E

Table 6-7
Geochemical Properties of Chemicals of Concern

Material	Units	Model Input Values for Base Case and Sensitivity Analysis			Data Source/Rationale
		Min.	Central	Max.	
Initial Source Concentrations in Contaminated Sediment Pore Waters					
Copper	µg/L	4	8	14	LWG (2009); Geometric Mean, Arithmetic Mean, and 90th Percentile of SBLT results
Naphthalene	µg/L	0.04	0.07	0.15	LWG (2009); Geometric Mean, Arithmetic Mean, and 90th Percentile of SBLT results
Benzo(a)pyrene	µg/L	0.12	0.23	0.52	LWG (2009); Geometric Mean, Arithmetic Mean, and 90th Percentile of SBLT results
Total DDX	µg/L	0.014	0.058	0.076	LWG (2009); Geometric Mean, Arithmetic Mean, and 90th Percentile of SBLT results
Total PCB Aroclors	µg/L	0.22	0.87	2.17	LWG (2009); Geometric Mean, Arithmetic Mean, and 90th Percentile of SBLT results
Metal Partitioning Coefficient [Kd]					
Copper [Sediment]	L/kg	-	8,900	-	Anchor QEA and Newfields (2010); LWG (2009); Geometric Mean of AOPCs
Copper [Berm, Cap]	L/kg	100	165	-	NewFields (2007b)
Copper [Quarry Spall]	L/kg	1	20	-	USEPA (2005; Table 3); Minimum and 1st Percentile Kd
Log Organic Partitioning Coefficient [Koc] - Sediment					
Naphthalene	Log L/kg-OC	-	4.97	-	Anchor QEA and Newfields (2010); LWG (2009); Geometric Mean of AOPCs
Benzo(a)pyrene	Log L/kg-OC	-	5.18	-	Anchor QEA and Newfields (2010); LWG (2009); Geometric Mean of AOPCs
Total DDX	Log L/kg-OC	-	4.87	-	Anchor QEA and Newfields (2010); LWG (2009); Geometric Mean of AOPCs
Total PCB Aroclors	Log L/kg-OC	-	4.86	-	Anchor QEA and Newfields (2010); LWG (2009); Linear Isotherm Model
Log Organic Partitioning Coefficient [Koc] - Berm					
Naphthalene	Log L/kg-OC	3.12	3.30	3.53	LWG RI Report Table E6 (2009)
Benzo(a)pyrene	Log L/kg-OC	5.68	6.01	6.67	LWG RI Report Table E6 (2009)
Total DDX	Log L/kg-OC	5.69	6.44	6.62	LWG RI Report Table E6 (2009); Geometric Mean of DDT, DDE, and DDD
Total PCB Aroclors	Log L/kg-OC	5.96	6.39	7.59	LWG RI Report Table E6 (2009); Geometric Mean of Ar-1254 and Ar-1260
Biodegradation Half Life in Sediment [Anaerobic]					
Naphthalene	days	-	1,100	Infinite[1]	Central value = 95% UCL from Bach et al. (2005); Coates et al. (1996a, 1996b, 1997); Chang et al. (2001); Heitkamp & Cerniglia (1987); Rothermich et al. (2002)
Benzo(a)pyrene	days	-	15,000	Infinite[1]	
Total DDX	days	-	33,000	Infinite[1]	Eganhouse et al. (2000a, 2000b)
Total PCB Aroclors	days	-	22,000	Infinite[1]	Magar et al. (2005); van Dort et al. (1997); Mackay et al. (1994); Davis (2004)

Notes: [1] Infinite half life corresponds to zero biodegradation

"Base case" input values used in Figures 6-2A through 6-2E

Table 8-1
ARARs for Confined Disposal Facility

Legal Requirement	Citation	Criterion/Standard and Applicability	Compliance Reference
Federal ARARs			
Clean Water Act, Section 404	33 USC 1344 40 CFR 230	Regulates discharge of dredged and fill material into waters of the United States. Action specific—potentially applicable to construction of in-water disposal facility.	Appendix Q of the Engineering Evaluation/Cost Analysis (EE/CA; BBL 2005) provides a preliminary draft 404(b)(1) evaluation and concludes that there is a need for compensatory mitigation due to the permanent loss of aquatic habitat. Conceptual Compensatory Mitigation Plan and Draft Mitigation Plan identify mitigation actions to offset losses of aquatic habitat. The Draft Mitigation Plan will be updated post- Record of Decision (ROD) and will reflect decisions made during the Portland Harbor Feasibility Study (FS) process. Biological Assessment and Water Quality Monitoring Plan (WQMP; Appendix E of the Design Analysis Report [DAR]) address action-specific best management practices (BMPs) to minimize short-term water quality impacts due to discharges.

Note: Table 8-1 is based on "EPA's Preliminary Identification of ARARs at the Portland Harbor Site for Development of the Feasibility Study," dated January 6, 2010, and subsequent letters between EPA and the Lower Willamette Group dated February 1, 2010 and February 10, 2010. The Harbor-wide ARARs are not final and are subject to change through the FS process.

Table 8-1
ARARs for Confined Disposal Facility

Legal Requirement	Citation	Criterion/Standard and Applicability	Compliance Reference
Clean Water Act, Ambient Water Quality Criteria	33 USC 1313, 1314 Most recent 304(a) list, as updated up to issuance of the ROD	Provides minimum standards for water quality programs established by states. Two kinds of water quality criteria exist: one for protection of human health, and one for protection of aquatic life. Chemical-specific; action-specific—potentially relevant and appropriate as performance standards for the confined disposal facility's (CDF's) containment of hazardous substances only if more stringent than promulgated state criteria.	Section 6 of the DAR, Water Quality, addresses water quality details related to the construction of the CDF. The WQMP (Appendix E of the DAR) details water quality monitoring activities for construction of the CDF and details ambient water quality criteria as exceedance triggers. The CDF Sediment Management Plan (Appendix J of the DAR) provides a process for accepting material for placement into the CDF based on contaminant transport modeling through the berm (see also Appendix A of the DAR). Ambient water quality criteria are the basis of the model evaluation. Biological Assessment and WQMP address action-specific BMPs to minimize short-term water quality impacts due to construction activities.
Clean Water Act, Section 401	33 USC 1341 40 CFR Section 121.2(a)(3),(4), and (5)	Applies to any federally authorized activity that may result in any discharge into navigable waters and requires that such discharge comply with applicable provisions of sections 1311, 1312, 1313, 1316, and 1317 of the Clean Water Act. Action-specific—potentially applicable to discharges into the river during in-water disposal activities if more stringent than state implementation regulations.	Section 6 of the DAR, Water Quality, addresses water quality details related to the Removal Action. The WQMP (Appendix E of the DAR) details water quality monitoring activities during construction and identifies criteria that must be met during construction.

Note: Table 8-1 is based on "EPA's Preliminary Identification of ARARs at the Portland Harbor Site for Development of the Feasibility Study," dated January 6, 2010, and subsequent letters between EPA and the Lower Willamette Group dated February 1, 2010 and February 10, 2010. The Harbor-wide ARARs are not final and are subject to change through the FS process.

Table 8-1
ARARs for Confined Disposal Facility

Legal Requirement	Citation	Criterion/Standard and Applicability	Compliance Reference
Clean Water Act, Section 402	33 USC 1342	Regulates discharges of pollutants from point sources to waters of the U.S., and requires compliance with the standards, limitations, and regulations promulgated per Sections 301, 304, 306, 307, 308 of the Clean Water Act. Potentially relevant and appropriate to the operation of the CDF if hydraulic dredging is used to fill the CDF and a point-source return flow of dredge elutriate water to the Willamette River is established over an extended period of time.	If hydraulic dredging is determined to be a preferred filling option for one or more Areas of Potential Concern (AOPCs) and a point-source discharge of dredge elutriate water is established, then additional analysis of water quality effects associated with the discharge will be conducted.
Safe Drinking Water Act	42 USC 300f 40 CFR Part 141, Subpart O, Appendix A 40 CFR Part 143	Establishes national drinking water standards to protect human health from contaminants in drinking water. Chemical-specific—Potentially relevant and appropriate to surface water designated as a potential drinking water supply for performance criteria for the CDF's containment of hazardous substances.	The CDF Sediment Management Plan (Appendix J of the DAR), Section 6 of the DAR (Water Quality), and the WQMP (Appendix E of the DAR) address performance criteria for the CDF and includes drinking water maximum contaminant levels (MCLs). (Note: aquatic life standards are more stringent for most analytes.) The Long-term Monitoring and Reporting Plan (LTMRP; Appendix K of the DAR) will address long-term performance criteria related to the CDF.
Resource Conservation and Recovery Act	40 CFR 260, 261	Establishes identification standards and definitions for solid and hazardous waste, including when dredged material is exempt from the definition of a hazardous waste. Action-specific—Potentially relevant and appropriate for use in identifying acceptance criteria for CDF.	The CDF Sediment Management Plan (Appendix J of the DAR) details sediment exclusions, including characteristic hazardous waste as defined by hazardous waste criteria listed in 40 CFR 261.24

Note: Table 8-1 is based on "EPA's Preliminary Identification of ARARs at the Portland Harbor Site for Development of the Feasibility Study," dated January 6, 2010, and subsequent letters between EPA and the Lower Willamette Group dated February 1, 2010 and February 10, 2010. The Harbor-wide ARARs are not final and are subject to change through the FS process.

Table 8-1
ARARs for Confined Disposal Facility

Legal Requirement	Citation	Criterion/Standard and Applicability	Compliance Reference
Resource Conservation and Recovery Act—Solid Waste	40 CFR 257 Subpart A	Resource Conservation and Recovery Act Solid Waste requirements may be relevant and appropriate for upland and in-water disposal of dredged material.	This regulation has been determined to not be applicable and relevant to the Terminal 4 CDF per the Terminal 4 Action Memorandum (Action Memo; USEPA, May 11, 2006), Response to Comment Golder-1 and Comment 75-1, which provides the following: sediments are not solid wastes under federal law; sediments that contain a listed hazardous waste or exhibit hazardous waste characteristics are exempt from the definition of hazardous waste if managed under the Clean Water Act (40 CFR 261.4(g)); and Clean Water Act Section 404 and 401 are the controlling ARARs for in-water disposal, not the Resource Conservation and Recovery Act.
Hazardous Materials Transportation Act	49 USC § et seq. 40 CFR Parts 171-177	Hazardous Materials Transportation Act requirements are applicable to remedial actions that involve the transport of hazardous materials (i.e., dredged material). Potentially applicable to the transport of hazardous dredged material brought to the CDF for disposal.	
Fish and Wildlife Coordination Act Requirements	16 USC 662, 663 40 CFR 6.302(g)	Requires federal agencies to consider effects on fish and wildlife from projects that may alter a body of water and mitigate or compensate for project-related losses. Action-specific—Potentially applicable to determining appropriate mitigation for effects on fish and wildlife from construction and performance of the CDF.	The Biological Assessment for Phase II will detail potential impacts of the CDF construction and performance on Endangered Species Act (ESA)-listed fish and wildlife species and construction BMPs and conservation measures that will be implemented to minimize potential impacts. Conceptual Mitigation Plan Proposal and Draft Mitigation Plan details permanent habitat losses at Terminal 4 due to the Removal Action and summarizes mitigation actions to off-set those losses. The Draft Mitigation Plan will be updated post-ROD and will reflect decisions made during the Portland Harbor FS process.

Note: Table 8-1 is based on "EPA's Preliminary Identification of ARARs at the Portland Harbor Site for Development of the Feasibility Study," dated January 6, 2010, and subsequent letters between EPA and the Lower Willamette Group dated February 1, 2010 and February 10, 2010. The Harbor-wide ARARs are not final and are subject to change through the FS process.

Table 8-1
ARARs for Confined Disposal Facility

Legal Requirement	Citation	Criterion/Standard and Applicability	Compliance Reference
Magnuson-Stevens Fishery Conservation and Management Act	50 CFR Part 600.920	Evaluation of impacts to Essential Fish Habitat (EFH) is necessary for activities that may aversely affect EFH. Location-specific—Potentially applicable if the construction of the CDF adversely affects EFH.	The Biological Assessment for Phase II will provide an evaluation of EFH impacts related to CDF construction activities.
Federal Emergency Management Act	44 CFR 60.3(d)(2) and (3)	Federal Emergency Management Act flood rise requirements are considered relevant and appropriate requirements for remedial actions, including construction of the CDF.	Appendix I of the DAR contains information related to the Flood Analysis.
Rivers and Harbors Act	33 USC 401 et seq. 33 CFR parts 320 to 323	Section 10 prohibits the unauthorized obstruction or alteration of any navigable water. Structures or work in, above, or under navigable waters are regulated under Section 10. Action-specific—potentially applicable to construction of the CDF.	Appendix Q of the EE/CA contains a Draft 404(b)(1) Analysis Memorandum, which evaluates the Removal Action's potential impact on the aquatic environment, including navigation. The Portland Harbor 404(b)(1) Analysis will include the Terminal 4 CDF and will be an appendix to the FS.
Clean Air Act	42 USC §7401 et seq.	Action-specific. Applicable to remedial activities that generate air emissions. Potentially applicable to equipment used to construct the CDF.	BMPs for emission standards for fugitive emissions of air contaminants are provided in the Construction Specifications (Appendix C of the DAR).
Toxic Substances Control Act	15 USC §2601 et seq. 40 CFR Part 761	Action-specific. Toxic Substances Control Act requirements are applicable to contaminated material or surface water with contamination. Potentially applicable to the acceptance of material for placement in the CDF.	The Sediment Acceptance Criteria Memorandum to be prepared during 100 Percent Design will detail the acceptance criteria for material that will be placed into the CDF, including cover material.

Note: Table 8-1 is based on "EPA's Preliminary Identification of ARARs at the Portland Harbor Site for Development of the Feasibility Study," dated January 6, 2010, and subsequent letters between EPA and the Lower Willamette Group dated February 1, 2010 and February 10, 2010. The Harbor-wide ARARs are not final and are subject to change through the FS process.

Table 8-1
ARARs for Confined Disposal Facility

Legal Requirement	Citation	Criterion/Standard and Applicability	Compliance Reference
Marine Mammal Protection Act	16 USC §1361 et seq. 50 CFR 216	Action-specific. Applicable to remedial actions that have the potential to affect marine mammals. Not applicable to the CDF construction and operation as there are no marine mammals that are present in the vicinity of Terminal 4.	
Migratory Bird Treaty Act	16 USC 703-702 50 CFR 10.12	Makes it unlawful to take, import, export, possess, buy, sell purchase, or barter any migratory bird. "Take" is defined as pursuing, hunting, shooting, poising, wounding, killing, capturing, trapping, and collecting. Action-specific—potentially relevant and appropriate to impacts, if any, on migratory birds from construction of the CDF.	
National Historic Preservation Act	16 USC 470 et seq. 36 CFR Part 800	Requires the identification of historic properties potentially affected by the agency undertaking, and assessment of the effects on the historic property and seek ways to avoid, minimize or mitigate such effects. Historic property is any district, site, building, structure, or object included in or eligible for the National Register of Historic Places, including artifacts, records, and material remains related to such a property. Action-specific—potentially applicable if historic properties are potentially affected by the construction of the CDF.	The Archaeological Monitoring Protocol for the Terminal 4 site is provided as an attachment to the Construction Quality Assurance Plan (CQAP; Appendix D of the DAR) and details the process for identifying whether or not existing structures identified for demolition are historic properties and protocol to follow for compliance with this Act.

Note: Table 8-1 is based on "EPA's Preliminary Identification of ARARs at the Portland Harbor Site for Development of the Feasibility Study," dated January 6, 2010, and subsequent letters between EPA and the Lower Willamette Group dated February 1, 2010 and February 10, 2010. The Harbor-wide ARARs are not final and are subject to change through the FS process.

Table 8-1
ARARs for Confined Disposal Facility

Legal Requirement	Citation	Criterion/Standard and Applicability	Compliance Reference
Archaeological and Historic Preservation Act	16 USC 469a-1	Provides for the preservation of historical and archaeological data that may be irreparably lost as a result of a federally-approved project and mandates only preservation of the data Action-specific—potentially applicable if historical and archaeological data may be irreparably lost by construction of the CDF.	The Archaeological Monitoring Protocol for the Terminal 4 site is provided as an attachment to the CQAP (Appendix D of the DAR) and details protocol for conducting ground-disturbing activities in archaeologically sensitive areas of Terminal 4. Given the highly disturbed condition of Slip 1 from prior excavation, dredging and filling, removal actions, and sampling, it is not expected that historical and archaeological resources will be encountered.
Native American Graves Protection and Reparation Act	25 USC 3001-3013 43 CFR 10	Requires federal agencies and museums that have possession of or control over Native American cultural items (including human remains associated and unassociated funerary items, sacred objects, and objects of cultural patrimony) to compile an inventory of such items. Prescribes when such federal agencies and museums must return Native American cultural items. "Museums" are defined as any institution or state or local government agency that received federal funds and has possession of, or control over, Native American cultural items. Location-specific; Action-specific—if Native American cultural items are present on property belonging to the Oregon Department of State Lands (DSL) that is a part of Slip 1, this requirement is potentially applicable. If Native American cultural items are collected by an entity that is either a federal agency or museum, then the requirements of the law are potentially applicable.	The Archaeological Monitoring Protocol for the Terminal 4 site is provided as an attachment to the CQAP (Appendix D of the DAR) and details protocol for conducting ground-disturbing activities in archaeologically sensitive areas of Terminal 4. Given the highly disturbed condition of Slip 1 from prior excavation, dredging and filling, removal actions, and sampling, it is not expected that historical and archaeological resources will be encountered.

Note: Table 8-1 is based on "EPA's Preliminary Identification of ARARs at the Portland Harbor Site for Development of the Feasibility Study," dated January 6, 2010, and subsequent letters between EPA and the Lower Willamette Group dated February 1, 2010 and February 10, 2010. The Harbor-wide ARARs are not final and are subject to change through the FS process.

Table 8-1
ARARs for Confined Disposal Facility

Legal Requirement	Citation	Criterion/Standard and Applicability	Compliance Reference
Endangered Species Act	16 USC 1531 et seq. 50 CFR 17	Actions authorized, funded, or carried out by federal agencies may not jeopardize the continued existence of endangered or threatened species or adversely modify or destroy their critical habitats. Agencies are to avoid jeopardy or take appropriate mitigation measures to avoid jeopardy. Action-specific—potentially applicable due to potential impacts the construction and operation of the CDF may have on endangered or threatened species or critical habitat present at the site or that may be affected by the action.	The Biological Assessment for Phase II will detail potential impacts of the CDF on ESA-listed fish and wildlife species and designated critical habitat. The assessment will also detail construction BMPs, conservation measures, and Clean Water Act 404(b)(1) mitigation actions that will be implemented to minimize potential impacts such that the CDF construction activities do not jeopardize the continued existence of endangered or threatened species or adversely modify or destroy their critical habitats.
Executive Order for Wetlands Protection	Executive Order 11990 (1977) 40 CFR 6.302 (a) 40 CFR Part 6, App. A	Requires measures to avoid adversely impacting wetlands whenever possible, minimize wetland destruction, and preserve the value of wetlands. Location-specific—potentially relevant and appropriate in assessing impacts to wetlands, if any, from the CDF and for developing appropriate compensatory mitigation for the project.	The Draft and Final Mitigation Plans will address potential impacts to wetlands.
Executive Order for Floodplain Management	Exec. Order 11988 (1977) 40 CFR Part 6, App. A 40 CFR 6.302 (b) 42 U.S.C 4001 et seq.	Requires measures to reduce the risk of flood loss, minimize impact of floods, and restore and preserve the natural and beneficial values of floodplains. Location-specific—potentially relevant and appropriate for assessing impacts, if any, to the floodplain and flood storage from the CDF and developing compensatory mitigation that is beneficial to floodplain values.	Appendix I to the DAR addresses the floodway analysis for the 60% design of the CDF and concludes that the CDF would not impact the floodway or 100-year flood elevations. This analysis was an extension of the floodway and flood storage analysis conducted for the EE/CA and summarized in Appendix K of the EE/CA.

Note: Table 8-1 is based on "EPA's Preliminary Identification of ARARs at the Portland Harbor Site for Development of the Feasibility Study," dated January 6, 2010, and subsequent letters between EPA and the Lower Willamette Group dated February 1, 2010 and February 10, 2010. The Harbor-wide ARARs are not final and are subject to change through the FS process.

Table 8-1
ARARs for Confined Disposal Facility

Legal Requirement	Citation	Criterion/Standard and Applicability	Compliance Reference
National Flood Insurance Act and Flood Disaster Protection Act	42 USC 4001 et seq. 44 CFR National Flood Insurance Program Subpart	Requires measures to reduce the risk of flood loss, minimize impact of floods, and restore and preserve the natural and beneficial values of floodplains. Location-specific—potentially relevant and appropriate for assessing impacts, if any, to the floodplain and flood storage from the CDF and developing compensatory mitigation that is beneficial to floodplain values.	Appendix I to the DAR addresses the floodway analysis for the 60% design of the CDF and concludes that the CDF would not impact the floodway or 100-year flood elevations. This analysis was an extension of the floodway and flood storage analysis conducted for the EE/CA and summarized in Appendix K of the EE/CA.
State ARARs			
Oregon Environmental Cleanup Law	Oregon Hazardous Substance Remedial Action Rules OAR 340-122-0040(2)(a) and (c), 0115(3),(32) and (51) ORS 465.315	Sets standards for degree of cleanup required, including for oil and other petroleum products/ wastes. Establishes acceptable risk levels for human health at 1x10-6 for individual carcinogens, 1x10-5 for multiple carcinogens, and Hazard Index of 1 for noncarcinogens; and protection of ecological receptors at the individual level for threatened or endangered species and the population level for all others. OAR 340-122-0040 and 0115(3). Chemical-specific: a risk-based numerical value that, when applied to site-specific conditions, will establish concentrations of hazardous substances that may remain or be managed on-site in a manner avoiding unacceptable risk. Not applicable to the construction of the CDF.	

Note: Table 8-1 is based on "EPA's Preliminary Identification of ARARs at the Portland Harbor Site for Development of the Feasibility Study," dated January 6, 2010, and subsequent letters between EPA and the Lower Willamette Group dated February 1, 2010 and February 10, 2010. The Harbor-wide ARARs are not final and are subject to change through the FS process.

Table 8-1
ARARs for Confined Disposal Facility

Legal Requirement	Citation	Criterion/Standard and Applicability	Compliance Reference
Oregon Environmental Cleanup Law	OAR 340-122-0040(4) and (b), 340-122-0115(32) ORS 465.315	For hot spots of contamination in water, requires treatment, if feasible, when treatment would be reasonably likely to restore or protect beneficial uses within a reasonable time. Chemical-specific and action-specific: when contaminant concentrations fall within the definition of "hot spot" set forth in subpart 0115(32), treatment (including excavation and offsite disposal) of contaminated media to levels below such risk levels or beneficial-use impacts needs to be evaluated in the feasibility study. Not applicable to the construction of the CDF.	
Oregon Environmental Cleanup Law	OAR 340-122-0040(4) and (b), 340-122-0115(32) ORS 465.315	For hot spots contamination of sediments, requires treatment or excavation and off-site disposal of hazardous substances if treatment is reasonably likely to restore or protect such beneficial uses within a reasonable time. Not applicable to the construction of the CDF.	

Note: Table 8-1 is based on "EPA's Preliminary Identification of ARARs at the Portland Harbor Site for Development of the Feasibility Study," dated January 6, 2010, and subsequent letters between EPA and the Lower Willamette Group dated February 1, 2010 and February 10, 2010. The Harbor-wide ARARs are not final and are subject to change through the FS process.

Table 8-1
ARARs for Confined Disposal Facility

Legal Requirement	Citation	Criterion/Standard and Applicability	Compliance Reference
Hazardous Waste and Hazardous Materials II	ORS 466.005(7) OAR 340-102-0011 -Hazardous Waste Determination	Defines "Hazardous Waste," and the rule contains the criteria by which anyone generating residue must determine if that residue is a hazardous waste. Chemical- and Action-specific: specifies substantive requirements if remedial action will involve on-site treatment, disposal, or storage of Resource Conservation and Recovery Act-listed or characteristic hazardous waste. (Note: off-site treatment, storage, or disposal subject to all administrative and substantive state requirements.) Not applicable to the construction of the CDF.	Although sediments managed under the Clean Water Act are exempt from hazardous waste regulations, USEPA excluded material with hazardous waste characteristics from being placed in the Terminal 4 CDF without treatment as part of the Terminal 4 Action Memo (USEPA, May 11, 2006). The CDF Sediment Management Plan (Appendix J of the DAR) details sediment exclusions, including characteristic hazardous waste as defined by hazardous waste criteria. Toxic Characteristic Leaching Procedure (TCLP) testing will be required for determining hazardous waste characteristics for purposes of sediment acceptance into the CDF.
Identification and Listing of Hazardous Waste	OAR 340-101-0033	Identifies additional residuals that are subject to regulation as hazardous waste under state law. Action-specific: specifies requirements if remedial action will involve on-site treatment, disposal, or storage of additional listed wastes. Not applicable to the construction of the CDF.	See previous comment re: ORS 466.005(7).

Note: Table 8-1 is based on "EPA's Preliminary Identification of ARARs at the Portland Harbor Site for Development of the Feasibility Study," dated January 6, 2010, and subsequent letters between EPA and the Lower Willamette Group dated February 1, 2010 and February 10, 2010. The Harbor-wide ARARs are not final and are subject to change through the FS process.

Table 8-1
ARARs for Confined Disposal Facility

Legal Requirement	Citation	Criterion/Standard and Applicability	Compliance Reference
Solid Waste: General Provisions	Specific regulatory references to be provided by the Oregon Department of Environmental Quality (ODEQ) when alternatives are identified for FS analysis	Substantive requirements for the location, design, construction, operation, and closure of solid waste management facilities. Action-specific: applicable if upland disposal facility contemplated on-site for solid, nonhazardous, waste disposal, handling, treatment, or transfer. (Note: off-site transfer, treatment, handling, or disposal subject to all administrative and substantive state requirements.) Not applicable to the construction of the CDF.	
Solid Waste: General Provisions	Solid Waste: Land Disposal Sites Other than Municipal Solid Waste Landfills, specific regulatory references to be supplied by ODEQ	Requirements for the management of solid wastes at land disposal sites other than municipal solid waste landfills. Action-specific: applicable to the on-site management and disposal of contaminated sediment, soil, and/or groundwater. Potentially applicable and relevant to the CDF cover material.	The Sediment Acceptance Criteria Memorandum to be prepared during 100 Percent Design will detail the acceptance criteria for material to be placed in the CDF, including cover material.

Note: Table 8-1 is based on "EPA's Preliminary Identification of ARARs at the Portland Harbor Site for Development of the Feasibility Study," dated January 6, 2010, and subsequent letters between EPA and the Lower Willamette Group dated February 1, 2010 and February 10, 2010. The Harbor-wide ARARs are not final and are subject to change through the FS process.

Table 8-1
ARARs for Confined Disposal Facility

Legal Requirement	Citation	Criterion/Standard and Applicability	Compliance Reference
Water Pollution Control Act	Water Quality Standards OAR 340-041-0340, Table 20 and Table 33A ORS 468B.048	ODEQ is authorized to administer and enforce Clean Water Act programs in Oregon. ODEQ rules designate beneficial uses for water bodies and narrative and numeric water quality criteria necessary to protect those uses. OAR 340-041-0340 designates and defines the beneficial uses that shall be protected in the Willamette Basin. For the purposes of state law, Table 20 are the applicable criteria, unless there is a corresponding criterion under Table 33A, in which case Table 33A is applicable. (Note: if Oregon promulgates new criteria prior to ROD, such new criteria will be ARAR). Chemical- and action-specific: applicable to any discharges to surface water from point sources, groundwater, overland flow of stormwater, and activities that may result in discharges to waters of the State, such as, dredge and fill, de-watering sediments, and other remedial activities. Relevant and appropriate as performance standards for surface water quality and/or for long-term monitoring of protectiveness of disposal sites and where contaminants are left in place. Potentially applicable and relevant to the construction and operation of the CDF.	Section 6 of the DAR, Water Quality, addresses water quality details related to the construction of the CDF. The WQMP (Appendix E of the DAR) details water quality monitoring activities for construction of the CDF. The CDF Sediment Management Plan (Appendix J of the DAR) provides a process for accepting material for placement into the CDF based on contaminant transport modeling through the berm (see also Appendix A of the DAR). Biological Assessment and WQMP address action-specific BMPs to minimize short-term water quality impacts due to construction activities.

Note: Table 8-1 is based on "EPA's Preliminary Identification of ARARs at the Portland Harbor Site for Development of the Feasibility Study," dated January 6, 2010, and subsequent letters between EPA and the Lower Willamette Group dated February 1, 2010 and February 10, 2010. The Harbor-wide ARARs are not final and are subject to change through the FS process.

Table 8-1
ARARs for Confined Disposal Facility

Legal Requirement	Citation	Criterion/Standard and Applicability	Compliance Reference
Water Pollution Control Act	Regulations Pertaining to National Pollutant Discharge Elimination System (NPDES) Discharges, specific regulatory references to be supplied by ODEQ ORS 468B.048	Effluent limitations and management practices for point-source discharges into waters of the State (otherwise subject to NPDES permit but for on-site permit exemption). Chemical- and Action-specific: applies state water quality standards and effluent limitations to point-source discharges to the Willamette River. Not applicable to the operation of the CDF. Section 401 of the Clean Water Act ensures that any point source return flows from the CDF will meet State water quality standards.	
Certification of Compliance with Water Quality Requirements and Standards	ORS 468b.035	Provides that federally-approved activities that may result in a discharge to waters of the State require an evaluation of whether the activity may proceed and meet water quality standards. Certifications may be approved with conditions, which if met, will ensure that water quality standards are met. Action-specific: Applicable to construction of the CDF that may result in a discharge to waters of the State.	If hydraulic dredging is determined to be a preferred filling option for one or more AOPCs and a point-source discharge of dredge elutriate water is established, then additional analysis of water quality effects associated with the discharge will be conducted. Section 6 of the DAR, Water Quality, addresses water quality details related to the CDF construction and operation. The WQMP (Appendix E of the DAR) details water quality monitoring activities by construction action and identifies criteria that must be met during construction. Additionally, the WQMP addresses action-specific BMPs to minimize short-term water quality impacts due to CDF construction activities.

Note: Table 8-1 is based on "EPA's Preliminary Identification of ARARs at the Portland Harbor Site for Development of the Feasibility Study," dated January 6, 2010, and subsequent letters between EPA and the Lower Willamette Group dated February 1, 2010 and February 10, 2010. The Harbor-wide ARARs are not final and are subject to change through the FS process.

Table 8-1
ARARs for Confined Disposal Facility

Legal Requirement	Citation	Criterion/Standard and Applicability	Compliance Reference
Rules Governing the Issuance and Enforcement of Removal-Fill Authorizations within Waters of Oregon Including Wetlands	OAR 141-085 0680, 141-085-0695, 141-085-0710, 141-085-0765	Substantive requirements for dredge and fill activities in waters of the State, including in designated Essential Indigenous Anadromous Salmonid Habitat. Action-specific: Applicable to dredge and fill activities associated with the construction of the CDF.	The Biological Assessment for Phase II will detail potential impacts of the CDF construction and operation on ESA-listed fish and wildlife species and construction BMPs and conservation measures that will be implemented to minimize potential impacts. The WQMP (Appendix E of the DAR) addresses action-specific BMPs to minimize short-term water quality impacts due to CDF construction activities. The Draft Mitigation Plan details mitigation actions that will be implemented to off-set loss of aquatic habitat from the CDF construction activities. The Draft Mitigation Plan will be updated post-ROD and will reflect decisions made during the Portland Harbor FS process.
Indian Graves and Protected Objects	ORS 97.740-760	Prohibits willful removal of cairn, burial, human remains, funerary object, sacred object or object of cultural patrimony. Provides for reinterment of human remains or funerary objects under the supervision of the appropriate Indian tribe. Proposed excavation by a professional archaeologist of a native Indian cairn or burial requires written notification to the State Historic Preservation Officer and prior written consent of the appropriate Indian tribe. Location-specific; Action-specific—potentially relevant and appropriate if archaeological materials encountered.	The Archaeological Monitoring Protocol for the Terminal 4 site is provided as an attachment to the CQAP (Appendix D of the DAR), details protocol for conducting ground-disturbing activities in archaeologically sensitive areas of Terminal 4, and describes actions to be taken if archaeological materials are encountered. Given the highly disturbed condition of Slip 1 from prior excavation, dredging and filling, removal actions, and sampling, it is not expected that historical and archaeological resources will be encountered.

Note: Table 8-1 is based on "EPA's Preliminary Identification of ARARs at the Portland Harbor Site for Development of the Feasibility Study," dated January 6, 2010, and subsequent letters between EPA and the Lower Willamette Group dated February 1, 2010 and February 10, 2010. The Harbor-wide ARARs are not final and are subject to change through the FS process.

Table 8-1
ARARs for Confined Disposal Facility

Legal Requirement	Citation	Criterion/Standard and Applicability	Compliance Reference
Archaeological Objects and Sites	ORS 358.905-955 ORS 390.235	Prohibits persons from excavating, injuring, destroying or damaging archaeological sites or objects on public or private lands unless authorized by permit. Imposes conditions for excavation or removal of archaeological or historical materials. Location-specific; Action-specific—Potentially relevant and appropriate if archaeological material encountered.	The Archaeological Monitoring Protocol for the Terminal 4 site is provided as an attachment to the CQAP (Appendix D of the DAR), details protocol for conducting ground-disturbing activities in archaeologically sensitive areas of Terminal 4, and describes actions to be taken if archaeological materials are encountered. Given the highly disturbed condition of Slip 1 from prior excavation, dredging and filling, removal actions, and sampling, it is not expected that historical and archaeological resources will be encountered.
Survival Guidelines	OAR 635-100-0135	Survival Guidelines are rules for state agency actions affecting species listed under Oregon's Threatened or Endangered Wildlife Species law. Action-and location specific: Substantive requirements of Survival Guidelines potentially relevant and appropriate to remedial activities affecting state-listed species, such as construction of the CDF.	Appendix Q of the EE/CA (BBL 2005) contains a Draft 404(b)(1) Analysis Memorandum, which evaluates the Removal Action's potential impact on the aquatic environment. The Biological Assessment for Phase II will detail potential impacts of the CDF construction and operation on ESA-listed fish and wildlife species and construction BMPs and conservation measures that will be implemented to minimize potential impacts. The Draft Mitigation Plan details mitigation actions that will be implemented to off-set loss of aquatic habitat from the CDF construction activities. The Draft Mitigation Plan will be updated post-ROD and will reflect decisions made during the Portland Harbor FS process.

Note: Table 8-1 is based on "EPA's Preliminary Identification of ARARs at the Portland Harbor Site for Development of the Feasibility Study," dated January 6, 2010, and subsequent letters between EPA and the Lower Willamette Group dated February 1, 2010 and February 10, 2010. The Harbor-wide ARARs are not final and are subject to change through the FS process.

Table 8-1
ARARs for Confined Disposal Facility

Legal Requirement	Citation	Criterion/Standard and Applicability	Compliance Reference
Guidance for Assessing Bioaccumulative Chemicals of Concern in Sediment (ODEQ 2007)		Describes a process to evaluate chemicals found in sediment for their potential contribution to risk as a result of bioaccumulation. Provides alternative methods for developing sediment screening levels and bioaccumulation bioassay data. To Be Considered: in level of cleanup or standard of control that is protective. Not applicable to the construction of the CDF.	
Oregon Air Pollution Control	General Emissions Standards OAR 340-226 ORS 468A et. seq.	ODEQ is authorized to administer and enforce Clean Air program in Oregon. Rules provide general emission standards for fugitive emissions of air contaminants and require highest and best practicable treatment or control of such emissions. Action-specific—applicable to remedial actions taking place in on-site uplands. Potentially relevant and appropriate to certain activities during construction of the CDF.	BMPs for emission standards for fugitive emissions of air contaminants are provided in the Construction Specifications (Appendix C of the DAR).

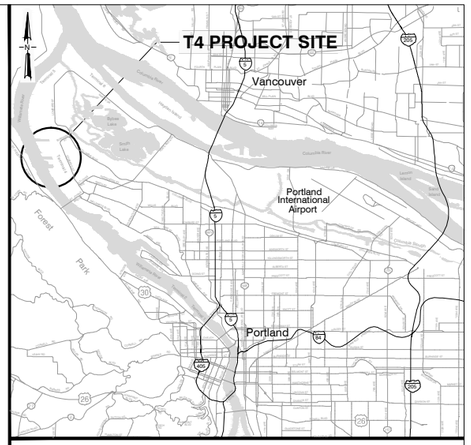
Note: Table 8-1 is based on "EPA's Preliminary Identification of ARARs at the Portland Harbor Site for Development of the Feasibility Study," dated January 6, 2010, and subsequent letters between EPA and the Lower Willamette Group dated February 1, 2010 and February 10, 2010. The Harbor-wide ARARs are not final and are subject to change through the FS process.

Table 8-1
ARARs for Confined Disposal Facility

Legal Requirement	Citation	Criterion/Standard and Applicability	Compliance Reference
Oregon Air Pollution Control	Fugitive Emission Requirements OAR 340-208 ORS 468A et. seq.	Prohibits any handling, transporting, or storage of materials, or use of a road, or any equipment to be operated, without taking reasonable precautions to prevent particulate matter from becoming airborne. These rules for "special control areas" or other areas where fugitive emissions may cause nuisance and control measures are practicable. Action-specific: applicable to remedial actions taking place in on-site uplands. Could apply to earth-moving equipment, dust from vehicle traffic, and mobile-source exhaust, among other things.	BMPs for emission standards for fugitive emissions of air contaminants are provided in the Construction Specifications (Appendix C of the DAR).
Oregon Department of Fish and Wildlife Fish Management Plans for the Willamette River	OAR 635, div 500	Provides basis for in-water work windows in the Willamette River. To Be Considered—potentially applicable to construction of the CDF due to presence of protected species at the site.	The Biological Assessment for Phase II will detail construction in-water work windows that apply to the in-water components of the CDF construction.

Note: Table 8-1 is based on "EPA's Preliminary Identification of ARARs at the Portland Harbor Site for Development of the Feasibility Study," dated January 6, 2010, and subsequent letters between EPA and the Lower Willamette Group dated February 1, 2010 and February 10, 2010. The Harbor-wide ARARs are not final and are subject to change through the FS process.

FIGURES



VICINITY MAP
SCALE: N.T.S.

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Scale in Feet

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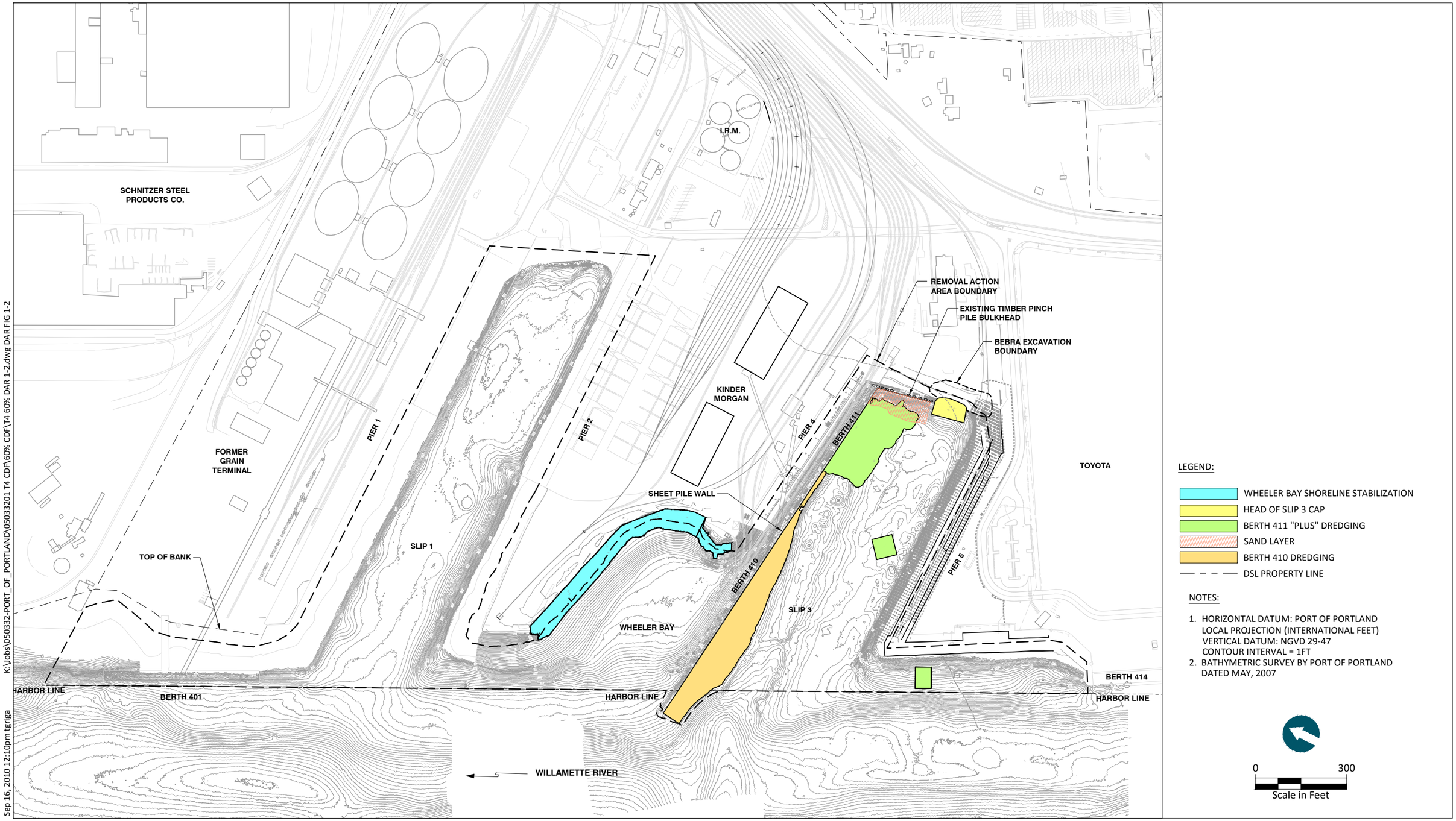
ANCHOR QEA

Figure 1-1
Site Plan and Vicinity Map
Terminal 4 Confined Disposal Facility - Design Analysis Report
Portland, Oregon



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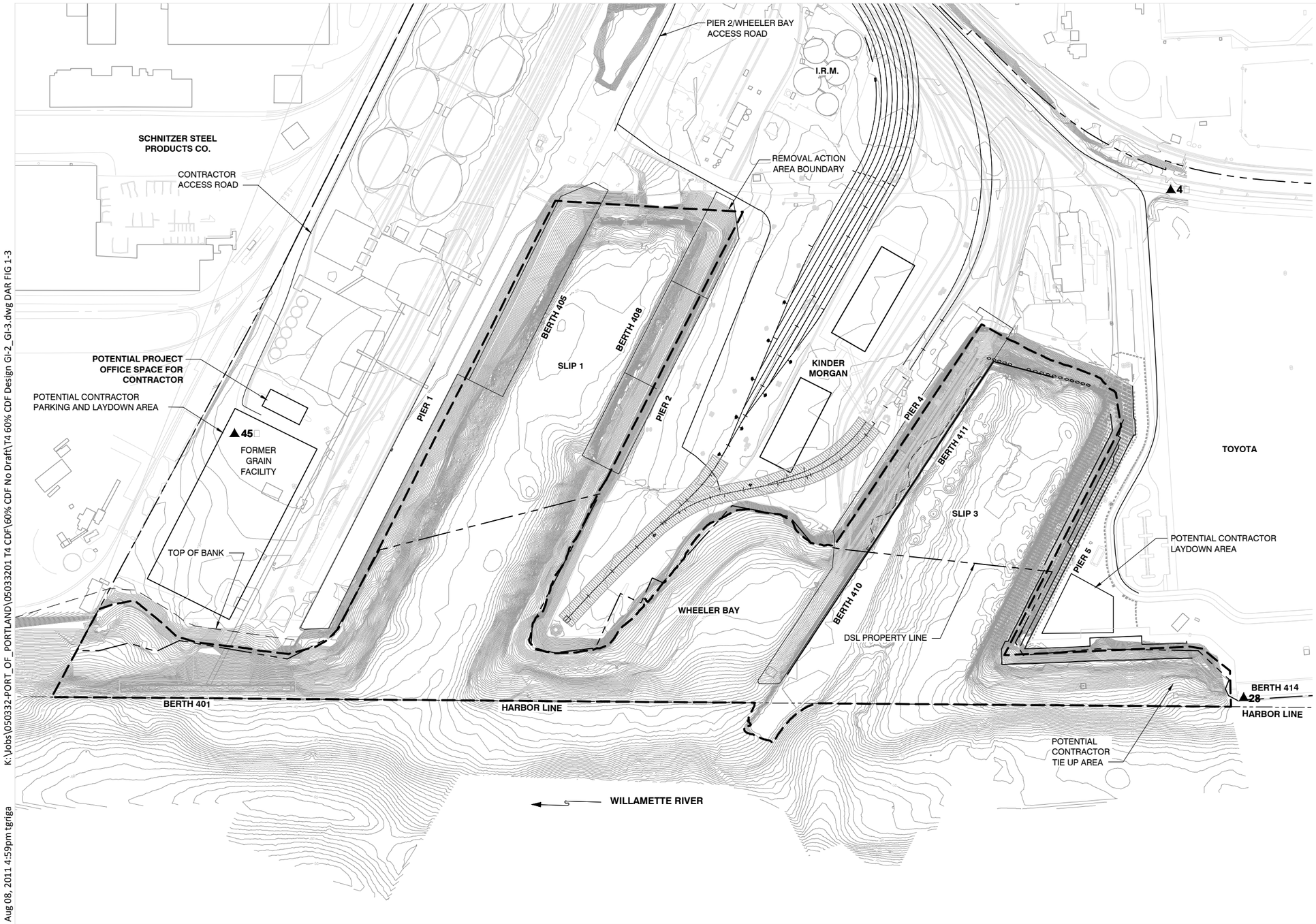
ANCHOR QEA

Figure 1-2
Summary of Phase I Removal Action
Terminal 4 Confined Disposal Facility - Design Analysis Report
Portland, Oregon



NOTES:

1. HORIZONTAL DATUM: PORT OF PORTLAND LOCAL PROJECTION (INTERNATIONAL FEET)
   VERTICAL DATUM: NGVD 29-47
   CONTOUR INTERVAL = 1 FT
2. FOR NGVD CONTROL POINT, SEE PORT OF PORTLAND DRAWING RG 2006-3024 (NOVEMBER 2006)

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Scale in Feet

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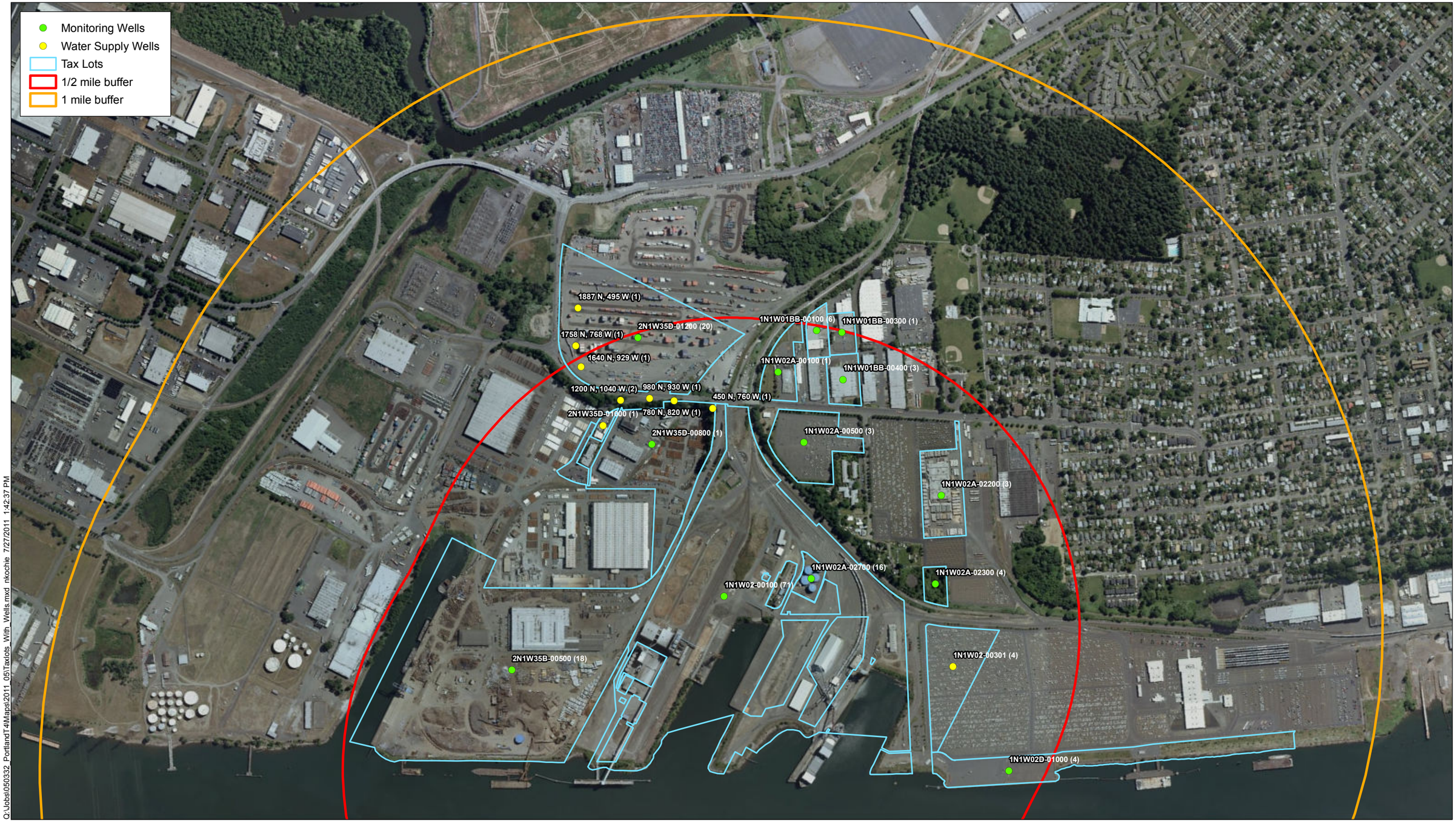
ANCHOR QEA

Figure 1-3
Summary of Physical Conditions
Terminal 4 Confined Disposal Facility - Design Analysis Report
Portland, Oregon



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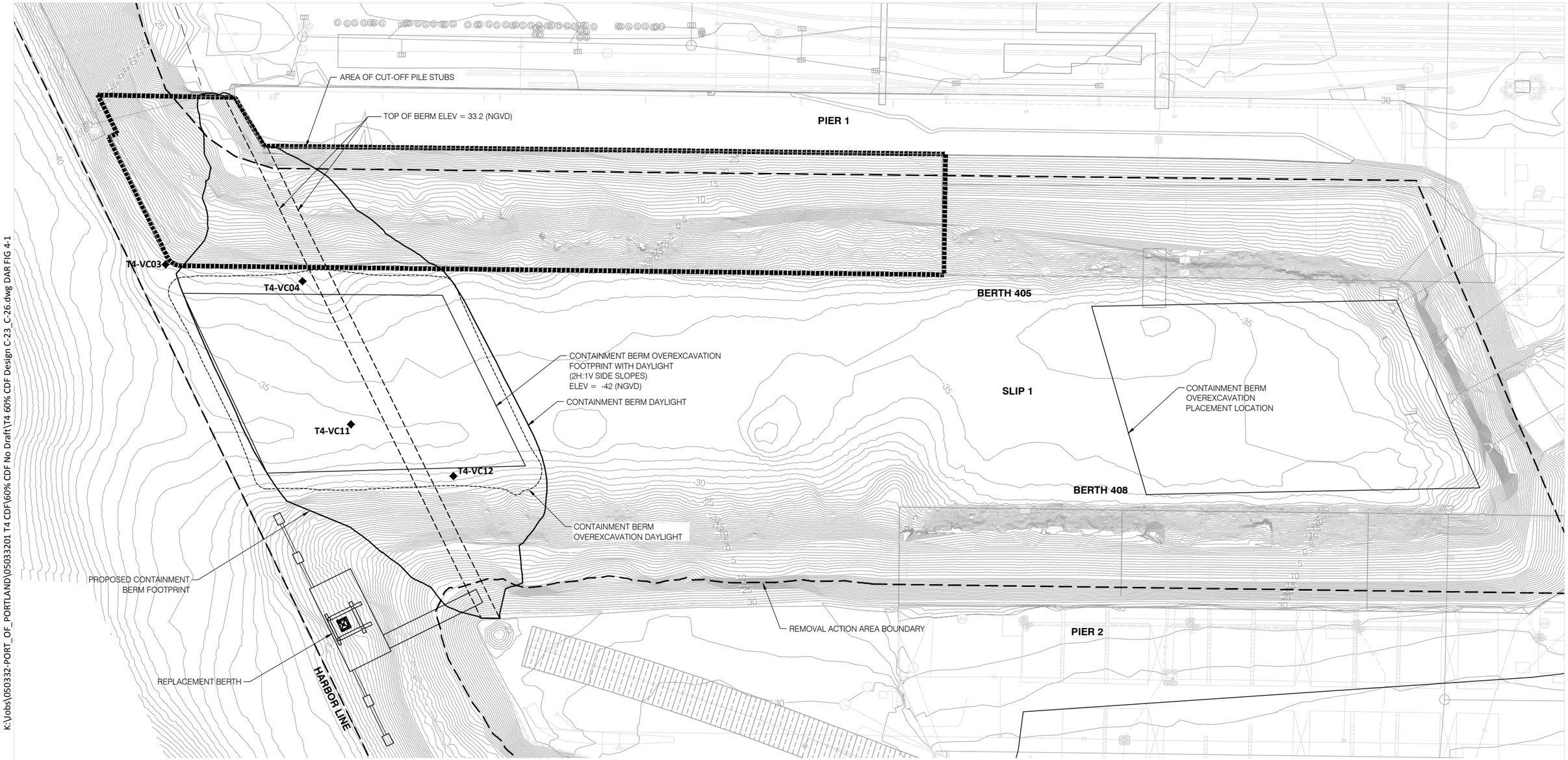
ANCHOR QEA

Feet
0 400 800 1,200 1,600

NOTE:
Well locations are approximate and based on data obtained from the Oregon Water Resources Department Well Log Database. Where appropriate, individual wells are grouped by tax lot. The number of wells associated with each tax lot is indicated in parentheses.

Figure 3-1
Map of Groundwater Wells in T4 Vicinity
Terminal 4 Confined Disposal Facility – Design Analysis Report
Portland, Oregon



LEGEND

T4-VC11◆ Core Sample Location

NOTES

1. HORIZONTAL DATUM: PORT OF PORTLAND LOCAL PROJECTION (INTERNATIONAL FEET)
   VERTICAL DATUM: NGVD 29-47
   CONTOUR INTERVAL = 1 FT

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Scale in Feet

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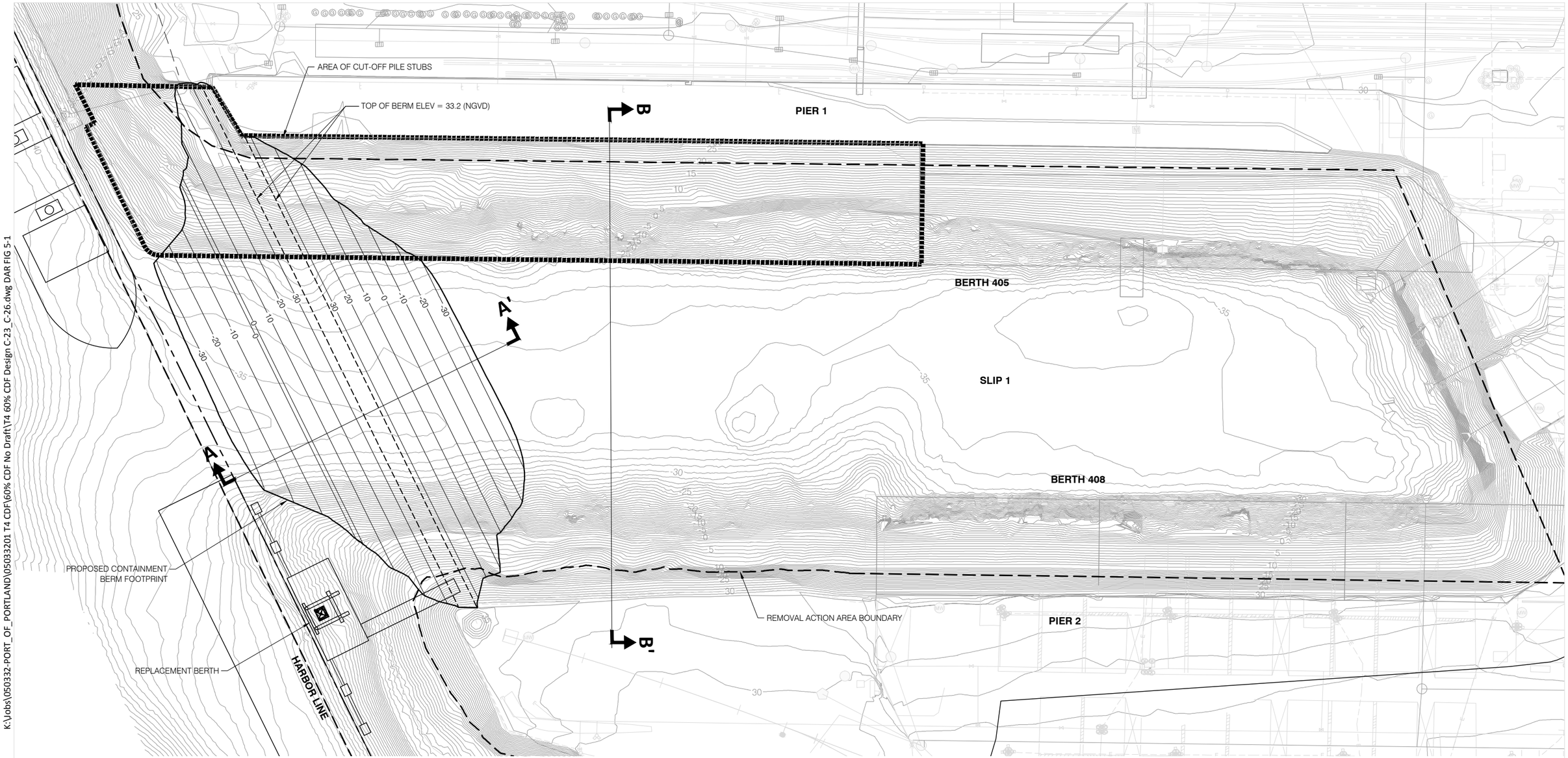
ANCHOR QEA

Figure 4-1
Berm Key Dredge Plan
Terminal 4 Confined Disposal Facility - Design Analysis Report
Portland, Oregon



NOTES:

1. HORIZONTAL DATUM: PORT OF PORTLAND
   LOCAL PROJECTION (INTERNATIONAL FEET)
   VERTICAL DATUM: NGVD 29-47
   CONTOUR INTERVAL = 1 FT

0 120
Scale in Feet

K:\Jobs\050332-PORT_OF_PORTLAND\05033201 T4 CDF\60% CDF No Draft\T4 60% CDF Design C-23_C-26.dwg DAR FIG 5-1

Aug 08, 2011 5:04pm tgriga

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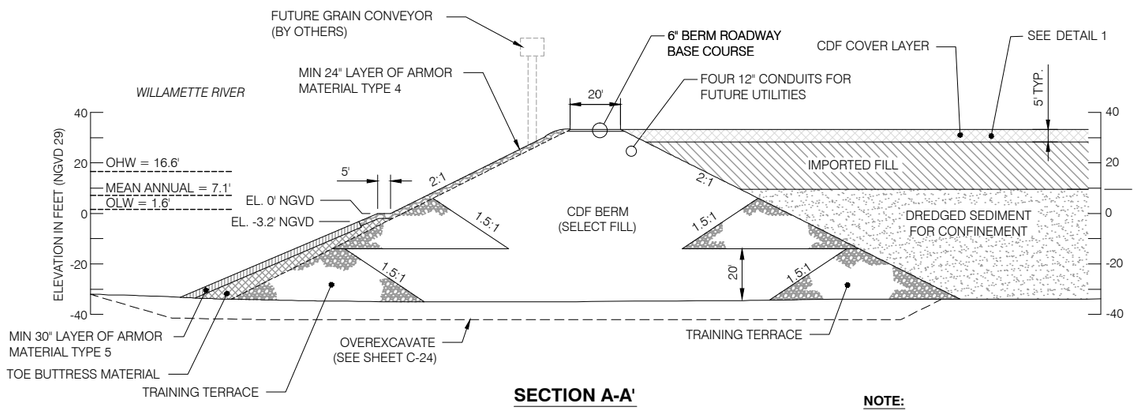
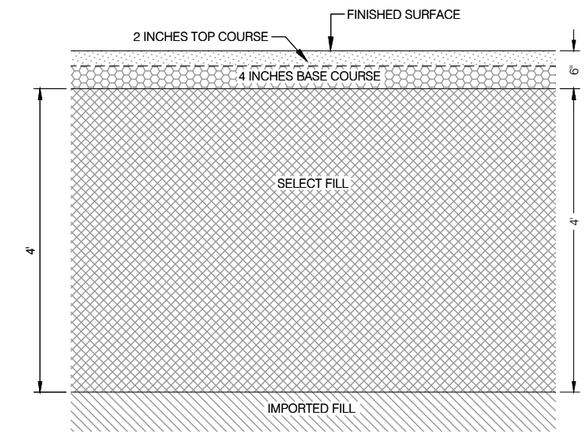
Figure 5-1
Confined Disposal Facility Plan
Terminal 4 Confined Disposal Facility - Design Analysis Report
Portland, Oregon



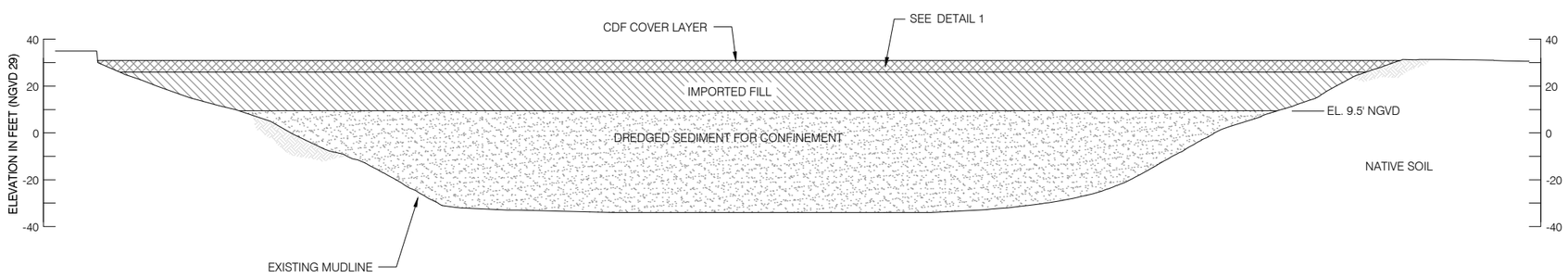
SECTION A-A'

NOTE:

CONTRACTOR CAN USE TRAINING TERRACES TO BUILD THE BERM. THE TERRACES SHALL EACH BE 20' IN HEIGHT. SEE SPECIFICATIONS FOR MORE DETAILS.



DETAIL 1 CDF COVER LAYER DETAIL



SECTION B-B'

HORIZONTAL DATUM: PORT OF PORTLAND
LOCAL PROJECTION (INTERNATIONAL FEET)
VERTICAL DATUM: NGVD 29-47

Aug 08, 2011 5:09pm tgriga K:\Jobs\050332-PORT_OF_PORTLAND\05033201 T4 CDF\60% CDF No Draft\T4 60% CDF Design Revised Fig 5-2.dwg DAR FIG 5-2

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Figure 5-2
Confined Disposal Facility Sections
Terminal 4 Confined Disposal Facility - Design Analysis Report
Portland, Oregon

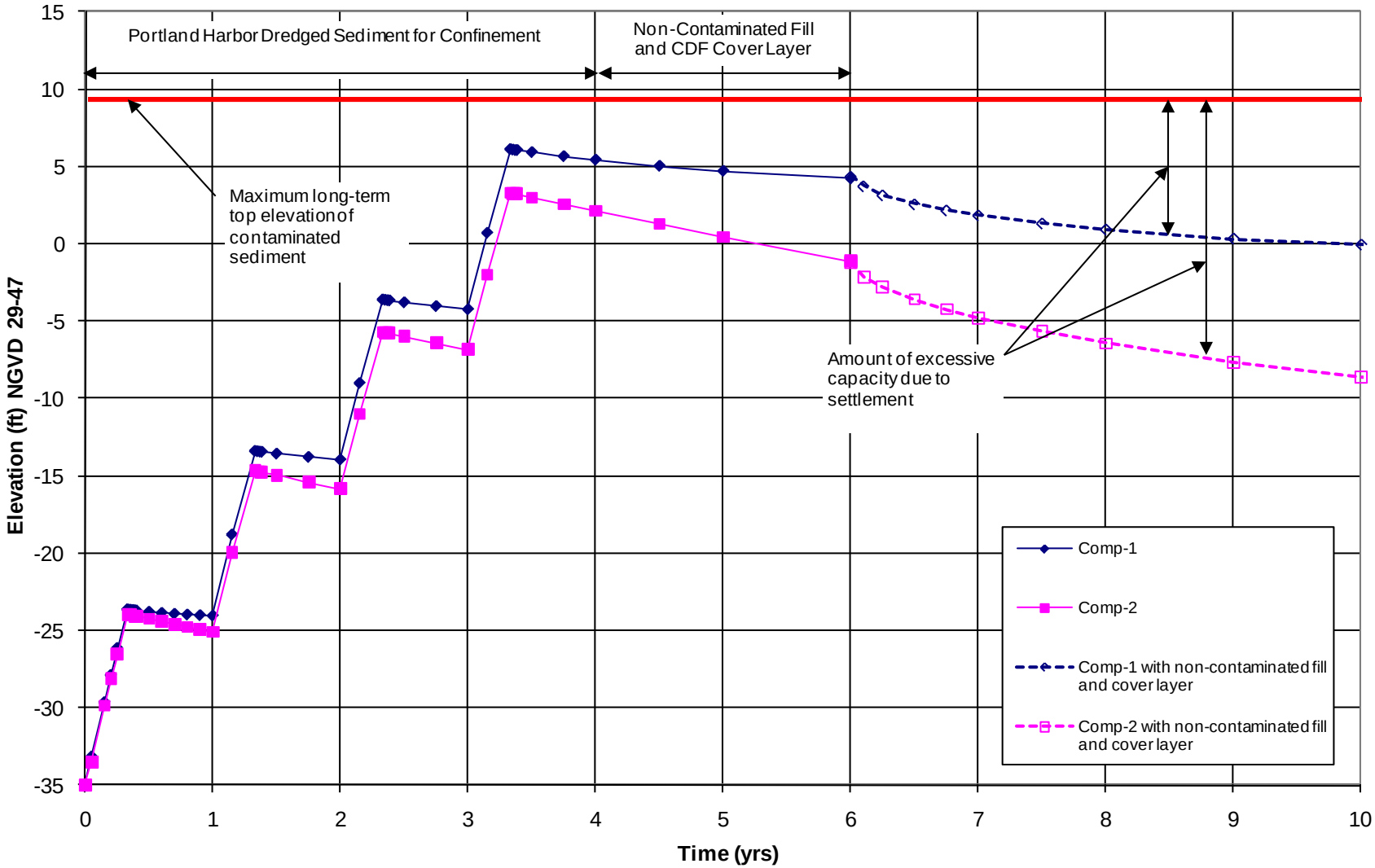

Figure 5-3
Fill Rate and Elevation of Dredged Sediment for Confinement Surface
Terminal 4 Confined Disposal Facility - Design Analysis Report
Portland, Oregon

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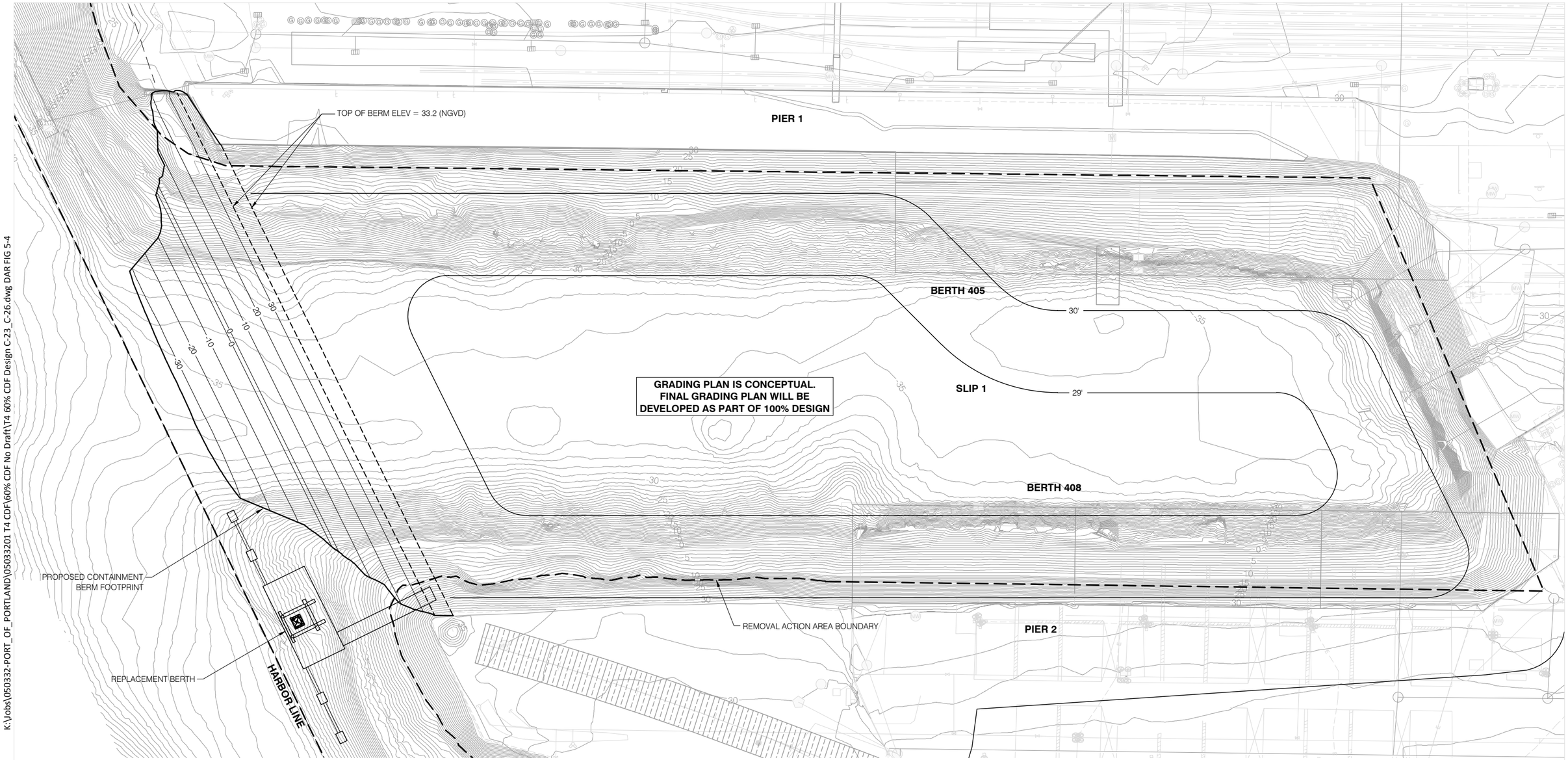

NOTES:

1. HORIZONTAL DATUM: PORT OF PORTLAND
   LOCAL PROJECTION (INTERNATIONAL FEET)
   VERTICAL DATUM: NGVD 29-47
   CONTOUR INTERVAL = 1 FT

0 120
Scale in Feet

K:\Jobs\050332-PORT_OF_PORTLAND\05033201 T4 CDF\60% CDF No Draft\T4 60% CDF Design C-23_C-26.dwg DAR FIG 5-4

Aug 08, 2011 5:06pm tgriga

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Figure 5-4
Final CDF Grading Plan
Terminal 4 Confined Disposal Facility - Design Analysis Report
Portland, Oregon

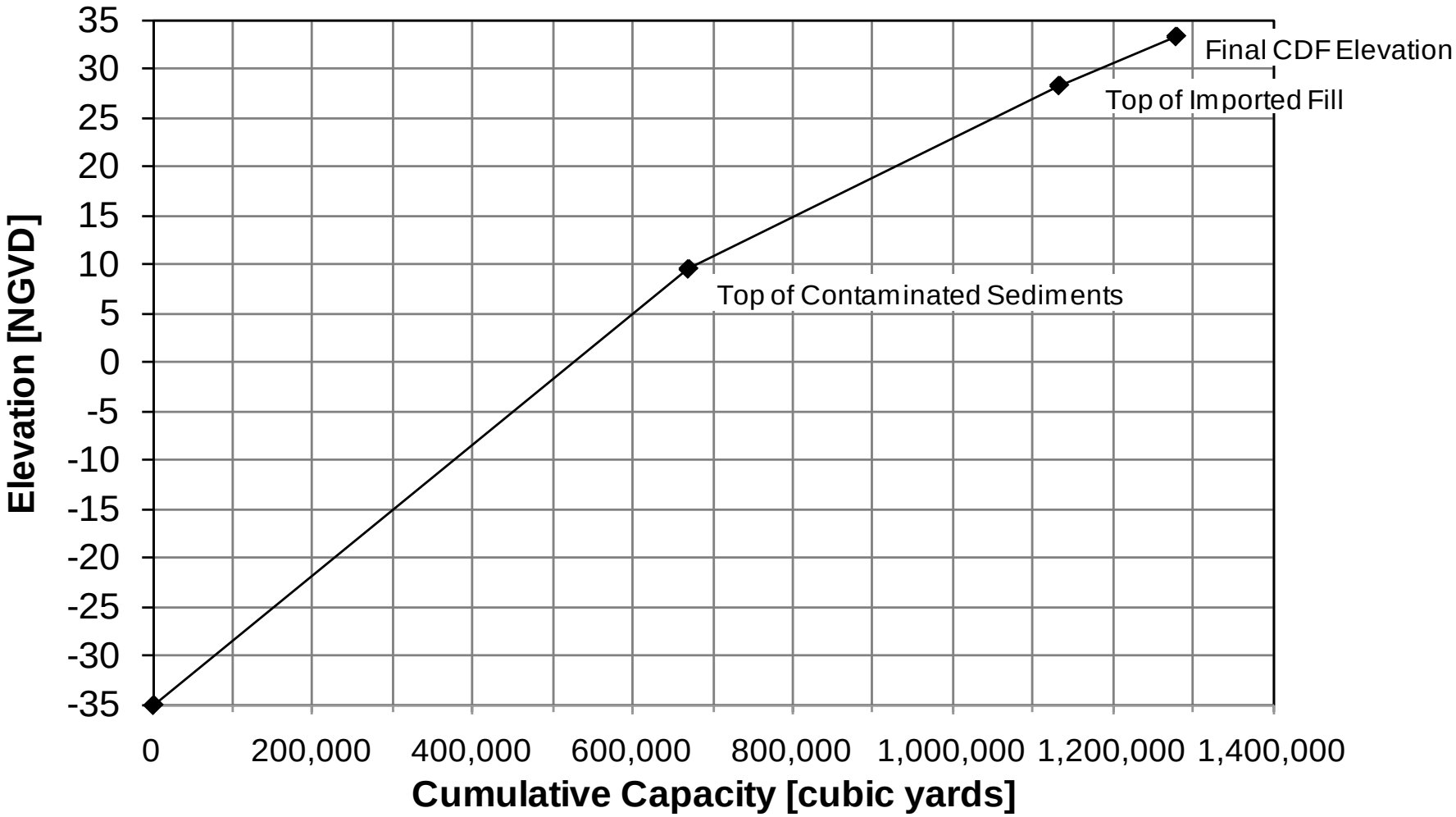

Figure 5-5
CDF Elevation versus Cumulative Capacity
Terminal 4 Confined Disposal Facility - Design Analysis Report
Portland, Oregon

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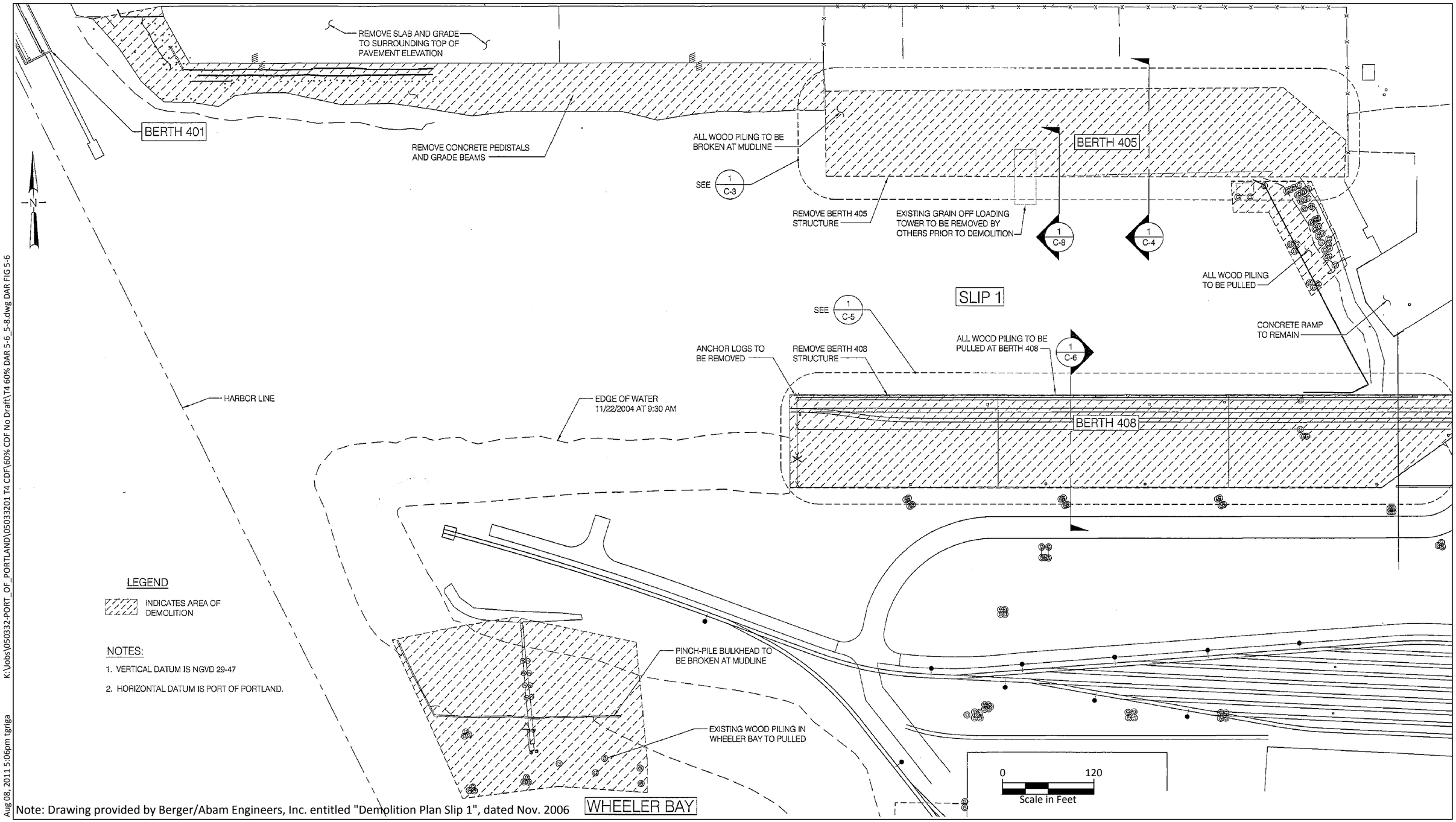

Note: Drawing provided by Berger/Abam Engineers, Inc. entitled "Demolition Plan Slip 1", dated Nov. 2006

K:\Jobs\050332-PORT_OF_PORTLAND\05033201 T4 CDF\60% CDF No Draft\T4 60% DAR 5-6_5-8.dwg DAR FIG 5-6

Aug 08, 2011 5:06pm tgriga

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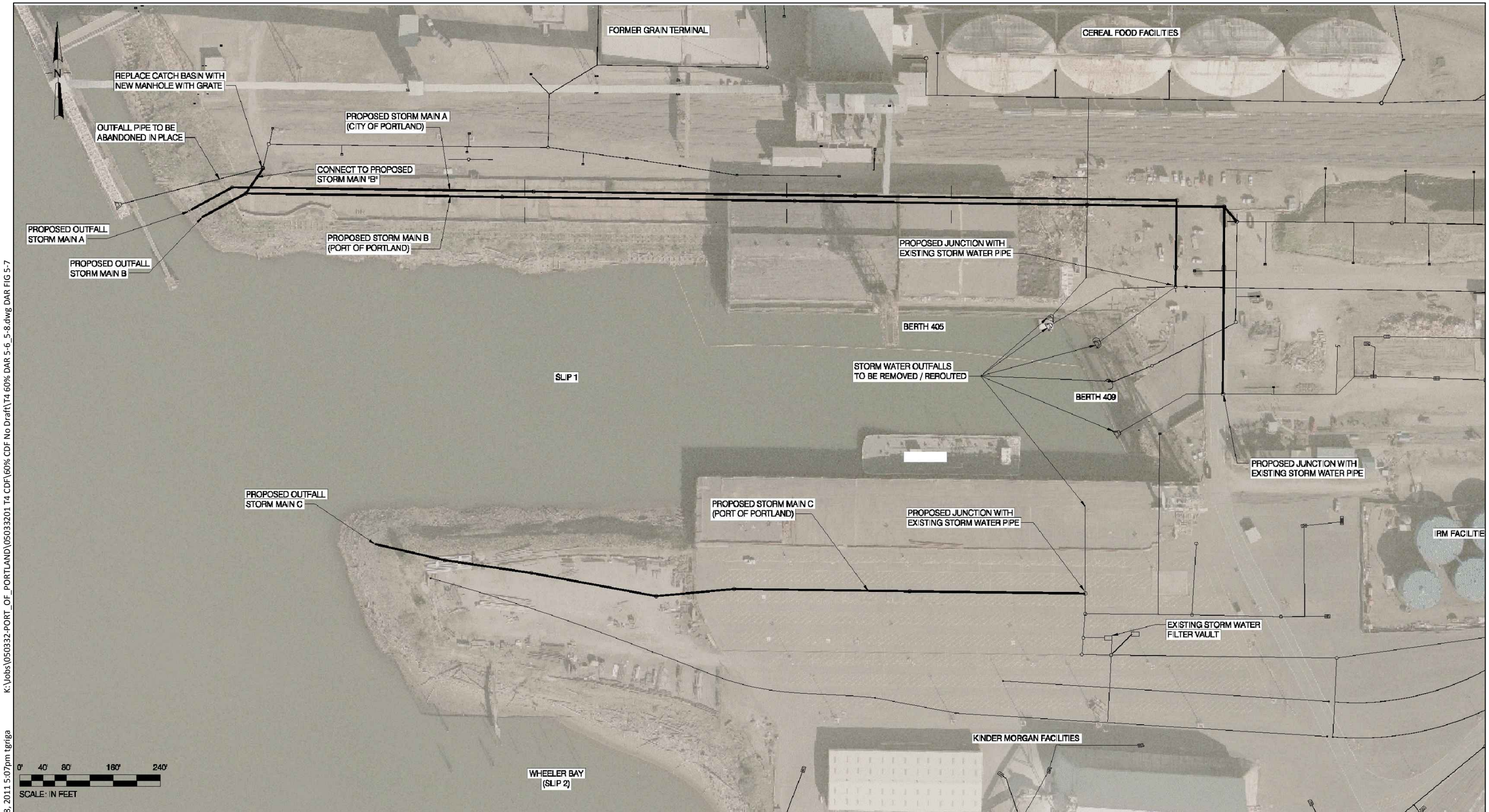
Figure 5-6
Slip 1 Demolition Plan
Terminal 4 Confined Disposal Facility - Design Analysis Report
Portland, Oregon



Note: Drawing provided by Berger/Abam Engineers, Inc. entitled "Slip 1 Stormwater Reroute", dated Nov. 2006.

K:\Jobs\050332-PORT_OF_PORTLAND\05033201 T4 CDF\60% CDF No Draft\T4 60% DAR 5-6_5-8.dwg DAR FIG 5-7

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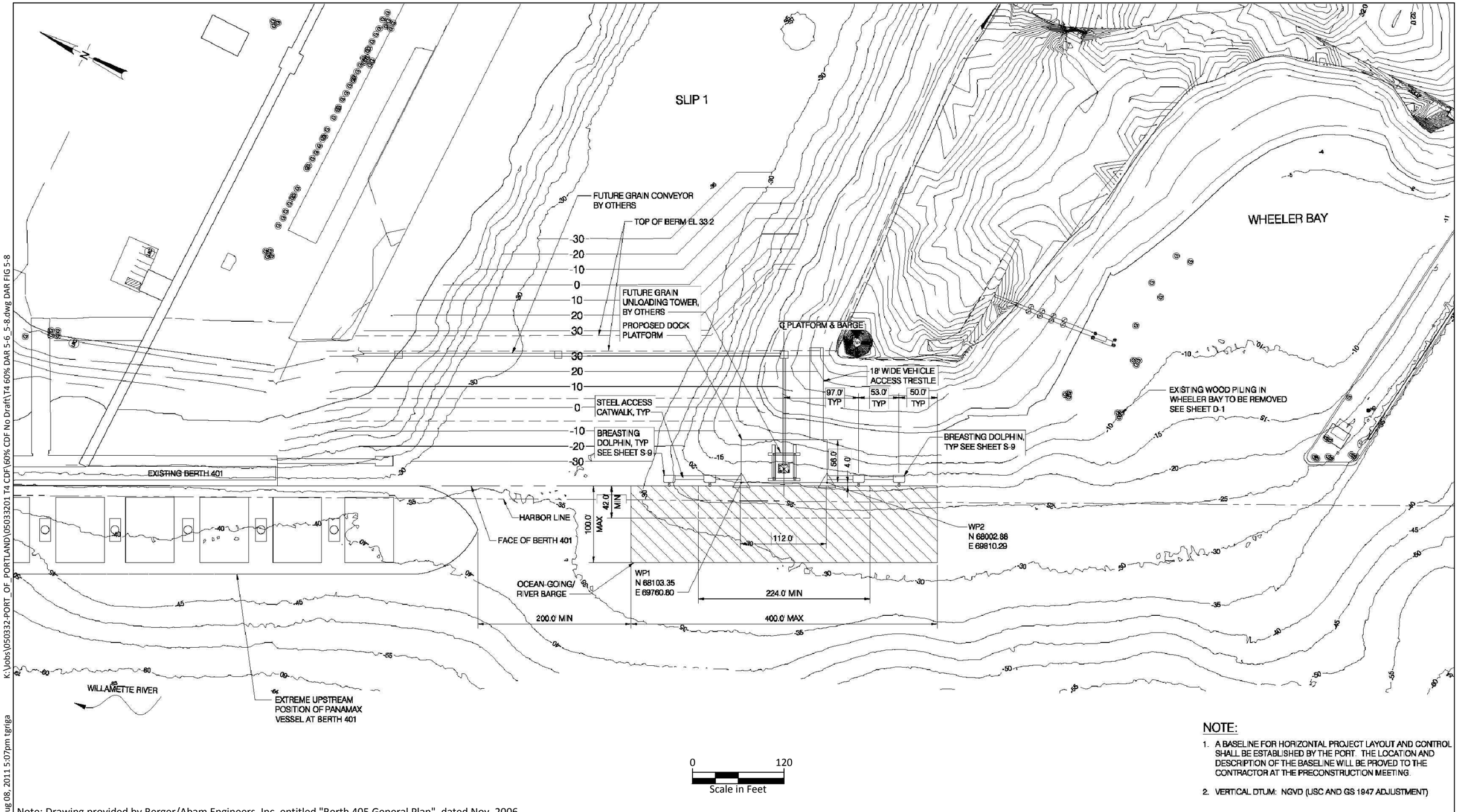
ANCHOR QEA

Figure 5-7
Slip 1 Stormwater Reroute Locations
Terminal 4 Confined Disposal Facility - Design Analysis Report
Portland, Oregon



Note: Drawing provided by Berger/Abam Engineers, Inc. entitled "Berth 405 General Plan", dated Nov. 2006.

K:\Jobs\050332-PORT_OF_PORTLAND\05033201 T4 CDF\60% CDF No Draft\T4 60% DAR 5-6_5-8.dwg DAR FIG 5-8

Aug 08, 2011 5:07pm tgriga

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Figure 5-8
Replacement Berth Structure
Terminal 4 Confined Disposal Facility - Design Analysis Report
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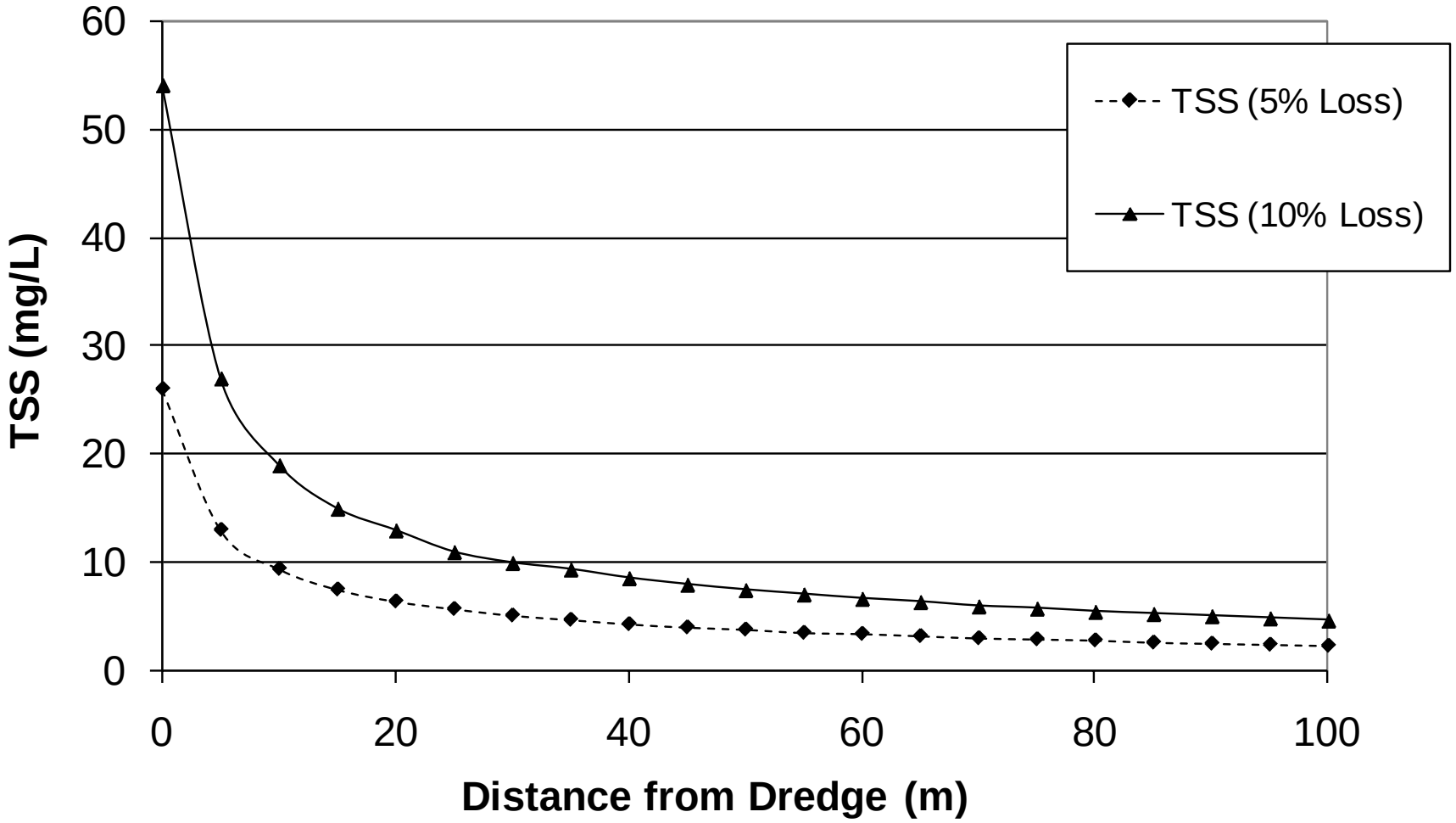

Figure 6-1
DREDGE Model Results
Terminal 4 Confined Disposal Facility - Design Analysis Report
Portland, Oregon

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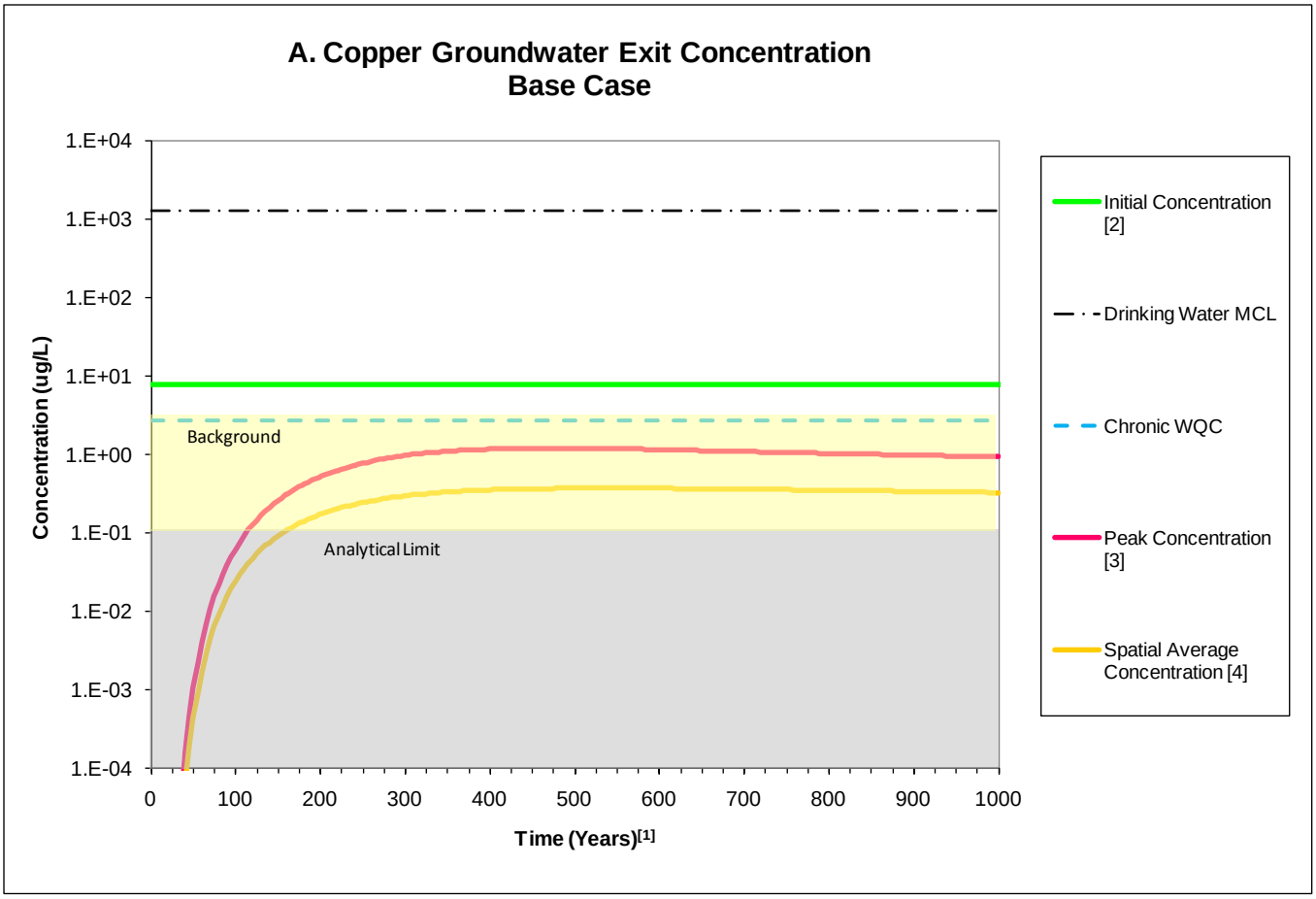

Notes:

Groundwater observation point is the predicted concentration in last model cell adjacent to river boundary, approximately one foot below the berm face.

[1] Time zero refers to the time when CDF construction is complete. It may take up to 4 to 6 years to fill and cover the CDF.

[2] Initial Concentration = sediment leachate concentration in CDF estimated using SBLT test results; see Appendix A and Table 6-7.

[3] Peak Concentration = peak contaminant concentration in groundwater exiting the CDF berm.

[4] Spatial Average Concentration = average contaminant concentration in groundwater exiting the CDF berm averaged vertically over the CDF berm face.

Figure 6-2A

Predicted Groundwater Release Concentrations – Copper

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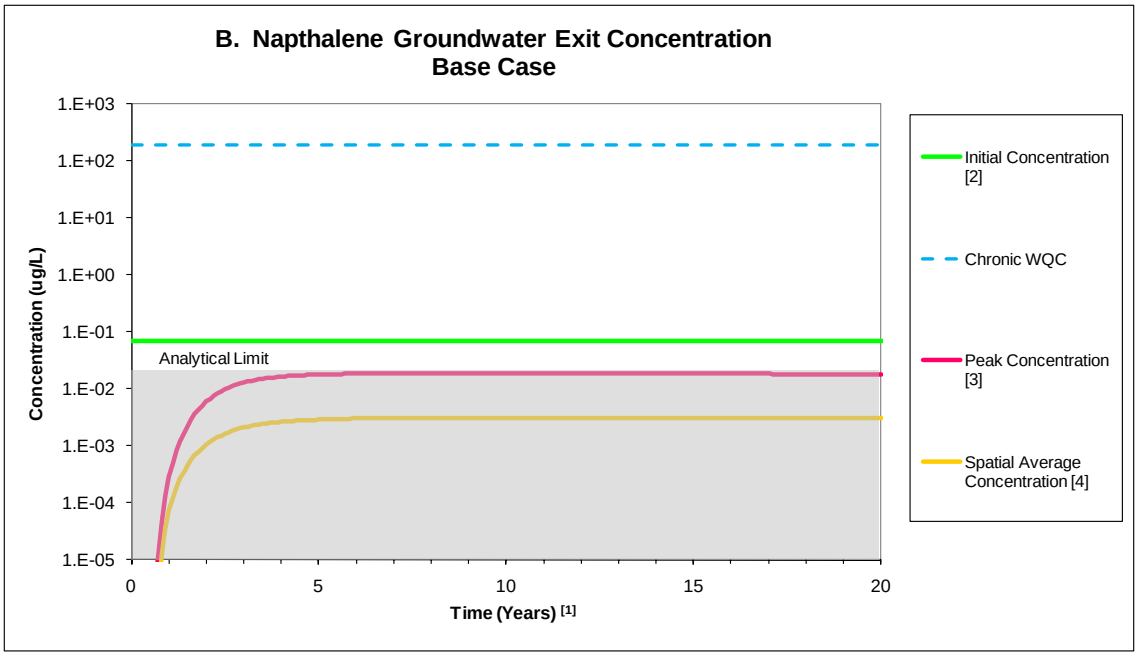

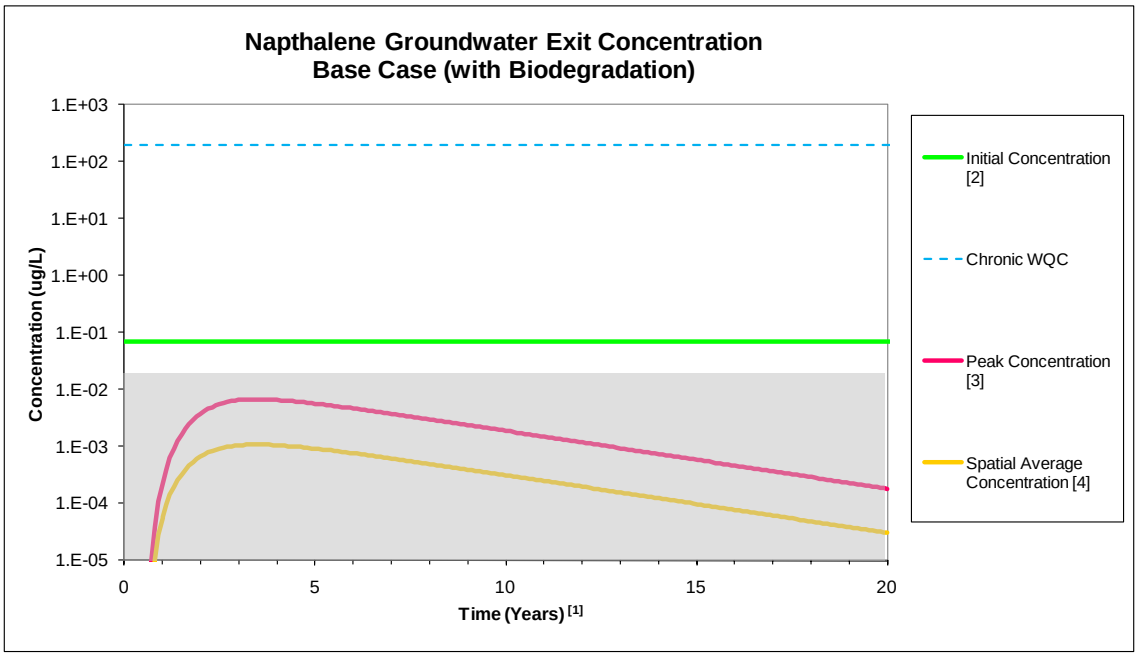

Notes:

Groundwater observation point is the predicted concentration in last model cell adjacent to river boundary, approximately one foot below the berm face.

Naphthalene predictions were terminated early after it was observed that exit concentrations had peaked and were subsequently declining.

[1] Time zero refers to the time when CDF construction is complete. It may take up to 4 to 6 years to fill and cover the CDF.

[2] Initial Concentration = sediment leachate concentration in CDF estimated using SBLT test results; see Appendix A and Table 6-7.

[3] Peak Concentration = peak contaminant concentration in groundwater exiting the CDF berm.

[4] Spatial Average Concentration = average contaminant concentration in groundwater exiting the CDF berm averaged vertically over the CDF berm face.

Figure 6-2B

Predicted Groundwater Release Concentrations – Naphthalene
Terminal 4 Confined Disposal Facility - Design Analysis Report
Portland, Oregon

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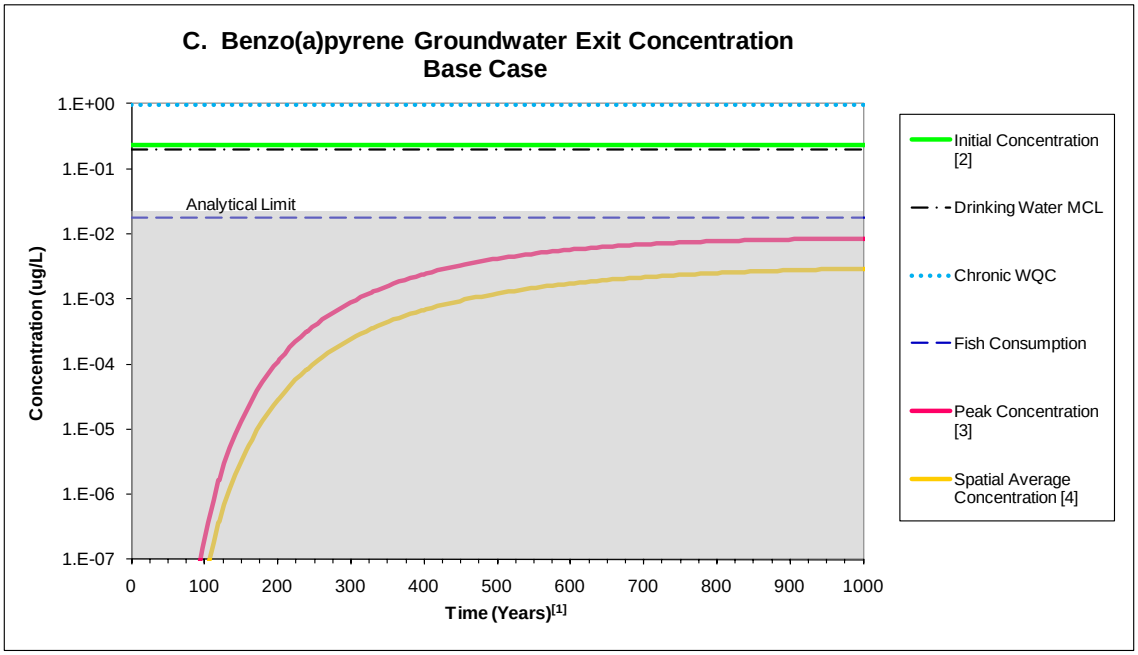

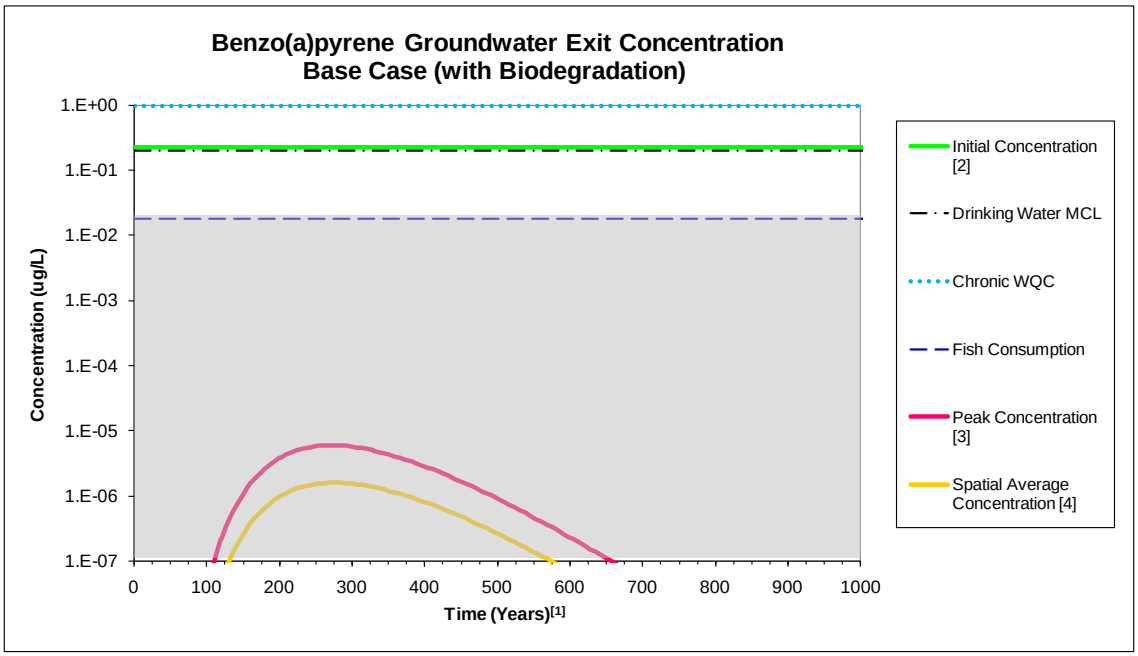

Notes:

Groundwater observation point is the predicted concentration in last model cell adjacent to river boundary, approximately one foot below the berm face.

[1] Time zero refers to the time when CDF construction is complete. It may take up to 4 to 6 years to fill and cover the CDF.

[2] Initial Concentration = sediment leachate concentration in CDF estimated using SBLT test results; see Appendix A and Table 6-7.

[3] Peak Concentration = peak contaminant concentration in groundwater exiting the CDF berm.

[4] Spatial Average Concentration = average contaminant concentration in groundwater exiting the CDF berm averaged vertically over the CDF berm face.

Figure 6-2C

Predicted Groundwater Release Concentrations – Benzo(a)pyrene
Terminal 4 Confined Disposal Facility - Design Analysis Report
Portland, Oregon

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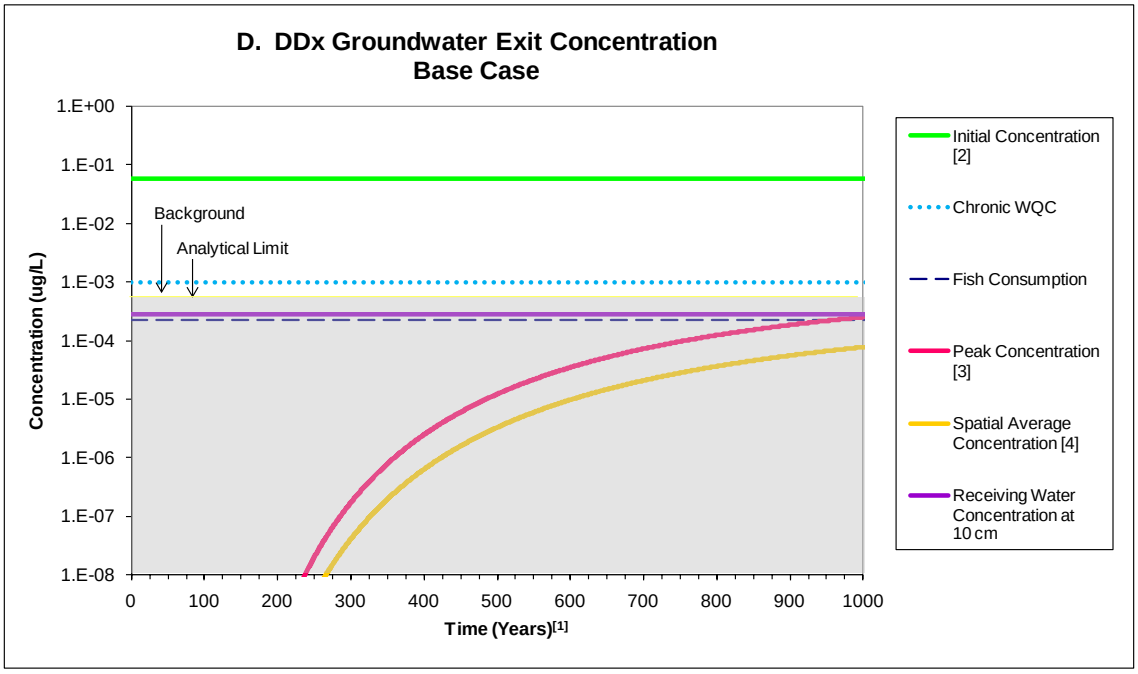

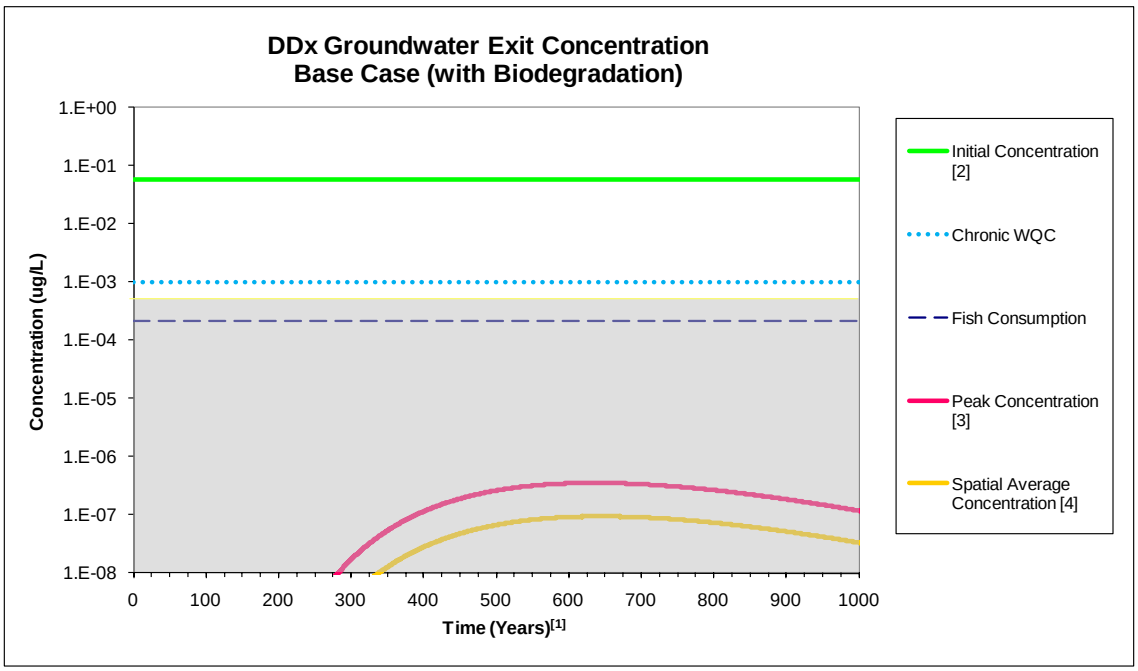

Notes:

Groundwater observation point is the predicted concentration in last model cell adjacent to river boundary, approximately one foot below the berm face.

[1] Time zero refers to the time when CDF construction is complete. It may take up to 4 to 6 years to fill and cover the CDF.

[2] Initial Concentration = sediment leachate concentration in CDF estimated using SBLT test results; see Appendix A and Table 6-7.

[3] Peak Concentration = peak contaminant concentration in groundwater exiting the CDF berm.

[4] Spatial Average Concentration = average contaminant concentration in groundwater exiting the CDF berm averaged vertically over the CDF berm face.

Figure 6-2D

Predicted Groundwater Release Concentrations – DDx

Terminal 4 Confined Disposal Facility - Design Analysis Report

Portland, Oregon

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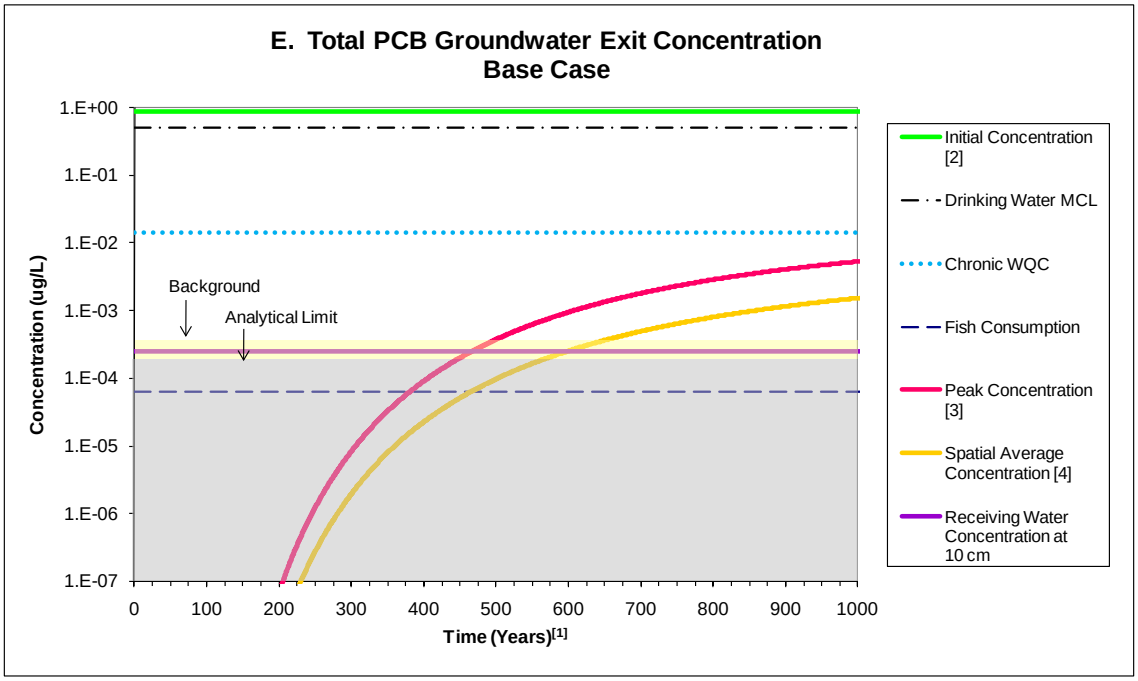

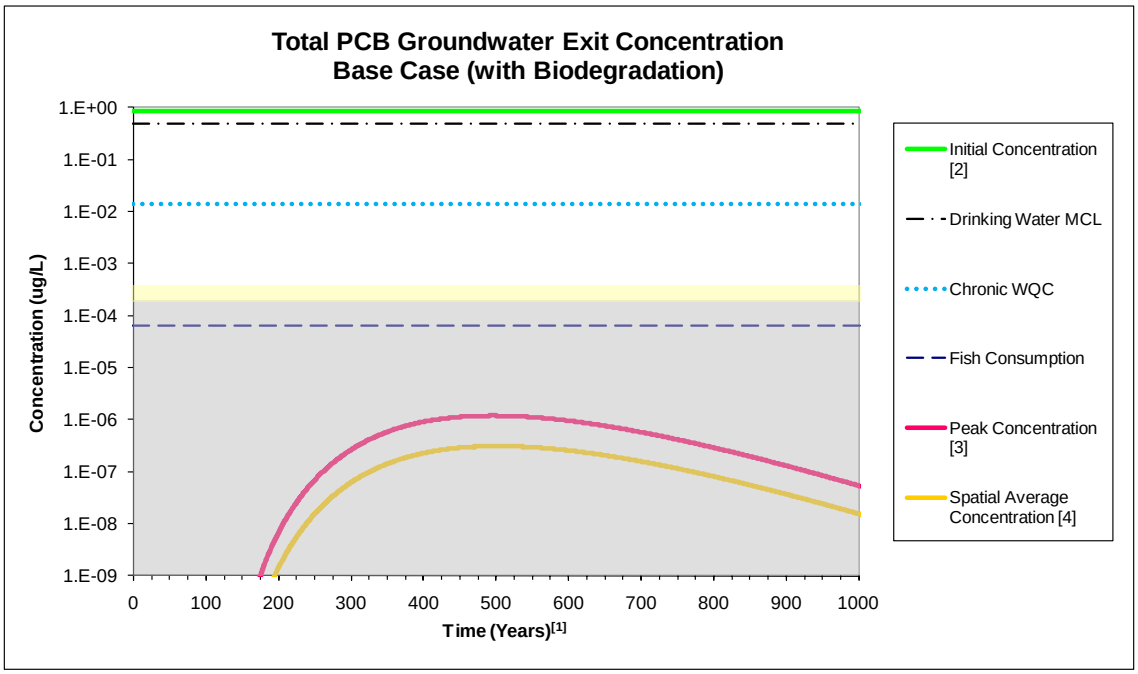

Notes:

Groundwater observation point is the predicted concentration in last model cell adjacent to river boundary, approximately one foot below the berm face.

[1] Time zero refers to the time when CDF construction is complete. It may take up to 4 to 6 years to fill and cover the CDF.

[2] Initial Concentration = sediment leachate concentration in CDF estimated using SBLT test results; see Appendix A and Table 6-7.

[3] Peak Concentration = peak contaminant concentration in groundwater exiting the CDF berm.

[4] Spatial Average Concentration = average contaminant concentration in groundwater exiting the CDF berm averaged vertically over the CDF berm face.

Figure 6-2E

Predicted Groundwater Release Concentrations – Total PCB

Terminal 4 Confined Disposal Facility - Design Analysis Report

Portland, Oregon

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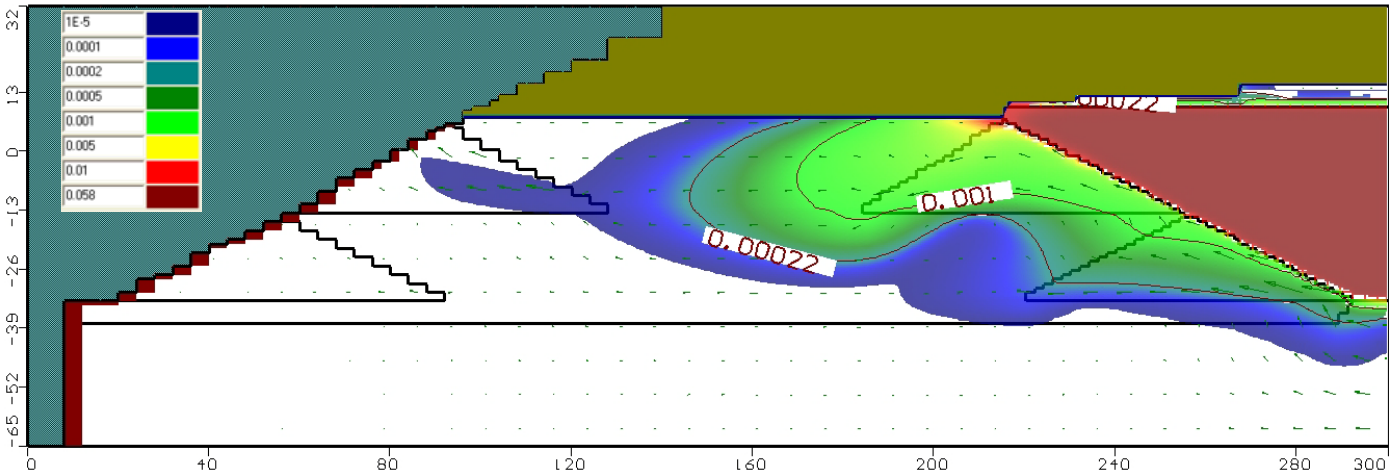
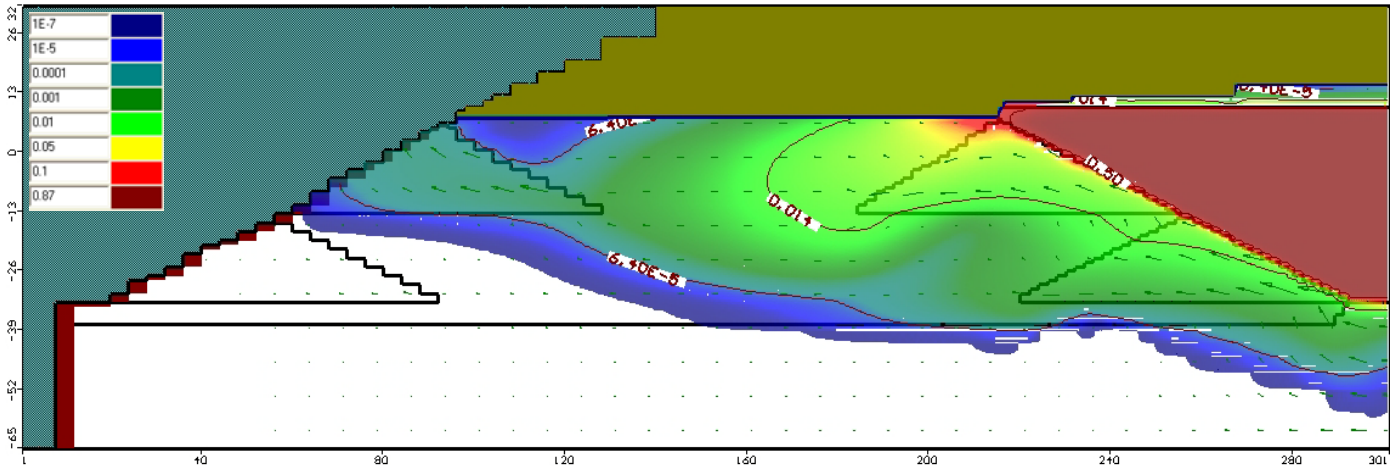


DDx at 475 years (in µg/L)



Total PCBs at 475 years (in µg/L)

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Figure 6-3
Contaminant Distributions at 475 Years
Terminal 4 Confined Disposal Facility - Design Analysis Report
Portland, Oregon

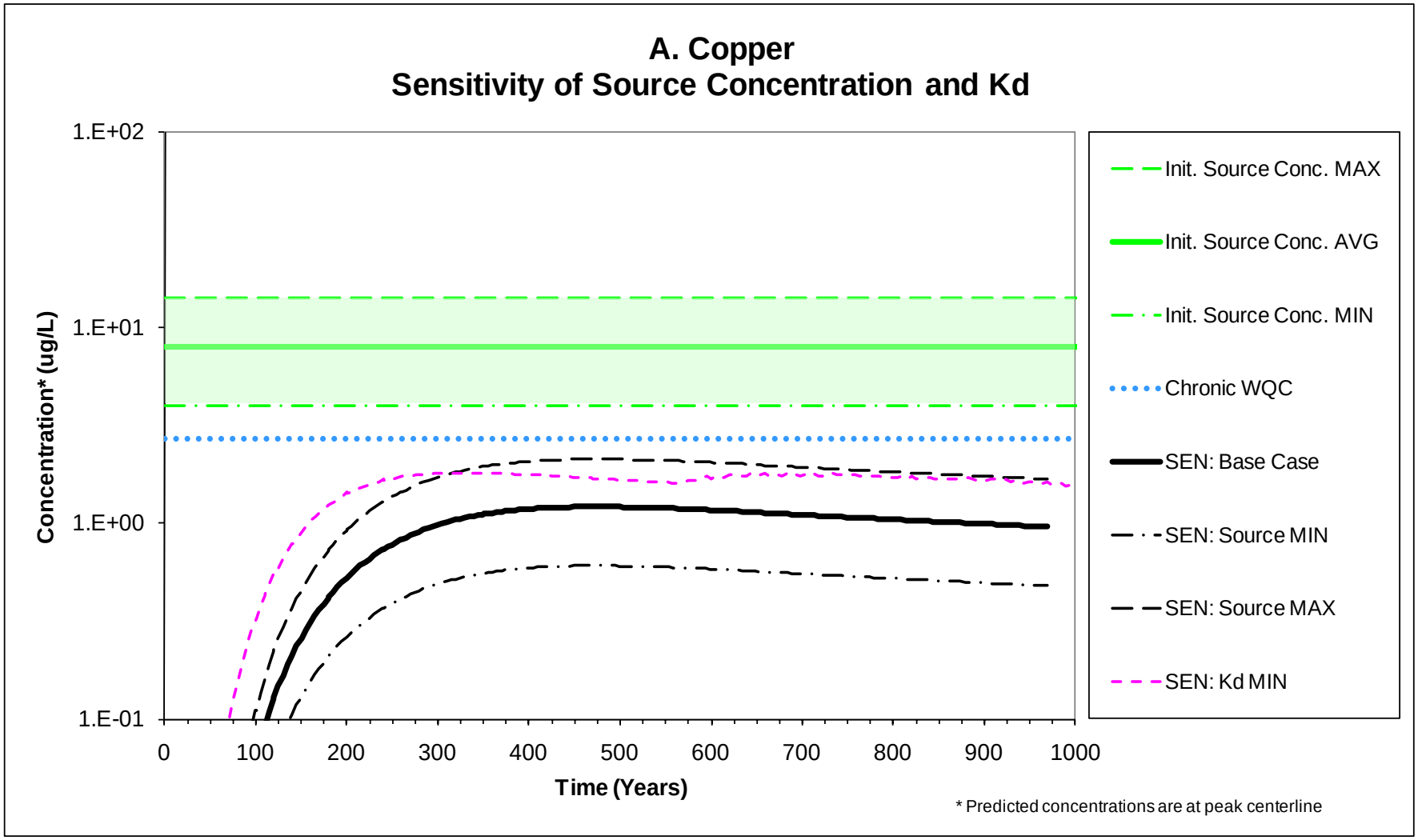

Figure 6-4A
Uncertainty Analysis of Groundwater Exit Concentrations – Copper
Terminal 4 Confined Disposal Facility - Design Analysis Report
Portland, Oregon

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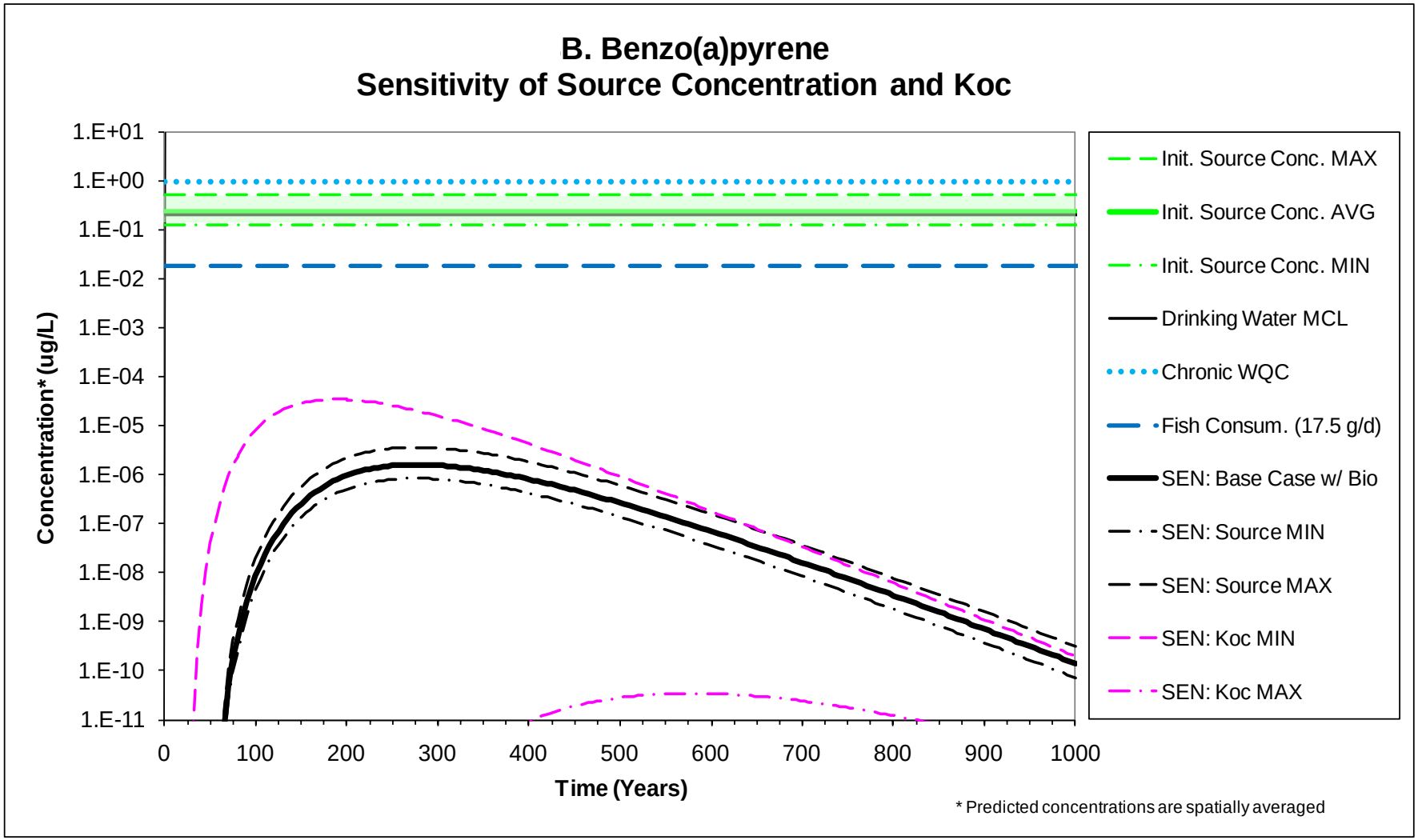

Figure 6-4B
Uncertainty Analysis of Groundwater Exit Concentrations – Benzo(a)pyrene
Terminal 4 Confined Disposal Facility - Design Analysis Report
Portland, Oregon

ANCHOR QEA

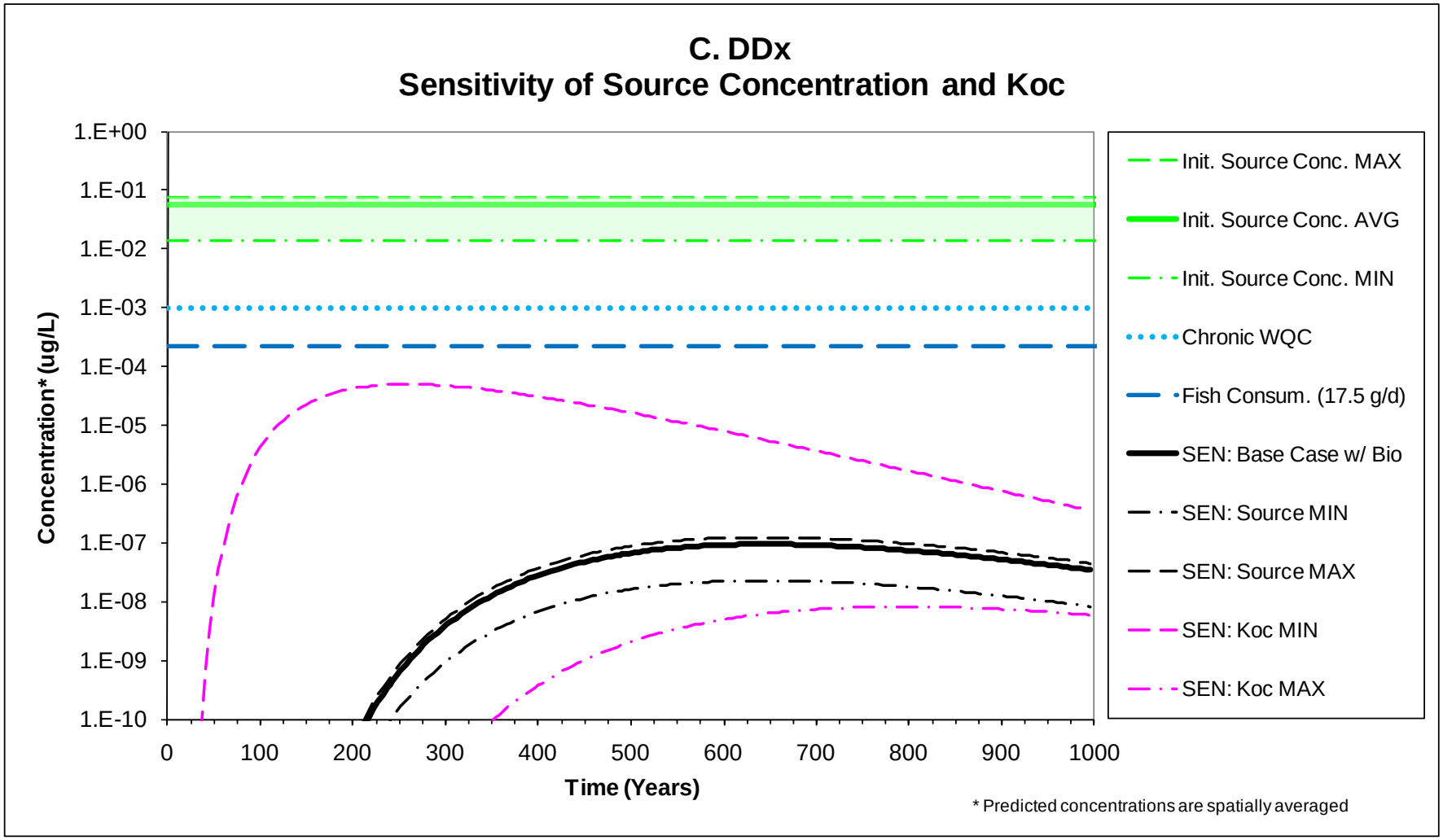

Figure 6-4C
Uncertainty Analysis of Groundwater Exit Concentrations – DDx
Terminal 4 Confined Disposal Facility - Design Analysis Report
Portland, Oregon

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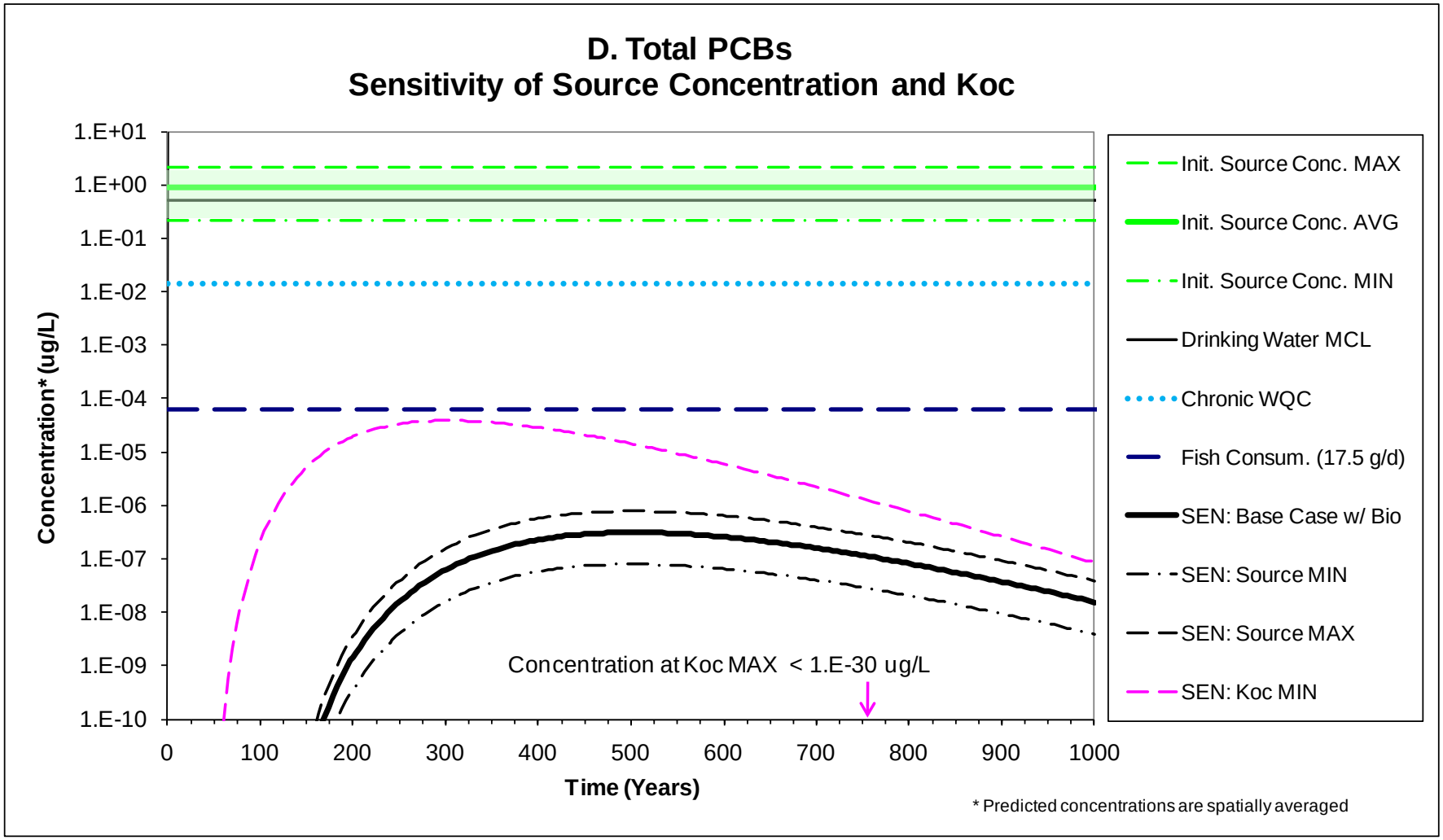

Figure 6-4D
Uncertainty Analysis of Groundwater Exit Concentrations – Total PCBs
Terminal 4 Confined Disposal Facility - Design Analysis Report
Portland, Oregon

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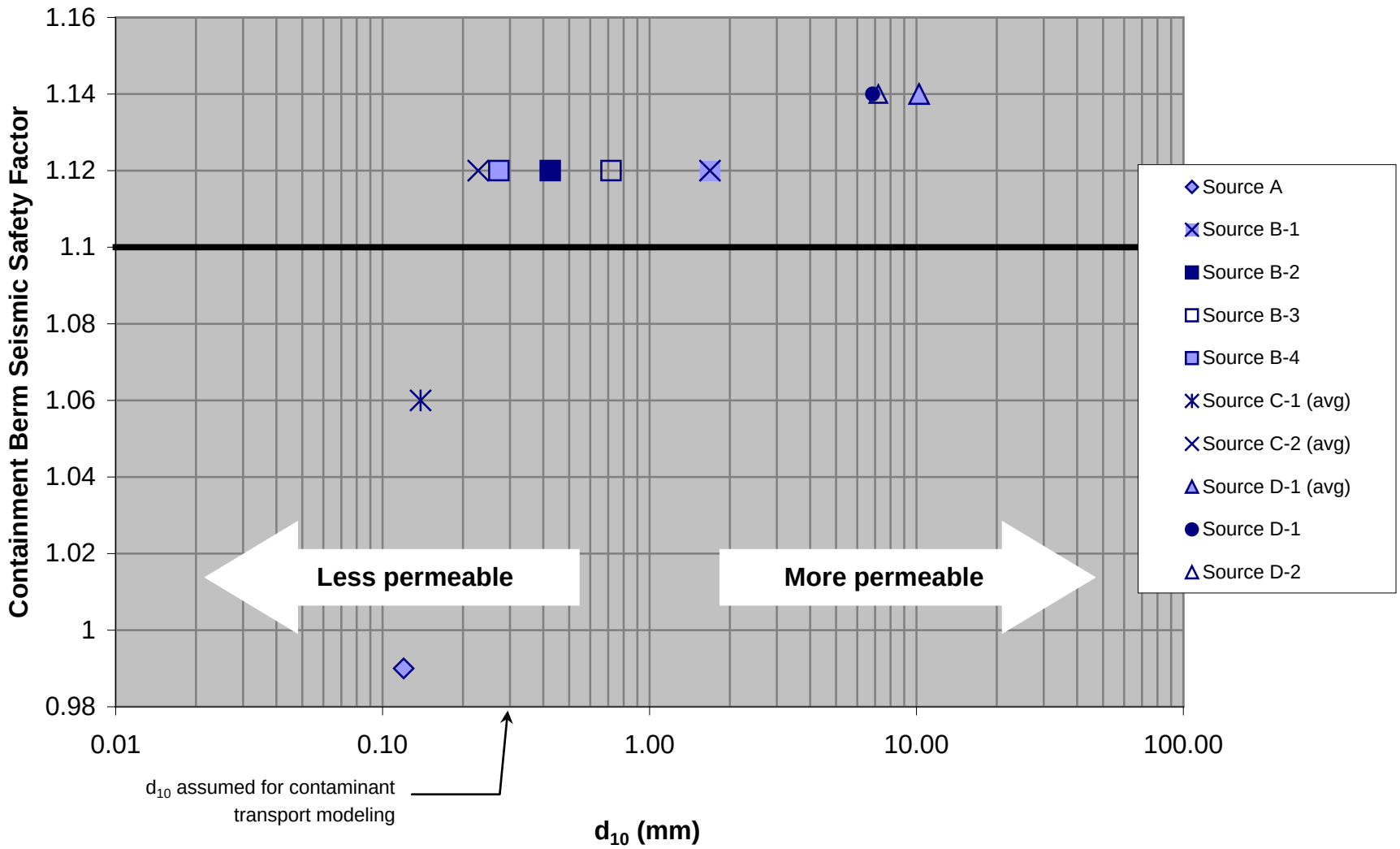

Figure 6-5
Berm Material vs. Permeability and Seismic Safety Factor
Terminal 4 Confined Disposal Facility - Design Analysis Report
Portland, Oregon

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ID	Task Name	Duration	Task Calendar
1	**Demolition**	**120 days**	**None**
2	Berth 405	24 days	6 days
3	Berth 408	33 days	6 days
4			
5	Stormwater Rerouting	120 days	Standard
6			
7	Replacement Berth Construction	96 days	6 days
8			
9	**Containment Berm Construction**	**120 days**	**None**
10	Berm overexcavation and placement	9 days	6 days
11	Berm construction from water	78 days	6 days
12	Berm construction from land	50 days	6 days
13	Fish Removal	5 days	Standard
14			
15	In-water Work Closure - No In-water Construction	347 days	None

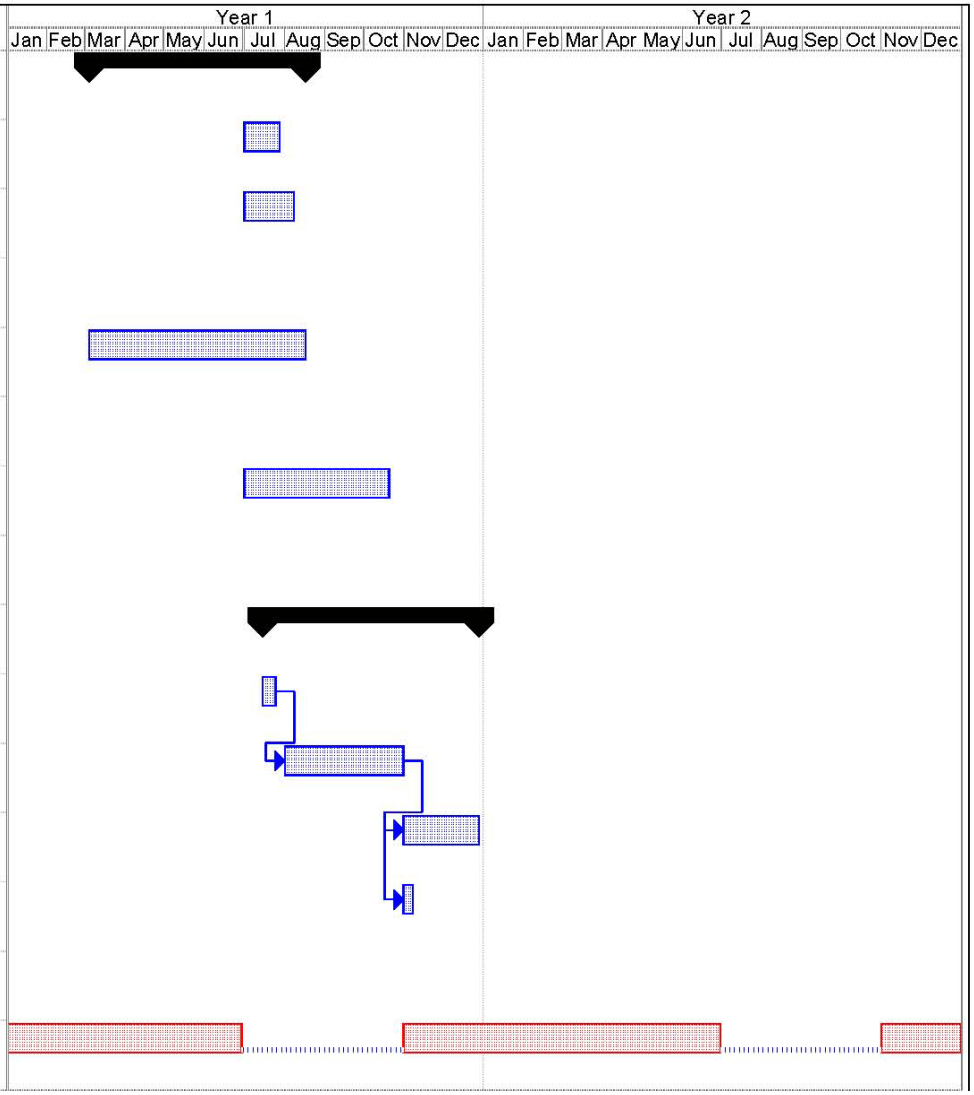

Figure 9-1
Terminal 4 CDF Construction Sequencing
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Portland, Oregon

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APPENDIX A
CONTAMINANT TRANSPORT MODELING OF THE CDF

ANCHOR QEA

6650 SW Redwood Lane, Suite 333
Portland, Oregon 97224
Phone 503.670.1108
Fax 503.670.1128
www.anchorqea.com

TECHNICAL MEMORANDUM

To:	Kelly Madalinski, Port of Portland Krista Koehl, Port of Portland	**Date:**	October 5, 2010 *(Updated August 8, 2011)*
From:	Todd Thornburg, Anchor QEA Pete Townsend, NewFields	**Project:**	050332-01
Re:	Groundwater Model Input Parameter Memorandum Port of Portland Terminal 4 Confined Disposal Facility		

This memorandum presents the input parameters proposed for use in the groundwater model of the Terminal 4 confined disposal facility (T4 CDF). The selection of model input parameters builds on the collaborative work performed by the Port of Portland (Port) and U.S. Environmental Protection Agency (USEPA) during the informal dispute resolution (IDR) process in 2007, as summarized in Table 1. At the conclusion of the IDR process, the T4 CDF modeling work was put on hold until significant new information could be obtained by the Lower Willamette Group (LWG) as part of the Portland Harbor Remedial Investigation/Feasibility Study (RI/FS). This new RI/FS information includes a better understanding of Portland Harbor chemicals of concern (COCs) accounting for most of the estimated human health and ecological risk, a comprehensive suite of contaminant mobility tests from Portland Harbor areas of potential concern (AOPCs), progress toward developing a Portland Harbor chemical fate and transport model (QEA-FATE model), and achieving consistency between the T4 and LWG modeling efforts to the extent possible.

The following topics are discussed in more detail in the sections below:

- Representative AOPCs to be considered in the T4 CDF evaluation
- COCs to be evaluated
- Modeling overview (short-term and long-term approaches)
- Physical and chemical input parameters to be used

This memorandum does not focus on engineering design or operational parameters that may affect the T4 CDF performance, such as the physical configuration of the containment berm (in particular, the size of the training dikes), the finish surface of the cover layer (i.e., paved or unpaved), or specific placement strategies (elevations and locations) for contaminated sediments from particular AOPCs. However, these engineering design or operational parameters may be evaluated during the modeling effort as necessary to optimize the protectiveness of the facility based on engineering constraints, construction experience, and input from the concurrent CDF design process.

REPRESENTATIVE AOPCS FOR T4 CDF EVALUATION

A key data input requirement of the T4 CDF groundwater model is the characterization of bulk sediment and leachate characteristics from a representative cross-section of potential dredging sites in Portland Harbor. The LWG collected and tested composite sediment samples from 11 AOPCs within Portland Harbor (LWG 2009) and subjected these sediment samples to sequential batch leachate tests (SBLT), a U.S. Army Corps of Engineers (USACE) laboratory procedure designed to simulate chemical leaching characteristics of sediments in a CDF (USACE 2003). Sediment and leachate tests performed by the Port at T4 were also included in the analysis. In all, bulk sediment and leachate data are available for the following AOPCs:

AOPC	River Mile	Bank	Site Vicinity
1	2.2	East	Evraz Oregon Steel
3	3.8	East	Schnitzer
6	4.3	East	Terminal 4
8	4.8	West	BP-Arco
9	6.3	West	Gasco
11	5.7	East	Mar Com Marine
13	6.8	East	Willamette Cove
14	7.1	West	Arkema
17	8.2	East	Cascade General Shipyard
17	9.0	East	Swan Island Lagoon
19	8.8	West	Gunderson
20	9.7	West	Fireboat Cove

The 12 AOPCs listed above are among the sites most likely to be addressed with active remediation, including the consideration of dredging. These AOPCs provide a representative cross-section of contaminated sediments throughout Portland Harbor; the sediment test sites extend from River Mile (RM) 2.2 to RM 9.7 on both the east and west banks of the river, and include a wide spectrum of waterfront industries and COCs. Contaminated sediments from 10 of the 12 AOPCs are being evaluated for dredging and disposal in the T4 CDF.

Leachate test results from two of the AOPCs (Site 9 and Site 14, Gasco and Arkema, respectively) are not currently included in the T4 CDF modeling analysis because sediment from portions of these areas contains evidence of sheen or oily product, and USEPA has indicated such sediment may not be appropriate for placement in the CDF without treatment. Leachate concentrations of polycyclic aromatic hydrocarbons (PAHs) and DDT isomers from Gasco and Arkema samples, respectively, are two to four orders of magnitude higher than other AOPCs; these samples were generally collected in areas of highest concentration, potentially containing free product (see Attachment 1). It may be appropriate that sediment in marginal areas from these two AOPCs with lower COC concentrations and no free product is suitable for evaluation. In addition, sediment containing higher COC concentrations and/or free product may later be evaluated for suitability if such sediment is first subjected to a treatment process such as stabilization. Additional leaching tests from these two AOPCs would need to be conducted on less-impacted areas and/or treated sediment according to the procedures that are ultimately developed in the Sediment Acceptance Criteria Memorandum to determine if they are suitable for placement in the CDF.

CONSTITUENTS OF CONCERN

A number of COCs are being considered for evaluation in the chemical fate and transport portion of the QEA-FATE model for Portland Harbor. QEA-FATE is a finite difference code that simulates hydrodynamics, sediment transport, and contaminant fate and transport within a linked framework. It is based on USEPA's EFDC code for hydrodynamics and transport in the water column, and also includes modeling of the sediment bed. The contaminant fate and transport code has its roots in another USEPA-supported mode, WASP (Water Quality Analysis Simulation Program). Further details on QEA-FATE model structure will be provided in the Portland Harbor FS.

A subset of key COCs from the Portland Harbor QEA-FATE model is proposed for evaluation in the T4 CDF groundwater model, as listed below.

COC for Portland Harbor Fate and Transport Model (QEA-FATE)	COC for T4 CDF Groundwater Model
Arsenic	
Copper	✓
Mercury	
Naphthalene	✓
Benzo(a)pyrene	✓
Bis(2-ethylhexyl)phthalate	
Tributyltin	
4,4'-DDD	
4,4'-DDE	
4,4'-DDT	
Total DDX	✓
PCB-77*	
PCB-126*	✓
Total PCBs	✓

Note:
* PCB congeners have been removed from consideration in QEA-FATE.

The rationale for selecting the COCs for the T4 CDF groundwater model is provided below.

Metals

Several metals are being evaluated as Portland Harbor COCs, including arsenic, copper, mercury, and tributyltin (TBT). Copper will be carried forward as a COC in the T4 CDF model because the upper percentile leachate concentrations in SBLT tests are above the chronic water quality criterion for the Willamette River. Arsenic will not be carried forward in the CDF model because all of the composited bulk sediment samples from Portland Harbor AOPCs are within the range of natural background concentrations in soil (i.e., all are less than 7 milligrams per kilogram [mg/kg]; WDOE 1994), and leachate concentrations are within the range of natural background concentrations in groundwater (USGS 1999), with the possible exception of AOPC 3. Mercury will not be carried forward because it was

detected in only one out of 40 leachate samples (see Attachment 1, Table 1-1). TBT will not be modeled because this parameter was not analyzed in LWG leachate samples, and because TBT is a relatively short-lived constituent, with an anaerobic half-life in sediment of only a few years (Champ and Seligman 1996; Dowson et al. 1996).

Cadmium and lead are COCs at T4. However, these COCs are not carried forward in the CDF modeling evaluation because earlier modeling runs showed predicted concentrations of cadmium and lead were well below chronic water quality criteria (Anchor 2006). In addition, T4 sediments are estimated to compose less than 15 percent of the total capacity of the CDF; therefore, the modeling efforts are best focused on Portland Harbor COCs with more widespread distributions.

Semivolatile Organic Compounds

PAHs are one of the primary groups of COCs for Portland Harbor, and are derived from a variety of different sources. Two key PAHs—naphthalene and benzo(a)pyrene—will be carried forward in the T4 CDF model. These two compounds represent low molecular weight and high molecular weight PAHs, respectively, and bracket the range of chemical characteristics and mobilities of the PAHs. In addition, benzo(a)pyrene is one of the carcinogenic PAHs with the highest toxicity.

Bis(2-ethylhexyl)phthalate (BEHP) will not be carried forward because only three out of 40 leachate samples exceeded fish consumption criteria, and in every case the exceedance was an isolated anomaly not replicated in the other leachate cycles from the same AOPC. Note that there is no chronic criterion for BEHP because "BEHP is not toxic to aquatic organisms at or below its solubility limit" (see USEPA National Recommended Water Quality Criteria 2010). USEPA previously agreed to remove BEHP from further consideration in the CDF model (USEPA 2007).

DDT Isomers

T4 CDF modeling efforts will be focused on Total DDX (i.e., the sum of 4,4'-DDT, 4,4'-DDE, and 4,4'-DDD). None of the 2,4'-DDX isomers were detected in LWG leachate samples outside of AOPC 14 (which is currently excluded from this modeling effort). Total DDX model predictions will be compared directly to aquatic life criteria, which are similarly

expressed on a total basis. However, fish consumption criteria are evaluated on the basis of individual isomers. As an initial conservative screening evaluation, model predictions for Total DDX will be compared to the most stringent of the individual fish consumption criteria (i.e., fish consumption criteria for 4,4'-DDT and 4,4'-DDE are the same, both being more stringent than 4,4'-DDD). If the predicted Total DDX concentration is above the fish consumption criterion for 4,4'-DDT, then the relative contributions of the different isomers to the total DDX concentration will be assessed. A proportional allocation of the Total DDX to the individual isomers will be performed using the Harbor-wide leachate statistics. On average, DDT, DDE, and DDD comprise 15, 61, and 24 percent of the Total DDX concentration, respectively, based on the mean Harbor-wide leachate concentrations.

Polychlorinated Biphenyls

Initial polychlorinated biphenyl (PCB) modeling efforts will be focused on Total Aroclors to characterize the bulk composition of Portland Harbor sediments, and because most water quality criteria are expressed on the basis of Total PCBs. PCB-126, an important dioxin-like congener, will also be modeled and evaluated on the basis of its toxicity equivalency factor (TEF) relative to dioxin. PCB-77 will not be carried forward in the CDF model. Although PCB-77 leachate concentrations are about 10 times higher than PCB-126, modeling PCB-126 is more representative of potential risks because PCB-126 is 1,000 times more toxic than PCB-77, and both congeners have similar partitioning coefficients (see Attachment 1).

The QEA-FATE model employs a more complex approach for modeling PCBs. The five principal homolog groups (tri- through hepta-chlorinated homologs), which account for 90 percent of the total PCB mass on average, are modeled separately in QEA-FATE. Then, the five homolog groups are summed and proportionately scaled to calculate a Total PCB concentration.

OVERVIEW OF MODELING APPROACH

Two types of groundwater models are being developed for the T4 CDF. The short-term groundwater model is designed to evaluate short-term (i.e., days to weeks) transport of COCs in dredge elutriate water from a hydraulic slurry that would be discharged into the open pond behind the berm during CDF construction. The long-term groundwater model is

designed to evaluate long-term (i.e., decades to centuries) transport of COCs in groundwater migrating through the contaminated sediment material after the CDF is constructed.

Short-Term Groundwater Model

The short-term groundwater model is used to assess the initial filling of the CDF pond by hydraulic dredging. The hydraulic dredge slurry, which includes large quantities of sediment and entrained water, is temporarily ponded behind the berm. This creates a differential hydraulic head across the berm and causes dredge elutriate water to flow through the berm toward the river. In contrast, mechanical dredging and placement techniques, in which sediments are placed in the pond at near in situ water content, will cause very little head difference in the pond and will not induce any substantive flow through the berm. For example, mechanical disposal of a barge with a 2,000-cubic yard (cy) sediment load will cause approximately 0.1-foot of head rise in the pond, which is negligible compared to the typical 1- to 2-foot daily tidal fluctuation in the river.

USEPA and the Port reached agreement on the short-term groundwater modeling approach and model input parameters during IDR (see Table 1). Short-term groundwater modeling for the T4 sediments was subsequently completed and results were submitted to USEPA in July 2007 (NewFields 2007a). The short-term model results indicated copper, lead, Total DDX, and Total PCBs would be over a million times lower than chronic criteria before groundwater enters the river, as summarized below:

Constituent	Chronic Criterion (µg/L)	Short-Term Groundwater Discharge Concentration (µg/L)
Copper	2.7	~1 E -17
Lead	0.54	~1 E -8
Total PCBs	0.014	~1 E -18
Total DDX	0.001	~1 E -14

Thus, water quality impacts during short-term filling of the CDF are expected to be negligible in a T4 hydraulic dredging scenario with conservatively high production rates. With the completion of the T4 Phase I Removal Action, less sediment requires dredging than previously assumed for the short-term groundwater model. Therefore, the short-term

groundwater model results represent a worst-case scenario and will be used for the CDF design at this time. Short-term model results may be updated at later design stages based on the final T4 dredge prism.

Hydraulic dredging may not be a feasible option for most or all of the other AOPCs in Portland Harbor, given that most of the AOPCs are located a long distance from T4, and many are on the opposite bank of the river. AOPC 3 is located about a half mile downstream of the CDF, but the next nearest AOPCs on the same side of the river are about 1.4 miles upstream and 2.1 miles downstream of the CDF. Mechanical dredging, rather than hydraulic dredging, may be a more feasible option for removing Portland Harbor sediment and placing this material into the CDF. Further work on the short-term groundwater model would be more appropriately conducted on a site-specific basis during later phases of design, if hydraulic dredging is determined to be a practicable and cost-effective alternative for a particular AOPC. Therefore, short-term groundwater modeling will not be further developed for the T4 CDF design.

Long-Term Groundwater Model

The long-term groundwater model will be used to assess the ability of the CDF to provide long-term protection of surface water quality via groundwater migration to the river. To perform this analysis, the long-term groundwater modeling period must be defined. The long-term modeling period was selected to coincide with the longest applicable engineering design standard being applied to the CDF. The design seismic event, corresponding to a 10 percent probability of exceedance in 50 years, or a return period of 475 years, is the longest applicable design standard. Therefore, the long-term groundwater model will be evaluated at 475 years. Model simulations will be extended to 1,000 years to better understand the shape and trajectory of the time trend.

Key Model Processes. The long-term groundwater model estimates the COC concentrations in groundwater exiting the CDF based on the physical and chemical properties of the confined dredged sediment, alluvium, and berm material. COCs originating in the dredged material are attenuated by various processes as they are transported in groundwater through the alluvium and the berm material. The primary attenuation mechanisms are advection and dispersion, adsorption to matrix materials, mixing with regional groundwater and incident

rainwater, and surface water intrusion. For organics, the base case scenario will include zero biodegradation, and an alternative scenario will be evaluated using a conservatively slow rate of biodegradation based on peer-reviewed literature studies.

Conservation of mass is a fundamental governing principle for the model. A linear adsorption isotherm is assumed for chemical partitioning relationships. Site-specific field and laboratory data are used to the extent possible to define model input parameters.

Model Output. Groundwater concentrations will be modeled and presented at the exit point to the river, approximately 1 foot inside the berm. The primary graphical representation of model output will be a series of breakthrough curves of groundwater concentrations over time for the duration of the long-term modeling period. Groundwater isopleths (concentration distributions in berm cross-section) will be presented for a few critical model scenarios to illustrate the preferential transport pathways and geochemical gradients within the berm. Bulk sediment concentrations will not be mapped because they change very little over time.

Steady-State River Boundary Condition. Due to the extended simulation period, the modeling will be performed using a simplified steady-state boundary condition at the river interface to streamline model computations and run times (Table 1). This model scenario is conservatively protective because it does not fully account for tidal dispersion and groundwater-surface water interactions in the shallow subsurface transition zone. If a higher level of accuracy is required, pending the outcome of initial steady-state model results, the effect of a more realistic transient boundary condition simulating diurnal tides and/or seasonal fluctuations in river levels may be incorporated in future long-term model evaluations.

PHYSICAL AND CHEMICAL MODEL INPUT PARAMETERS

Groundwater model input parameters, including the physical and hydraulic properties of CDF building materials, initial leachate concentrations in the confined sediment layer, and partitioning coefficients and biodegradation rates of COCs, are discussed in this section (see Tables 2 and 3). In addition, leachate concentrations and partitioning coefficients derived

from Portland Harbor sediments are compared to other sites in Region 10 where sediments have been evaluated for placement in a CDF (see Table 4).

Material and Hydraulic Properties

USEPA and the Port reached agreement on a majority of the material and hydraulic properties of the CDF building materials, including the contaminated sediment fill material, the cover material, the regional aquifer, the import material for the berm, and the training dikes (quarry spalls) (see Table 1). Material and hydraulic input parameters and their supporting data and rationale are summarized in Table 2. The only physical parameter to be updated since the IDR agreements is the organic carbon content of the contaminated sediment material. The organic carbon content (ranging from 1.0 to 1.8 percent, averaging 1.5 percent) is a representative Harbor-wide value estimated from bulk sediment analyses of ten Portland Harbor AOPCs selected for evaluation in the CDF model (see Attachment 1).

Initial Source Concentrations

SBLT data from Portland Harbor provide an estimate of the porewater concentrations that are expected to equilibrate with contaminated sediments in the T4 CDF. These data are used to initialize the source concentrations in the CDF. The source concentrations represent the potential for COCs to be mobilized in groundwater as the COCs move through the CDF (undergoing fate and transport processes) toward the river.

The geometric mean, arithmetic mean, and 90th percentile leachate concentrations from Portland Harbor SBLT results (excluding leachate results from AOPCs 9 and 14; see Attachment 1) were selected to represent the range of initial conditions in the model; i.e., the "minimum," "average," and "maximum" source concentrations, respectively. Because the CDF is comprised of a mixture of sediment and leachate from a variety of different AOPCs, an average concentration (i.e., arithmetic mean) is the appropriate statistic to characterize the source strength of this material. On the other hand, it would not be appropriate to assume that all of the material in the CDF was equivalent to the maximum concentration of any one individual AOPC. A nonparametric statistic (90th percentile) was used to define the upper-bound or "maximum" source concentration for the dredged sediment mixture. In the future, volume-weighted averaging of AOPC leachate quality may be performed, but information on the comparative removal volumes of the AOPCs is not currently available.

The initial source concentrations for the various groundwater COCs are compiled in Table 3.

Partitioning Coefficients

The ratio of the bulk sediment concentration to the SBLT leachate concentration is used to develop site-specific partitioning coefficients for contaminated sediment placed in the CDF. The partitioning coefficient describes how readily contaminants are desorbed from the sediments, dissolved in groundwater, and made available for transport through the CDF. The derivation of partitioning coefficients from SBLT tests on bulk sediment from Portland Harbor AOPCs is presented in Attachment 1. Geometric mean partitioning coefficients for the various groundwater COCs are compiled in Table 3. The geometric mean values are averaged across the 10 Portland Harbor AOPC sites because sediment from the different sites will be mixed during placement, and groundwater particles will be exposed to sediment from different sites during transport through the CDF. In the future, more specific placement and layering scenarios may be explored in the groundwater model, but currently there is not enough information on the relative volumes and sequencing of sites to evaluate AOPC-specific filling scenarios.

The initial source concentrations and the partitioning coefficients are dependent variables in that both are derived from SBLT leachate analyses; therefore, a sensitivity analysis should be conducted on only one or the other of these variables. The initial source concentrations, being the more direct measurement, will be used in the sensitivity analysis.

The SBLT leachate results are applicable to the contaminated sediment material but are not representative of the geochemical environment in the berm. The physical properties (sand and gravel) and source characteristics (regional quarries) of the berm material are fundamentally different, as are the thermodynamic conditions in the berm (i.e., dominated by adsorption processes rather than desorption). Applicable partitioning coefficients for metals in the berm material were established in NewFields (2007b). Partitioning coefficients for organic constituents are adopted from the LWG RI Report, Table E6 (LWG 2009); these are the same partitioning coefficients proposed for use in the QEA-FATE model. Subsequently, the minimum Koc value for DDD was revised based on site-specific Willamette River water column data.

Biodegradation Rates

Published biodegradation rates were compiled and evaluated for use in the T4 CDF model. It is expected that anaerobic degradation processes will prevail in the confined contaminated sediments, whereas aerobic degradation processes will be more important in the berm. The proposed long-term model scenarios to be evaluated will include a range of conservatively protective biodegradation rates from the lower end of published literature values, (i.e., slower rates), with particular emphasis on field and regional studies. For DDX and PCBs, zero degradation will be evaluated as a worst-case scenario. Because of the significantly longer time period of the CDF model predictions (475 years) compared to the QEA-FATE simulation period (30 years), biodegradation is likely to be a more important attenuation process for contaminants in the CDF and should be carefully considered in the CDF evaluation (USACE 1996; M. Palermo, pers. comm.).

Proposed biodegradation rates (expressed as half-lives, in days) are presented in Table 3, along with supporting literature citations. These rates were selected in consideration of the following:

- Biodegradation rates compiled by the LWG for use in the chemical fate and transport portion of the QEA-FATE model, as well as ongoing updates/refinements of those rates, and in consideration of the significantly longer time period of the CDF simulations
- Biodegradation references and comments provided by USEPA to the Port on June 20 and July 18, 2007 (see Table 1)
- Other relevant literature studies of anaerobic sediment biodegradation with particular emphasis on field and regional studies, as referenced in Table 3.

In situations where biodegradation produces intermediate daughter products (e.g., DDE degrading to DDMU), the toxicity of those products will be considered in the analysis.

Comparison with Other Region 10 Sites

Leaching data for three key COCs at Portland Harbor—benzo(a)pyrene, Total PCBs, and Total DDX—are compared to data from other Region 10 CDF sites in Table 4. The other

Region 10 CDF sites are predominantly marine sites in Puget Sound waterways. The elevated salinity at these sites is likely to have a pronounced effect on the partitioning behavior of metals, but less of an effect on the partitioning of organic contaminants such as the three COCs listed above.

The following general observations are evident from inspection of Table 4:

- The bulk sediment concentrations in Portland Harbor are typical and near the average of the bulk sediment concentrations at Puget Sound sites, which include sites with both higher and lower concentrations of all three COCs.
- The leachate concentrations from Portland Harbor are in many cases higher than those measured at Puget Sound sites, in spite of relatively similar bulk sediment concentrations.
- Because of the higher leachate concentrations, the calculated partitioning coefficients for Portland Harbor are typically about an order of magnitude lower than those calculated at Puget Sound sites.

The observed differences in leachate concentrations and partitioning coefficients between Portland Harbor and Puget Sound sites may be an artifact of using incomparable laboratory test procedures. The Portland Harbor leaching tests were conducted using the SBLT protocol, whereas the Puget Sound leaching tests, because of their marine salinity, required the use of pancake column leaching tests (PCLT; USACE 2003). The leaching of metals in Puget Sound sediments is especially complex because in these environments marine sediment is leached with freshwater, mimicking upland groundwater intrusion into formerly marine sediments. These conditions create transient effects in metals leachability, the so-called "salt washout" effect. Such transient effects in the leaching behavior of marine or estuarine sediments are described in USACE (2003, Appendix D).

The PCLT is a sediment column test in which porewater is eluted slowly over a period of several weeks and months, whereas the SBLT is a sediment-water slurry subjected to 24-hour contact periods, then the leachate is centrifuged, decanted, and filtered. In the SBLT, metals are filtered through a 0.45-micron cellulose filter and organics are filtered through a 1-micron glass fiber filter (USACE 2003). Very fine clay particles, as well as colloids, have the ability to pass through the filtration step of the SBLT, especially the 1-micron filter used for

organic constituents. Some amount of colloidal transport through the CDF berm (0.5 percent of the suspended solids concentration in modified elutriate tests) was assumed in the prior short-term modeling analysis (Anchor and Palermo 2007). However, laboratory observations of high turbidity levels in the filtered leachate support the interpretation that SBLT results may be biased high due to the inclusion of excessive particulate matter. If the elevated leachate concentrations in the SBLT tests are caused by an inefficient filtration step in the laboratory, then the use of these results provides an additional element of conservatism in T4 CDF model predictions.

TABLES

Table 1 Status of Terminal 4 CDF Groundwater Model Input Parameters and Issues
Table 2 Physical and Hydraulic Properties of CDF Materials
Table 3 Geochemical Properties of CDF Chemicals of Concern
Table 4 Comparison of Leaching Test Data from Portland Harbor and Other Region 10 Sites

ATTACHMENT

Attachment 1 Derivation of Partitioning Coefficients from Portland Harbor Sequential Batch Leachate Tests
Attachment 2 Response to EPA Comments on Groundwater Model Input Parameter Memorandum, Port of Portland Terminal 4 Confined Disposal Facility
Attachment 3 Terminal 4 Phase II CDF 60 Percent Design Approach Meeting Summary

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TABLES

Table 1
Status of Terminal 4 CDF Groundwater Model Input Parameters and Issues

Model Input Parameter and Supporting Document(s)	Date of Document Submittal	Description	Status[1,2]
Long-Term Groundwater Model			
CDF Groundwater Modeling Period	12/6/2006	The proposed CDF groundwater modeling period is the longest of the applicable engineering design periods, corresponding to a design seismic event with a return period of 475 years (i.e., 10 percent probability of exceedance in 50 years).	Resolved: USEPA approval of the seismic performance standard proposed in the 60 Percent Design Analysis Report (Anchor 2006) without comment, as per comments provided on 1/15/07.
Physical Model Parameters (K, TOC, porosity, density)	3/30/2007	Specification of physical input parameters for characterizing groundwater flow and chemical exchange properties of import material (berm, cap, dikes) and CDF fill material from T4 and Portland Harbor.	Resolved: Initial agreement on physical model parameters and sensitivity ranges occurred in 3/30/07 Groundwater Modeling Meeting (see meeting notes). See also *Borrow Source Analytical Results* and *Dredged Material Permeability Evaluation,* below.
Borrow Source Analytical Results	6/8/2007	Laboratory analysis of TOC values from material collected at potential borrow source sites that could be used to construct the CDF berm.	Resolved: During the 6/8/07 IDR meeting, Port proposed a mean value of 0.06% TOC based on borrow source sampling results from two local quarries; USEPA agreed to the Port's approach.
Explanation of Effective Dispersion (NewFields 2007c)	4/20/2007	Compares the use of a steady-state versus transient groundwater flow solutions in long-term contaminant transport predictions. Similarities of approach are compared to previous CDF modeling studies, including St. Paul Waterway, Tacoma, Terminal 91, Seattle, and Blair Slip 1, Tacoma.	Resolved: Use of a steady-state flow solution for the long-term model is acceptable. A transient river boundary may be added to the long-term model if greater accuracy is required. A transient flow solution is appropriate for the short-term model. This approach was approved by USEPA during the 5/17/07 meeting (see meeting notes).
Dredged Material Permeability Evaluation (Anchor 2007a)	5/4/2007	Provide hydraulic conductivity (permeability) values for the long-term groundwater model for Portland Harbor material after it has been placed within the CDF and allowed to consolidate.	Resolved; 6/12/07 email from Sean Sheldrake.
Metal Partitioning Coefficients for Berm (NewFields and Anchor 2007)	6/20/2007	Provide partitioning coefficients for the berm for use in groundwater model.	Resolved; final comments from USEPA on 7/12/07 via email from Sean Sheldrake.
SAP for Terminal 4 SBLT (Palermo and Anchor 2007a)	6/15/2007	Sampling and analysis plan to obtain more representative leachate testing of Terminal 4 dredge prism.	Resolved; USEPA approval of SAP on 6/19/07. Test results (leachate concentrations and partitioning coefficients) are incorporated in Table 3 of this memorandum.
Portland Harbor Stats Summary	6/11/2007	Source concentrations for COPCs had previously been derived from statistical analysis of Portland Harbor sediment samples.	No longer relevant. Concentrations have been updated with new LWG SBLT and bulk sediment data from representative AOPCs.
Portland Harbor Leachate Evaluation (Metals)	6/11/2007	Partitioning coefficients for metals had previously been derived from paired sediment/porewater data from Portland Harbor (Portland Harbor Site Investigation, Weston 1998).	No longer relevant. Concentrations have been updated with new LWG SBLT and bulk sediment data from representative AOPCs.
Portland Harbor Leachate Evaluation (Organics)	6/11/2007	Partitioning coefficients for organics had previously been derived from Region 10 leachability test data for organic constituents at Puget Sound CDF sites.	No longer relevant. Concentrations have been updated with new LWG SBLT and bulk sediment data from representative AOPCs.
Response to USEPA June 20 Comments on PH Values	7/19/2007	Responses to USEPA's comments on proposed leachate values for metals and organics in Portland Harbor.	No longer relevant. Concentrations have been updated with new LWG SBLT and bulk sediment data from representative AOPCs.
Biodegradation Rate Summary	7/17/2007	Input parameters for long-term groundwater model.	Proposed updated values are provided in Table 3 of this memorandum, based on degradation rates developed for use in the Portland Harbor chemical fate and transport model (QEA-FATE), comments previously provided by USEPA (in 7/18/07 email), and other appropriate literature references.
T4 Biodegradation Comments	7/18/2007	Comments from USEPA on Biodegradation Values (not the same values as in the 7/17/07 document).	
Points of Compliance and Criteria	11/15/2007	Points of compliance and criteria necessary for evaluating model output.	Preliminary CDF performance criteria were provided by USEPA to LWG on 2/18/10. Further refinement and resolution of these criteria will occur through the harbor-wide RI/FS process.
Short-Term Groundwater Model			
Explanation of Effective Dispersion (NewFields 2007c)	4/20/2007	See description in Long-Term Groundwater Model.	The short-term groundwater modeling approach and input parameters for Terminal 4 were resolved during IDR. Summary report of short-term model results for Terminal 4 was submitted to USEPA on 7/30/07, based on the hydraulic dredging scenario under evaluation in 2007. Short-term model results indicate groundwater concentrations entering the river are many orders of magnitude lower than chronic criteria. With the completion of the T4 Phase I Removal Action, it is currently unknown whether hydraulic dredging remains a cost-effective option for Phase II dredging at Terminal 4. In addition, hydraulic dredging may not be a feasible option for most or all of the AOPCs identified in Portland Harbor. Further work on the short-term model should be conducted on a site-specific basis during later stages of design, if hydraulic dredging is shown to be feasible and cost-effective alternative for a particular AOPC. Therefore, short-term groundwater modeling will not be further developed for the T4 CDF 60 percent design.
Short-term CDF Hydraulic Boundary Condition (NewFields 2007d)	4/30/2007	Methodology to estimate the short-term hydraulic head boundary condition during and following the CDF filling operation; boundary condition is input to short-term water quality model.	
SAP for Additional MET (Palermo and Anchor 2007b)	5/25/2007	Sampling and analysis to obtain more representative elutriate testing of Terminal 4 dredge prism.	
Estimated Source Concentrations for Short-Term GW Model (Anchor and Palermo 2007)	4/27/07 revised 7/9/2007	Provide source concentrations for short-term groundwater model; subsequently updated with new MET data.	
T4 Kd Comments; New MET Comments	7/12/2007	USEPA's comments on Kd values and Short-term GW Source (MET).	
Short-Term Water Quality Modeling (NewFields 2007a)	7/30/2007	Summary report of short-term model results.	

Notes:
1. Status information was obtained from the T4 EA IDR Action Item Tracking spreadsheet dated July 10, 2007; IDR Meeting Summaries; the comment resolution table attached to the November 15, 2007 letter from USEPA to the Port; and project emails.
2. Specific performance standards for CDFs developed during the harbor-wide process will apply to the T4 CDF.

Table 2
Physical and Hydraulic Properties of CDF Materials

Material	Units	Model Input Values for Base Case and Sensitivity Analysis			Data Source/Rationale
		Min.	Central	Max.	
Sediment Fill					
Fraction organic carbon	-	0.010	0.015	0.018	LWG (2009), Measured pH bulk sediment: 10% / Average / 90%
Porosity	-	-	0.35	-	Anchor (2006)
Hydraulic conductivity	ft/d	0.00017	0.00085	0.0028	Anchor (2007a); Consolidation tests from T4 and Region 10
Bulk density	g/cm^3	-	1.3	-	BBL (2005; Table 4-4); Consolidation tests from T4
Imported Fill					
Fraction organic carbon	-	0.0005	0.0006	0.0007	Anchor (2007b), Measured import from local quarries
Porosity	-	-	0.30	-	Anchor (2006)
Hydraulic conductivity	ft/d	-	28	-	Freeze and Cherry (1979; Table 2.2); clean sand
Bulk density	g/cm^3	-	2.0	-	Holz and Kovacs (1981; Table 2-1)
Berm Fill					
Fraction organic carbon	-	0.0005	0.0006	0.0007	Anchor (2007b), Measured import from local quarries
Porosity	-	-	0.30	-	Anchor (2006)
Hydraulic conductivity	ft/d	30	280	450	Hazen's approximation based on gradation specification for Select Fill
Bulk density	g/cm^3	-	2.0	-	Holz and Kovacs (1981; Table 2-1)
Dispersion - Horizontal	-	-	40	-	Anchor (2006); NewFields (2007c): Dynamic model calibration
Dispersion - Vertical	-	-	0.4	-	Anchor (2006); NewFields (2007c): Dynamic model calibration
Training Dikes					
Fraction organic carbon	-	-	0.00006	-	Assumed 10 percent of Berm Fill value
Porosity	-	-	0.30	-	Anchor (2006)
Hydraulic conductivity	ft/d	-	2,800	-	Freeze and Cherry (1979; Table 2.2); clean gravel
Bulk density	g/cm^3	-	2.2	-	Holz and Kovacs (1981; Table 2-1)
Aquifer					
Fraction organic carbon	-	-	0.003	-	BBL (2005); Average measured value in Slip 1 aquifer material
Porosity	-	-	0.30	-	Anchor (2006)
Hydraulic conductivity (K)	ft/d	-	65	-	Hart Crowser (2000); Pumping test results, as reported in BBL (2005)
Bulk Density	g/cm^3	-	2.0	-	Holz and Kovacs (1981; Table 2-1)

"Base case" input values

Table 3
Geochemical Properties of CDF Chemicals of Concern

Material	Units	Model Input Values for Base Case and Sensitivity Analysis			Data Source/Rationale
		Min.	Central	Max.	
Initial Source Concentrations in Contaminated Sediment Pore Waters					
Copper	µg/L	4	8	14	LWG (2009); Geometric Mean, Arithmetic Mean, and 90th Percentile of SBLT results
Naphthalene	µg/L	0.04	0.07	0.15	LWG (2009); Geometric Mean, Arithmetic Mean, and 90th Percentile of SBLT results
Benzo(a)pyrene	µg/L	0.12	0.23	0.52	LWG (2009); Geometric Mean, Arithmetic Mean, and 90th Percentile of SBLT results
Total DDX	µg/L	0.014	0.058	0.076	LWG (2009); Geometric Mean, Arithmetic Mean, and 90th Percentile of SBLT results
Total PCB Aroclors	µg/L	0.22	0.87	2.17	LWG (2009); Geometric Mean, Arithmetic Mean, and 90th Percentile of SBLT results
PCB-126	ng/L	0.08	0.27	0.68	LWG (2009); Geometric Mean, Arithmetic Mean, and 90th Percentile of SBLT results
Metal Partitioning Coefficient [Kd]					
Copper [Sediment]	L/kg	-	8,900	-	LWG (2009); Geometric Mean of AOPCs; see Attachment 1
Copper [Berm, Cap]	L/kg	100	165	-	NewFields (2007b)
Copper [Quarry Spall]	L/kg	1	20	-	USEPA (2005; Table 3); Minimum and 1st Percentile Kd
Log Organic Partitioning Coefficient [Koc] - Sediment					
Naphthalene	Log L/kg-OC	-	4.97	-	LWG (2009); Geometric Mean of AOPCs; see Attachment 1
Benzo(a)pyrene	Log L/kg-OC	-	5.18	-	LWG (2009); Geometric Mean of AOPCs; see Attachment 1
Total DDX	Log L/kg-OC	-	4.87	-	LWG (2009); Geometric Mean of AOPCs; see Attachment 1
Total PCB Aroclors	Log L/kg-OC	-	4.86	-	LWG (2009); Linear Isotherm Model; see Attachment 1
PCB-126	Log L/kg-OC	-	4.80	-	LWG (2009); Linear Isotherm Model; see Attachment 1
Log Organic Partitioning Coefficient [Koc] - Berm					
Naphthalene	Log L/kg-OC	3.12	3.30	3.53	LWG RI Report Table E6 (2009)
Benzo(a)pyrene	Log L/kg-OC	5.68	6.01	6.67	LWG RI Report Table E6 (2009)
Total DDX	Log L/kg-OC	5.69	6.44	6.62	LWG RI Report Table E6 (2009); Geometric Mean of DDT, DDE, and DDD
Total PCB Aroclors	Log L/kg-OC	5.96	6.39	7.59	LWG RI Report Table E6 (2009); Geometric Mean of Ar-1254 and Ar-1260
PCB-126	Log L/kg-OC	6.27	6.57	6.88	LWG RI Report Table E6 (2009)
Biodegradation Half Life in Sediment [Anaerobic]					
Naphthalene	days	-	1,100	Infinite[1]	Central value = 95% UCL from Bach et al. (2005); Coates et al. (1996a, 1996b, 1997); Chang et al. (2001); Heitkamp & Cerniglia (1987); Rothermich et al. (2002)
Benzo(a)pyrene	days	-	15,000	Infinite[1]	
Total DDX	days	-	33,000	Infinite[1]	Eganhouse et al. (2000a, 2000b)
Total PCB Aroclors	days	-	22,000	Infinite[1]	Magar et al. (2005); van Dort et al. (1997); Mackay et al. (1994); Davis (2004)
PCB-126	days	-	3,700	Infinite[1]	Sinkkonen & Paasivirta (2000); Beurskens & Stortelder (1995)

Notes: [1] Infinite half life corresponds to zero biodegradation

"Base case" input values

Table 4
Comparison of Leaching Test Data from Portland Harbor and Other Region 10 Sites

Medium	Units	Portland Harbor AOPCs[1]	Thea Foss Waterway[2]			Hylebos Waterway Segment 3/4[2]	Duwamish East Waterway[2]
			Dredge Area	SSMA-7S	SSMA-7D		
Total Organic Carbon (TOC)							
Bulk Sediment	%	1.5	3.0	3.9	3.8	1.9	1.6
Benzo(a)pyrene							
Bulk Sediment	µg/kg	990	6,730	2,700	32,000	190	210
Mean Leachate	µg/L	0.23	0.23	0.03	0.80	< 1.1	NA
90th Percentile Leachate	µg/L	0.52	0.39	0.05	1.10	< 1.4	NA
Mean Koc	L/kg-OC	151,000	976,000	2,310,000	1,050,000	NC	NC
Total PCB Aroclors							
Bulk Sediment	µg/kg	650	61	420	540	350	1,290
Mean Leachate	µg/L	0.87	< 0.05	< 0.05	< 0.05	< 0.04	< 0.10
90th Percentile Leachate	µg/L	2.17	< 0.09	< 0.05	< 0.05	0.09	0.05
Mean Koc	L/kg-OC	72,000	NC	NC	NC	1,090,000	1,610,000
Total DDX							
Bulk Sediment	µg/kg	55	< 9	71	< 120	13	NA
Mean Leachate	µg/L	0.058	< 0.005	< 0.005	< 0.008	< 0.004	NA
90th Percentile Leachate	µg/L	0.076	0.003	0.006	< 0.010	< 0.006	NA
Mean Koc	L/kg-OC	74,000	NC	730,000	NC	NC	NA

Notes:

[1] Sediment and leachate statistics are derived from SBLT results from 10 Portland Harbor AOPCs, not including AOPCs 9 and 14

[2] Sediment and leachate statistics for Puget Sound waterways are derived from a single PCLT with 15 or more sequential porewater elutions

NA - Not Analyzed

NC - Not Calculated, due to lack of detected concentrations

ATTACHMENTS

ATTACHMENT 1

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ATTACHMENT 1

DERIVATION OF PARTITIONING COEFFICIENTS FROM PORTLAND HARBOR SEQUENTIAL BATCH LEACHATE TESTS

The results and analysis of sequential batch leachate tests (SBLT; USACE 2003) conducted on sediments in areas of potential concern (AOPCs) in Portland Harbor are presented in this attachment. The AOPCs are being evaluated for remedial action in the Portland Harbor Feasibility Study. One of the remedial actions under consideration is dredging and placement of the dredged sediments in a nearshore confined disposal facility (CDF), such as the proposed CDF at the Port of Portland's (Port's) Terminal 4 (T4). SBLTs are laboratory tests specifically designed to evaluate the leaching characteristics of chemicals of concern (COCs) in dredged sediments placed in a CDF, and the potential for COCs to be mobilized in groundwater as it moves through the CDF toward the Willamette River.

One of the key results of the SBLTs is the estimation of chemical partitioning coefficients. Partitioning coefficients are an important input parameter for groundwater models currently being developed to characterize contaminant fate and transport in the T4 CDF. The partitioning coefficients developed from the SBLTs are appropriate for describing leaching (i.e., desorption) of COCs from contaminated sediments in a CDF.

Other methods must be used to estimate partitioning coefficients in the CDF berm, due to its significantly different material properties (i.e., the berm is comprised of import sand and gravel from local quarries) and thermodynamic conditions (i.e., adsorption-dominated processes rather than desorption; aerobic rather than anaerobic conditions). Partitioning coefficients applicable to the CDF berm have been adopted from the Portland Harbor Remedial Investigation Report (LWG 2009) and are compared with SBLT-derived coefficients later in this attachment.

SBLT SAMPLING AND ANALYSIS METHODS

SBLTs were conducted in 11 AOPCs by the Lower Willamette Group (LWG) in accordance with the methods described in the Portland Harbor RI/FS Sediment Chemical Mobility Testing Field Sampling Plan (LWG 2008) and U.S. Army Corps of Engineers protocols (USACE 2003). In addition, a SBLT conducted independently by the Port on sediment from T4 was also included in this evaluation (Palermo and Anchor 2007). The SBLT consists of four sequential extractions of leachate water from composited bulk sediment samples representing potential removal areas in Portland Harbor AOPCs. Each cycle of the SBLT is extracted from a slurry of 4 parts water to 1 part sediment by weight (USACE 2003). Because these tests are batch leachate extractions, they are well designed to estimate partitioning coefficients. Unlike column tests, however, they are not easily interpreted in terms of pore volume elutions in the CDF.

In all, 12 SBLTs were conducted on composite sediment samples from the following AOPCs:

AOPC	River Mile[1]	Bank	Site Vicinity
1	2.2	East	Evraz Oregon Steel
3	3.8	East	Schnitzer
6	4.3	East	Terminal 4
8	4.8	West	BP-Arco
9	6.3	West	Gasco
11	5.7	East	Mar-Com Marine
13	6.8	East	Willamette Cove
14	7.1	West	Arkema
17	8.2	East	Cascade General Shipyard
17	9.0	East	Swan Island Lagoon
19	8.8	West	Gunderson
20	9.7	West	Fireboat Cove

Note:
[1] Approximate river mile at center of AOPC sampling area

Partitioning coefficients were calculated for each individual AOPC, and Harbor-wide coefficients were calculated using the compiled results from 10 of the AOPCs. The SBLT results for the remaining two AOPCs (sites 9 and 14, adjacent to Gasco and Arkema,

respectively) were excluded from Harbor-wide calculations because portions of these AOPCs may contain free product, which increases the complexity of their leaching characteristics and is unrepresentative of other Harbor sediments. Sediments containing free product may require stabilization or some other form of treatment before they are considered suitable for placement in a CDF.

SBLT Chemicals of Concern

Partitioning coefficients were calculated for a comprehensive group of COCs, as listed below. This list is consistent with the COCs being considered for evaluation in related LWG modeling efforts (i.e., QEA-FATE model) for Portland Harbor. A more focused list of COCs will be selected for T4 CDF modeling.

- Metals:
  - Arsenic
  - Copper
  - Mercury
- Semivolatile Organic Compounds (SVOCs):
  - Naphthalene
  - Benzo(a)pyrene
  - Bis(2-ethylhexyl)phthalate
- Chlorinated Pesticides:
  - 4,4'-DDD
  - 4,4'-DDE
  - 4,4'-DDT
  - Total DDX
- Polychlorinated Biphenyls (PCBs):
  - Total PCB Aroclors
  - Total PCB Congeners
  - PCB-77
  - PCB-106/118
  - PCB-126
  - PCB-169

Chemical Partitioning Equations

The SBLT procedure results in extraction and analysis of four sequential leachate cycles from the test sediment. An initial chemical analysis of the composite bulk sediment sample is performed. For each leaching cycle, the mass of contaminant remaining in the sediment is adjusted to account for mass lost via leaching to the aqueous phase, using the principles of mass balance (USACE 2003, Appendix D):

$$C_{sed}(n) = C_{sed}(n-1) - 4 \times C_{leach}(n), \quad n = \text{cycles 1 through 4}$$

in which $C_{sed}(n)$ is the bulk sediment concentration associated with the nth leachate cycle [in mg/kg, µg/kg, or ng/kg], $C_{leach}(n)$ is the leachate concentration for the same cycle in consistent units [i.e., mg/L, µg/L, or ng/L, respectively], $C_{sed}(0)$ is the initial bulk sediment concentration prior to leaching, and the constant (4) represents the weight ratio of water-to-sediment (4-to-1) as specified in the SBLT procedure.

Partitioning coefficients [K_d in L/kg] are then calculated for each leaching cycle:

$$K_d = C_{sed}(n) / C_{leach}(n)$$

Metals partitioning coefficients are expressed as K_d values, as derived above. However, partitioning coefficients for organic compounds (including SVOCs, chlorinated pesticides, and PCBs) are normalized to the organic carbon content of the sediment, as follows:

$$K_{oc} = K_d / foc$$

in which K_{oc} is the organic carbon partitioning coefficient [L/kg-organic carbon] and foc is the unitless fraction of sedimentary organic carbon [kg-organic carbon/kg-sediment].

Treatment of Nondetects in SBLT Results

The occurrence of undetected analytical concentrations in either bulk sediment or leachate complicates the calculation of partitioning coefficients. The following general rules were observed when handling nondetects:

- **Nondetects in Bulk Sediment:** If a particular COC was not present at detectable concentrations in the initial bulk sediment phase in a particular AOPC, there is

insufficient data to calculate a partitioning coefficient for that COC and AOPC. Such data were not included in Harbor-wide calculations.

- **Detections in Bulk Sediment; Partial Detections in Leachate:** If a particular COC was present at detectable concentrations in at least one of the four leaching cycles, partitioning coefficients were calculated and included in Harbor-wide partitioning calculations. Partitioning coefficients calculated using undetected leachate concentrations may actually be greater than the calculated value and therefore carry an associated ">" flag.
- **Detections in Bulk Sediment; Nondetects in Leachate:** If a particular COC was not detected in all four leaching cycles, the data were generally not included in Harbor-wide calculations, unless the level of "censoring" provides useful information to help bound the range of values. Specifically, if the calculated partitioning coefficients, based on undetected leachate concentrations, fall within the upper quartile of values observed at other sites in the Portland Harbor, such data can add value to the Harbor-wide summary statistics and were, therefore, retained in the Harbor-wide dataset.

In situations where partitioning coefficients were calculated using undetected leachate concentrations, one-half the detection limit of the leachate analysis was used in the calculation (i.e., in the denominator of the sediment-to-water ratio).

SBLT Partitioning Calculations

The analytical results of the SBLTs, calculated partitioning coefficients for individual AOPCs, and Harbor-wide summary statistics are compiled in Table 1-1. This table includes the following information for each AOPC and COC:

- Initial measured bulk sediment COC concentrations, and calculated bulk sediment COC concentrations for each subsequent leaching cycle
- Measured fraction of organic carbon in bulk sediment (based on total organic carbon [TOC] analysis)
- Measured COC concentrations in each leachate extraction cycle
- Calculated partitioning coefficients for each leachate extraction cycle
- Geometric mean partitioning coefficients for each AOPC and COC, based on the central tendency of the four leachate cycles

- Harbor-wide summary statistics (including minimum, mean, maximum, and 10th and 90th percentile values of log partitioning coefficients) as derived from 10 AOPCs, excluding Sites 9 and 14

In developing recommended partitioning coefficients for Portland Harbor, four different calculation methods were considered, although not every method produced a reliable value in every AOPC, and one method (method 2) proved to be inapplicable to the Portland Harbor dataset. The use of multiple methods helps to provide corroboration of model input values and improved reliability. The following calculation methods were evaluated:

1. Harbor-wide summary statistics of log K_d or log K_{oc} values
2. Partitioning isotherms derived from analysis of sequential leaching cycles
3. Linear isotherms derived from regression analysis of Harbor-wide data pairs
4. Freundlich isotherms derived from regression analysis of Harbor-wide data pairs

These various partitioning calculations are described in more detail below:

1. Harbor-Wide Summary Statistics of Log K_d and Log K_{oc} Values

In a large majority of cases, there were no consistent trends in leachate concentrations over the four cycles of the SBLT; therefore, the data were simply analyzed as four replicate measurements. Partitioning coefficients were calculated for each cycle, and a geometric mean partitioning coefficient was calculated for each AOPC by averaging the results of the four cycles. Harbor-wide summary statistics (including mean, minimum, maximum, and 10th and 90th percentile values) were then calculated over the 10 AOPCs (see Table 1-1).

2. Partitioning Isotherms Derived from Analysis of Sequential Leaching Cycles

For some COCs, and in some environments, it is possible to develop partitioning isotherms based on the change in sediment and leachate concentrations that occur over the four leaching cycles of the SBLT (USACE 2003). However, Portland Harbor data are not amenable to this type of calculation for the following reasons (see Table 1-1):

1) The COCs in Harbor sediments are moderately to strongly hydrophobic. As a result, very little mass is desorbed during each leaching cycle and the overall change in sediment concentration over the four-cycle test is negligible.

2) It is unusual to observe consistently decreasing leachate concentrations over the course of the four test cycles. More typically, concentrations rise and fall randomly from one cycle to the next with no apparent trend. This type of non-ideal behavior has also been observed in other SBLT tests in other parts of the country (M. Palermo, pers. comm.).

For these reasons, the analytical results from the four leachate cycles were treated as four replicate measurements, as described in the previous section.

3. Linear Isotherms Derived from Regression Analysis of Harbor-Wide Data Pairs

A linear isotherm model is a common way to describe chemical partitioning relationships (Tchobanoglous and Schroeder 1985). For this study, the partitioning relationships were developed using all of the Harbor-wide data to provide coverage over the entire range of observed sediment and leachate concentrations. Each AOPC is represented by a data pair consisting of the mean sediment concentration and mean leachate concentration averaged over the four SBLT cycles. The 10 data pairs from 10 AOPCs are posted in a scatterplot, and a least-squares linear regression is fit to this Harbor-wide dataset. The scatterplots and regression lines are shown on the left-hand panels of Figure 1-1, and the linear regression statistics are summarized in Table 1-2 for each COC. Note that a minimum of three valid data pairs (i.e., valid SBLT results from at least three AOPCs; see discussion under *Treatment of Nondetects in SBLT Results*) is required to fit a regression model.

The slope of the regression line is an estimate of the linear partitioning coefficient. A linear partitioning coefficient is constant over the range of observed sediment concentrations. The regression line for metals is allowed to intercept the y axis, indicating some amount of residual and un-leachable metal can be fixed in the mineral framework of the sediment and this fraction does not interact with porewater. The regression line for organic compounds is forced through the origin because these compounds cannot be mineralized and are assumed to be fully exchangeable.

4. Freundlich Isotherms Derived from Regression Analysis of Harbor-Wide Data Pairs

A Freundlich isotherm model is another common way to describe chemical partitioning relationships (Tchobanoglous and Schroeder 1985). Similar to the linear isotherm model, scatterplots of the 10 sediment-leachate pairs from the 10 AOPCs are fitted with a least-squares regression line. To derive the Freundlich isotherm coefficients, however, the data are modeled in logarithmic space. The logarithmic scatterplots are shown in the right-hand panels of Figure 1-1, adjacent to their corresponding linear models. The Freundlich coefficients [K_f] and [1/n] correspond to the slope and intercept of the logarithmic regression model, respectively.

METHOD COMPARISON AND RECOMMENDATIONS

The log K_d and log K_{oc} values for metals and organics, respectively, are summarized in Table 1-2. For COCs that were amenable to all three calculation methods (primarily PCB aroclors and congeners), there is excellent agreement among the three estimates. The mean partitioning coefficient of the AOPCs (based on Harbor-wide summary statistics), the slope of the linear regression model, and the Freundlich coefficient [K_f] of the log regression model, differ by no more than one quarter to one half an order of magnitude for these constituents.

The recommended partitioning coefficients for use in the T4 CDF model were selected using the following decision logic:

1. The slope of the linear regression model is the preferred method for estimating the partitioning coefficient if a moderately strong correlation is observed (i.e., $0.78 < r^2 < 0.98$).
2. If a poor correlation is observed in the linear regression model, the mean of the log K_d or log K_{oc} values from the Harbor-wide summary statistics is used.
3. The Freundlich coefficients are not recommended for use because the Freundlich slope [1/n] is close to 1 in a majority of cases (i.e., it is not substantially different than the linear isotherm model). The added complexity of the Freundlich model is, therefore, not warranted.

In summary, the partitioning coefficients derived from the SBLT data are appropriate for characterizing the leaching (i.e., desorption) of COCs from contaminated sediments placed in

the T4 CDF. The recommended sediment desorption coefficients for use in the T4 CDF groundwater model are summarized in Table 1-2.

For comparison, partitioning coefficients recommended for use in the Portland Harbor chemical fate and transport model (component of QEA-FATE model) are also provided in Table 1-2. These partitioning coefficients were derived from a survey of literature values (LWG 2009) and from the analysis of LWG water column monitoring data in the Willamette River. They are more appropriate for characterizing surface water fate and transport processes in the Willamette River, as well as adsorptive processes and groundwater/surface water interactions in the CDF berm.

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Table 1-1
Summary of Bulk Sediment and Leachate Results, AOPC and Harbor-Wide Partitioning Coefficients

				Bulk Sediment Concentrations					SBLT Leachate Concentrations				LOG Kd/Koc (L/kg) [1][2]				AOPC Summary Statistics [3]			Harbor-Wide LOG Kd/Koc Summary Stats [5]	
	Sediment Unit	Leachate Unit	Fraction TOC	Initial Concentration	Cycle 1	Cycle 2	Cycle 3	Cycle 4	Cycle 1	Cycle 2	Cycle 3	Cycle 4	Cycle 1	Cycle 2	Cycle 3	Cycle 4	GeoMean Sediment[4]	GeoMean Leachate[4]	Average LOG Kd/Koc		
Arsenic																					
Site 1: Evraz Oregon Steel	mg/kg	mg/l	0.0112	4.45 T	4.33	4.32	4.31	4.30	0.0310 T	0.0027 T	0.0015 T	0.0013 T	2.14	3.21	3.46	3.54	4.31	0.0035	3.09	Min	2.34
Site 3: Schnitzer	mg/kg	mg/l	0.0151	3.90 J	3.83	3.75	3.68	3.62	0.0173	0.0204	0.0178	0.0139 T	2.35	2.26	2.32	2.42	3.72	0.0172	2.34		
Site 6: Terminal 4	mg/kg	mg/l	0.0156	6.20	6.18	6.15	6.13	6.12	0.0060	0.0065	0.0038	0.0026	3.01	2.98	3.21	3.37	6.15	0.0044	3.14	10th %-tile	3.01
Site 8: BP-Arco	mg/kg	mg/l	0.0071	4.00 JT	3.99	3.99	3.99	3.98	0.0014	0.0008	0.0007	0.0010	3.46	3.70	3.76	3.60	3.99	0.0009	3.63		
Site 11: Mar Com Marine	mg/kg	mg/l	0.0135	2.40	2.38	2.37	2.37	2.37	0.0051	0.0025 T	0.0006 T	0.0005 T	2.67	2.98	3.60	3.72	2.37	0.0014	3.24	Mean	3.25
Site 13: Willamette Cove	mg/kg	mg/l	0.0290	5.10	5.09	5.08	5.07	5.04	0.0028 T	0.0021 T	0.0016 T	0.0094 JT	3.26	3.39	3.50	2.73	5.07	0.0030	3.22		
Site 17: Cascade General	mg/kg	mg/l	0.0119	3.10	3.09	3.09	3.07	3.06	0.0024 T	0.0012 T	0.0030 T	0.0023 T	3.11	3.43	3.01	3.12	3.08	0.0021	3.17	90th %-tile	3.65
Site 17: Swan Is. Lagoon	mg/kg	mg/l	0.0167	3.00	3.00	2.99	2.99	2.99	0.0010 T	0.0011 T	0.0007 T	0.0010 T	3.48	3.45	3.63	3.50	2.99	0.0009	3.51		
Site 19: Gunderson	mg/kg	mg/l	0.0170	5.60	5.60	5.59	5.59	5.59	0.0009 T	0.0011	0.0006	0.0007	3.79	3.71	3.97	3.90	5.59	0.0008	3.84	Max	3.84
Site 20: Fireboat Cove	mg/kg	mg/l	0.0102	2.75 T	2.74	2.73	2.73	2.73	0.0017 T	0.0027 T	0.0010 T	0.0007 T	3.21	3.01	3.46	3.59	2.73	0.0013	3.32		
Site 9: Gasco	mg/kg	mg/l	0.1060	2.70 J	2.70	2.69	2.68	2.67	0.0012 T	0.0018	0.0020	0.0018	3.35	3.17	3.13	3.17	2.68	0.0017	3.21		
Site 14: Arkema	mg/kg	mg/l	0.0199	3.70	3.69	3.68	3.66	3.63	0.0024	0.0030 T	0.0049 T	0.0068 T	3.19	3.09	2.88	2.73	3.66	0.0039	2.97		
Copper																					
Site 1: Evraz Oregon Steel	mg/kg	mg/l	0.0112	16.6 JT	16.4	16.4	16.4	16.4	0.0392 T	0.0037 T	0.0022 T	0.0048 T	2.62	3.65	3.88	3.53	16.42	0.0062	3.42	Min	3.42
Site 3: Schnitzer	mg/kg	mg/l	0.0151	33.6 J	33.5	33.5	33.5	33.5	0.0145	0.0110	0.0073	0.0044 T	3.36	3.48	3.66	3.88	33.49	0.0085	3.60		
Site 6: Terminal 4	mg/kg	mg/l	0.0156	48.9	48.83	48.72	48.70	48.69	0.0170	0.0271	0.0051	0.0023	3.46	3.25	3.98	4.33	48.74	0.0086	3.75	10th %-tile	3.58
Site 8: BP-Arco	mg/kg	mg/l	0.0071	121.0 JT	121.0	121.0	121.0	120.9	0.0035	0.0032	0.0030	0.0036	4.54	4.58	4.61	4.53	120.97	0.0033	4.56		
Site 11: Mar Com Marine	mg/kg	mg/l	0.0135	20.8 J	20.8	20.8	20.8	20.8	0.0025 U	0.0030 T	0.0016 T	0.0019 T	> 4.22	3.84	4.13	4.05	20.78	0.0018	4.06	Mean	3.95
Site 13: Willamette Cove	mg/kg	mg/l	0.0290	67.6 J	67.6	67.6	67.6	67.2	0.0026 T	0.0026 T	0.0030 T	0.0909 T	4.41	4.41	4.35	2.87	67.48	0.0066	4.01		
Site 17: Cascade General	mg/kg	mg/l	0.0119	67.8 J	67.8	67.7	67.7	67.7	0.0120 T	0.0041 T	0.0020 T	0.0019 T	3.75	4.22	4.53	4.56	67.73	0.0037	4.27	90th %-tile	4.30
Site 17: Swan Is. Lagoon	mg/kg	mg/l	0.0167	14.5 J	14.5	14.5	14.4	14.4	0.0028 T	0.0017 T	0.0134 JT	0.0023 T	3.72	3.93	3.03	3.81	14.45	0.0034	3.62		
Site 19: Gunderson	mg/kg	mg/l	0.0170	50.6	50.6	50.6	50.6	50.5	0.0036 T	0.0035	0.0033	0.0028	4.15	4.16	4.19	4.26	50.57	0.0033	4.19	Max	4.56
Site 20: Fireboat Cove	mg/kg	mg/l	0.0102	28.7 T	28.7	28.7	28.7	28.7	0.0034 T	0.0012 T	0.0042 T	0.0023 T	3.93	4.38	3.83	4.10	28.67	0.0025	4.06		
Site 9: Gasco	mg/kg	mg/l	0.1060	33.6 J	33.6	33.6	33.6	33.5	0.0025 T	0.0029	0.0069	0.0046	4.13	4.06	3.69	3.86	33.56	0.0039	3.94		
Site 14: Arkema	mg/kg	mg/l	0.0199	70.4	70.4	70.4	70.4	70.3	0.0014	0.0030 T	0.0068 T	0.0063 T	4.70	4.38	4.01	4.05	70.37	0.0036	4.29		
Mercury																					
Site 1: Evraz Oregon Steel	mg/kg	mg/l	0.0112	0.06 T	0.06	0.06	0.06	0.06	0.0001 UT	0.0001 UT	0.0001 UT	0.0001 UT	NC	NC	NC	NC	0.06	0.0001	NC	Min	ID
Site 3: Schnitzer	mg/kg	mg/l	0.0151	0.18	0.18	0.18	0.18	0.18	0.0001 U	0.0001 U	0.0001 U	0.0001 UT	NC	NC	NC	NC	0.18	0.0001	NC		
Site 6: Terminal 4	mg/kg	mg/l	0.0156	0.08	0.08	0.08	0.08	0.08	0.0001 U	0.0001 U	0.0001 U	0.0001 U	NC	NC	NC	NC	0.08	0.0001	NC	10th %-tile	ID
Site 8: BP-Arco	mg/kg	mg/l	0.0071	0.09 T	0.09	0.09	0.09	0.09	0.0001 U	0.0001 U	0.0001 U	0.0001 U	NC	NC	NC	NC	0.09	0.0001	NC		
Site 11: Mar Com Marine	mg/kg	mg/l	0.0135	0.06	0.06	0.06	0.06	0.06	0.0001 U	0.0001 UT	0.0001 UT	0.0001 UT	NC	NC	NC	NC	0.06	0.0001	NC	Mean	ID
Site 13: Willamette Cove	mg/kg	mg/l	0.0290	0.98	0.98	0.98	0.98	0.97	0.0001 UT	0.0001 UT	0.0001 UT	0.0017 JT	> 4.29	> 4.29	> 4.29	2.75	0.98	0.0001	3.91		
Site 17: Cascade General	mg/kg	mg/l	0.0119	0.06	0.06	0.06	0.06	0.06	0.0001 UT	0.0001 UT	0.0001 UT	0.0001 UT	NC	NC	NC	NC	0.06	0.0001	NC	90th %-tile	ID
Site 17: Swan Is. Lagoon	mg/kg	mg/l	0.0167	0.15	0.15	0.15	0.15	0.15	0.0001 UT	0.0001 UT	0.0001 UT	0.0001 UT	NC	NC	NC	NC	0.15	0.0001	NC		
Site 19: Gunderson	mg/kg	mg/l	0.0170	0.54	0.54	0.54	0.54	0.54	0.0001 UT	0.0001 U	0.0001 U	0.0001 U	NC	NC	NC	NC	0.54	0.0001	NC	Max	ID
Site 20: Fireboat Cove	mg/kg	mg/l	0.0102	0.11 T	0.11	0.11	0.11	0.11	0.0001 UT	0.0001 UT	0.0001 UT	0.0001 UT	NC	NC	NC	NC	0.11	0.0001	NC		
Site 9: Gasco	mg/kg	mg/l	0.1060	0.19	0.19	0.19	0.19	0.19	0.0001 UT	0.0001 U	0.0001 U	0.0001 U	NC	NC	NC	NC	0.19	0.0001	NC		
Site 14: Arkema	mg/kg	mg/l	0.0199	0.41	0.41	0.41	0.41	0.41	0.0001 U	0.0001 UT	0.0001 UT	0.0001 UT	NC	NC	NC	NC	0.41	0.0001	NC		

Table 1-1
Summary of Bulk Sediment and Leachate Results, AOPC and Harbor-Wide Partitioning Coefficients

				Bulk Sediment Concentrations					SBLT Leachate Concentrations				LOG Kd/Koc (L/kg) [1][2]				AOPC Summary Statistics [3]			Harbor-Wide LOG Kd/Koc Summary Stats [5]	
	Sediment Unit	Leachate Unit	Fraction TOC	Initial Concentration	Cycle 1	Cycle 2	Cycle 3	Cycle 4	Cycle 1	Cycle 2	Cycle 3	Cycle 4	Cycle 1	Cycle 2	Cycle 3	Cycle 4	GeoMean Sediment[4]	GeoMean Leachate[4]	Average LOG Kd/Koc		
Benzo(a)pyrene																					
Site 1: Evraz Oregon Steel	ug/kg	ug/l	0.0112	100	100	100	99	99	0.055 J	0.055	0.041	0.053	5.21	5.21	5.34	5.22	8,882	0.051	5.24	Min	4.42
Site 3: Schnitzer	ug/kg	ug/l	0.0151	460	459	458	456	455	0.180	0.410	0.410	0.220	5.23	4.87	4.87	5.14	30,265	0.286	5.03		
Site 6: Terminal 4	ug/kg	ug/l	0.0156	7,900	7,899.60	7,899.20	7,898.80	7,898.40	0.100 UJ	0.100 UJ	0.100 UJ	0.100 UJ	> 7.01	> 7.01	> 7.01	> 7.01	506,378	0.050	7.01	10th %-tile	4.72
Site 8: BP-Arco	ug/kg	ug/l	0.0071	450	444	440	439	438	1.600	0.820	0.370	0.220	4.59	4.88	5.22	5.45	61,996	0.572	5.04		
Site 11: Mar Com Marine	ug/kg	ug/l	0.0135	240 J	238	237	237	234	0.480	0.220	0.160	0.550 J	4.57	4.90	5.04	4.50	17,522	0.310	4.75	Mean	5.18
Site 13: Willamette Cove	ug/kg	ug/l	0.0290	200 J	194	193	193	192	1.500	0.170	0.073	0.220	3.65	4.59	4.96	4.48	6,659	0.253	4.42		
Site 17: Cascade General	ug/kg	ug/l	0.0119	70	70	69	69	69	0.087	0.045	0.030	0.020	4.83	5.11	5.29	5.46	5,835	0.039	5.17	90th %-tile	5.48
Site 17: Swan Is. Lagoon	ug/kg	ug/l	0.0167	74	74	73	73	73	0.044	0.090	0.085	0.019 J	5.00	4.69	4.71	5.36	4,393	0.050	4.94		
Site 19: Gunderson	ug/kg	ug/l	0.0170	72 J	72	71	71	71	0.075	0.089	0.031	0.028	4.75	4.67	5.13	5.17	4,197	0.049	4.93	Max	7.01
Site 20: Fireboat Cove	ug/kg	ug/l	0.0102	290	289	288	288	287	0.140 J	0.320	0.058	0.140	5.31	4.95	5.69	5.30	28,257	0.138	5.31		
Site 9: Gasco	ug/kg	ug/l	0.1060	200,000	199,970	199,746	199,482	198,202	7.4	56.0	66.0 J	320.0	5.41	4.53	4.46	3.77	1,880,653	54.391	4.54		
Site 14: Arkema	ug/kg	ug/l	0.0199	800 J	800	799	796	794	0.051	0.095	0.730	0.670	5.90	5.63	4.74	4.77	40,069	0.221	5.26		
Naphthalene																					
Site 1: Evraz Oregon Steel	ug/kg	ug/l	0.0112	11	11	10	10	10	0.051 J	0.080	0.037 U	0.069	4.28	4.07	> 4.70	4.12	933	0.048	4.29	Min	4.22
Site 3: Schnitzer	ug/kg	ug/l	0.0151	150	150	150	150	150	0.013 U	0.010 U	0.038	0.046	> 6.18	> 6.30	5.42	5.33	9,923	0.015	5.81		
Site 6: Terminal 4	ug/kg	ug/l	0.0156	250	249.60	249.20	248.80	248.40	0.100 U	0.100 U	0.100 U	0.100 U	> 5.51	> 5.51	> 5.50	> 5.50	15,994	0.050	5.50	10th %-tile	4.26
Site 8: BP-Arco	ug/kg	ug/l	0.0071	27	27	27	27	27	0.032	0.021 U	0.017 U	0.011 U	5.07	> 5.56	> 5.65	> 5.84	3,777	0.011	5.53		
Site 11: Mar Com Marine	ug/kg	ug/l	0.0135	73	72	70	EX	EX	0.150	0.530	52.000	0.150 J	4.55	3.99	EX	EX	5,284	0.228	4.27	Mean	4.97
Site 13: Willamette Cove	ug/kg	ug/l	0.0290	240 J	239	239	238	238	0.220	0.140	0.080	0.087	4.57	4.77	5.01	4.97	8,223	0.121	4.83		
Site 17: Cascade General	ug/kg	ug/l	0.0119	6	6	6	6	5	0.094 U	0.036	0.031 U	0.057 U	> 4.03	4.14	> 4.50	> 4.22	491	0.029	4.22	90th %-tile	5.58
Site 17: Swan Is. Lagoon	ug/kg	ug/l	0.0167	35	35	35	34	34	0.052 U	0.069 U	0.030 U	0.034 U	NC	NC	NC	NC	2,081	0.022	NC		
Site 19: Gunderson	ug/kg	ug/l	0.0170	36	36	36	36	35	0.018	0.012	0.021	0.120	5.07	5.25	5.00	4.24	2,102	0.027	4.89	Max	5.81
Site 20: Fireboat Cove	ug/kg	ug/l	0.0102	65	65	64	64	64	0.071	0.086	0.012 U	0.022 U	4.95	4.87	> 6.02	> 5.76	6,317	0.025	5.40		
Site 9: Gasco	ug/kg	ug/l	0.1060	3,200,000	3,165,200	3,154,400	3,128,000	3,080,000	8,700	2,700	6,600 J	12,000	3.54	4.04	3.65	3.38	29,544,591	6,567.530	3.65		
Site 14: Arkema	ug/kg	ug/l	0.0199	190	176	164	162	160	3.500	2.900	0.630	0.500	3.40	3.45	4.11	4.21	8,313	1.337	3.79		
Bis(2-ethylhexyl)phthalate																					
Site 1: Evraz Oregon Steel	ug/kg	ug/l	0.0112	21	ED	20	19	18	6.20 U	0.28 U	0.26 U	0.25 U	NC	NC	NC	NC	1,779	0.132	NC	Min	4.20
Site 3: Schnitzer	ug/kg	ug/l	0.0151	95	94	93	91	90	0.26	0.25 U	0.50	0.25 U	4.38	> 4.69	4.08	> 4.68	6,123	0.212	4.46		
Site 6: Terminal 4	ug/kg	ug/l	0.0156	92 U	ND	ND	ND	ND	0.42 U	0.70 U	0.61 U	1.20 U	ND	ND	ND	ND	2,747	0.341	ND	10th %-tile	4.30
Site 8: BP-Arco	ug/kg	ug/l	0.0071	20 U	ND	ND	EX	EX	1.00 UJ	0.50	5.70	0.85	ND	ND	ND	ND	976	0.597	ND		
Site 11: Mar Com Marine	ug/kg	ug/l	0.0135	36	35	31	30	26	0.25 U	1.00 UJ	0.25 U	1.00 U	NC	NC	NC	NC	2,460	0.250	NC	Mean	4.64
Site 13: Willamette Cove	ug/kg	ug/l	0.0290	70	69	68	67	64	0.26 U	0.29 U	0.25 U	0.79 U	NC	NC	NC	NC	2,358	0.175	NC		
Site 17: Cascade General	ug/kg	ug/l	0.0119	340	335	325	321	317	1.30 UJ	2.40	1.00 U	1.00 U	> 4.64	4.06	> 4.74	> 4.74	27,618	0.790	4.54	90th %-tile	5.08
Site 17: Swan Is. Lagoon	ug/kg	ug/l	0.0167	260	256	249	245	238	1.00 UJ	1.70 J	1.00 U	1.90 J	> 4.49	3.95	> 4.47	3.88	14,966	0.948	4.20		
Site 19: Gunderson	ug/kg	ug/l	0.0170	840	838	836	835	EX	0.54 U	0.37 U	0.25 U	44.00 J	> 5.26	> 5.43	> 5.60	EX	49,309	0.184	5.43	Max	5.43
Site 20: Fireboat Cove	ug/kg	ug/l	0.0102	280	269	264	260	259	2.70 J	1.40 J	1.00 U	0.27 U	3.99	4.27	> 4.71	> 5.28	25,867	0.711	4.56		
Site 9: Gasco	ug/kg	ug/l	0.1060	900 U	ND	ND	ND	ND	0.36	0.63	0.61	2.80	ND	ND	ND	ND	4,176	0.789	ND		
Site 14: Arkema	ug/kg	ug/l	0.0199	170	169	146	145	136	0.25 U	5.70 U	0.25 U	2.20	> 4.83	> 3.45	> 4.80	3.53	7,956	0.559	4.15		

Table 1-1
Summary of Bulk Sediment and Leachate Results, AOPC and Harbor-Wide Partitioning Coefficients

				Bulk Sediment Concentrations					SBLT Leachate Concentrations				LOG Kd/Koc (L/kg) [1][2]				AOPC Summary Statistics [3]			Harbor-Wide LOG Kd/Koc Summary Stats [5]	
	Sediment Unit	Leachate Unit	Fraction TOC	Initial Concentration	Cycle 1	Cycle 2	Cycle 3	Cycle 4	Cycle 1	Cycle 2	Cycle 3	Cycle 4	Cycle 1	Cycle 2	Cycle 3	Cycle 4	GeoMean Sediment[4]	GeoMean Leachate[4]	Average LOG Kd/Koc		
PCB077																					
Site 1: Evraz Oregon Steel	ng/kg	ng/l	0.0112	542	517	504	499	493	6.19	3.26	1.28	1.45	3.87	4.14	4.54	4.48	44,944	2.474	4.26	Min	4.15
Site 3: Schnitzer	ng/kg	ng/l	0.0151	1,600	1,598	1,585	1,579	1,574	0.40	3.32	1.41	1.36	5.42	4.50	4.87	4.88	104,916	1.262	4.92		
Site 8: BP-Arco	ng/kg	ng/l	0.0071	9 U	ND	ND	ND	ND	0.17	0.06	0.02 U	0.01 U	ND	ND	ND	ND	499	0.024	ND	10th %-tile	4.21
Site 11: Mar Com Marine	ng/kg	ng/l	0.0135	48	46	46	45	45	0.45	0.24	0.11	0.12	3.88	4.14	4.47	4.46	3,365	0.194	4.24		
Site 13: Willamette Cove	ng/kg	ng/l	0.0290	116 T	110	109	108	108	1.47	0.26 J	0.19	0.07 J	3.41	4.16	4.29	4.73	3,755	0.266	4.15	Mean	4.43
Site 17: Cascade General	ng/kg	ng/l	0.0119	54	50	49	49	49	1.04	0.28 T	0.05	0.04	3.61	4.16	4.88	4.98	4,121	0.161	4.41		
Site 17: Swan Is. Lagoon	ng/kg	ng/l	0.0167	170	166	162	162	161	0.90	1.01	0.21	0.11 T	4.05	3.98	4.67	4.94	9,752	0.380	4.41	90th %-tile	4.67
Site 19: Gunderson	ng/kg	ng/l	0.0170	7,770	7,612	7,535	7,516	7,492	39.40	19.30	4.73	5.96	4.06	4.36	4.97	4.87	443,467	12.100	4.56		
Site 20: Fireboat Cove	ng/kg	ng/l	0.0102	414	389	380	378	376	6.23	2.27	0.59	0.34	3.79	4.22	4.80	5.04	37,325	1.295	4.46	Max	4.92
Site 9: Gasco	ng/kg	ng/l	0.1060	207 J	207	205	204	203	0.02 U	0.40 J	0.39	0.29	> 5.35	3.69	3.69	3.82	1,931	0.140	4.14		
Site 14: Arkema	ng/kg	ng/l	0.0199	3,350	3,349	3,342	3,303	3,268	0.29 T	1.72	9.80	8.67	5.77	4.99	4.23	4.28	166,597	2.540	4.82		
PCB106 & 118																					
Site 1: Evraz Oregon Steel	ng/kg	ng/l	0.0112	3,190	2,981	2,874	2,832	2,792	52.30	26.70	10.40	10.20	3.71	3.98	4.39	4.39	256,147	19.618	4.12	Min	4.07
Site 3: Schnitzer	ng/kg	ng/l	0.0151	323,000	322,646	319,970	318,462	316,934	88.50	669.00	377.00	382.00	5.38	4.50	4.75	4.74	21,158,679	303.874	4.84		
Site 8: BP-Arco	ng/kg	ng/l	0.0071	157	150	147	146	146	1.85	0.67	0.19	0.06 U	4.06	4.49	5.04	> 5.84	20,731	0.288	4.86	10th %-tile	4.08
Site 11: Mar Com Marine	ng/kg	ng/l	0.0135	707	669	649	640	629	9.46	5.00	2.41	2.52	3.72	3.98	4.29	4.27	47,900	4.117	4.07		
Site 13: Willamette Cove	ng/kg	ng/l	0.0290	2,230 T	2,092	2,067	2,049	2,044	34.60	6.13 J	4.50	1.30	3.32	4.07	4.20	4.73	71,132	5.935	4.08	Mean	4.36
Site 17: Cascade General	ng/kg	ng/l	0.0119	2,180	1,939	1,866	1,853	1,844	60.30	18.30 T	3.18	2.15	3.43	3.93	4.69	4.86	157,565	9.320	4.23		
Site 17: Swan Is. Lagoon	ng/kg	ng/l	0.0167	2,690	2,590	2,454	2,431	2,416	24.90	34.00	5.84	3.75 T	3.79	3.64	4.40	4.59	148,025	11.669	4.10	90th %-tile	4.85
Site 19: Gunderson	ng/kg	ng/l	0.0170	43,800	42,884	42,472	42,354	42,203	229.00	103.00	29.50	37.80	4.04	4.38	4.93	4.82	2,498,673	71.614	4.54		
Site 20: Fireboat Cove	ng/kg	ng/l	0.0102	7,500	6,968	6,751	6,699	6,679	133.00	54.20	13.00	4.97	3.71	4.09	4.70	5.12	664,065	26.124	4.41	Max	4.86
Site 9: Gasco	ng/kg	ng/l	0.1060	2,070	2,069	2,058	2,031	2,018	0.36	2.56	6.93	3.17	4.74	3.88	3.44	3.78	19,281	2.118	3.96		
Site 14: Arkema	ng/kg	ng/l	0.0199	19,200	19,192	19,139	18,819	18,535	2.06 T	13.10	80.20	71.00	5.67	4.87	4.07	4.12	950,713	19.799	4.68		
PCB126																					
Site 1: Evraz Oregon Steel	ng/kg	ng/l	0.0112	23.2	22.2	21.7	21.5	21.0	0.246	0.129	0.052	0.121 U	3.91	4.18	4.57	> 4.50	1,934	0.100	4.29	Min	3.99
Site 3: Schnitzer	ng/kg	ng/l	0.0151	1,100.0	1,098.7	1,090.2	1,085.2	1,080.2	0.319	2.120	1.270	1.240	5.36	4.53	4.75	4.76	72,090	1.016	4.85		
Site 8: BP-Arco	ng/kg	ng/l	0.0071	9.8 U	ND	ND	ND	ND	0.081	0.024 U	0.016 U	0.012 U	ND	ND	ND	ND	639	0.015	ND	10th %-tile	4.11
Site 11: Mar Com Marine	ng/kg	ng/l	0.0135	5.5 J	5.2	5.1	5.0	5.0	0.087 U	0.025 U	0.014 U	0.018 U	NC	NC	NC	NC	393	0.014	NC		
Site 13: Willamette Cove	ng/kg	ng/l	0.0290	12.0 JT	11.2	11.0	10.9	10.8	0.212 U	0.031 J	0.024 U	0.023 U	> 3.58	4.11	> 4.51	> 4.53	395	0.026	4.18	Mean	4.36
Site 17: Cascade General	ng/kg	ng/l	0.0119	10.0 J	9.1	8.8	8.8	8.7	0.219	0.074 JT	0.014 J	0.010 U	3.54	4.00	4.73	> 5.19	745	0.032	4.37		
Site 17: Swan Is. Lagoon	ng/kg	ng/l	0.0167	15.7	14.8	14.0	13.8	13.7	0.216	0.216	0.038	0.031 T	3.61	3.59	4.34	4.43	843	0.086	3.99	90th %-tile	4.61
Site 19: Gunderson	ng/kg	ng/l	0.0170	198.0	193.2	190.9	190.3	189.3	1.210	0.562	0.157	0.234	3.97	4.30	4.85	4.68	11,231	0.398	4.45		
Site 20: Fireboat Cove	ng/kg	ng/l	0.0102	45.3	43.0	42.1	41.8	41.5	0.577	0.222	0.066	0.096	3.86	4.27	4.79	4.62	4,127	0.169	4.39	Max	4.85
Site 9: Gasco	ng/kg	ng/l	0.1060	74.6 U	ND	ND	ND	ND	0.009 U	0.282 J	0.100 U	0.125 U	ND	ND	ND	ND	342	0.045	ND		
Site 14: Arkema	ng/kg	ng/l	0.0199	119.0	118.9	118.7	117.1	115.6	0.014 JT	0.072	0.398	0.371	5.62	4.92	4.17	4.19	5,907	0.111	4.73		

Table 1-1
Summary of Bulk Sediment and Leachate Results, AOPC and Harbor-Wide Partitioning Coefficients

				Bulk Sediment Concentrations					SBLT Leachate Concentrations				LOG Kd/Koc (L/kg) [1][2]				AOPC Summary Statistics [3]			Harbor-Wide LOG Kd/Koc Summary Stats [5]	
	Sediment Unit	Leachate Unit	Fraction TOC	Initial Concentration	Cycle 1	Cycle 2	Cycle 3	Cycle 4	Cycle 1	Cycle 2	Cycle 3	Cycle 4	Cycle 1	Cycle 2	Cycle 3	Cycle 4	GeoMean Sediment[4]	GeoMean Leachate[4]	Average LOG Kd/Koc		
PCB169																					
Site 1: Evraz Oregon Steel	ng/kg	ng/l	0.0112	2.4 U	ND	ND	ND	ND	0.019 U	0.009 U	0.012 U	0.055 U	ND	ND	ND	ND	98	0.009	ND	Min	ID
Site 3: Schnitzer	ng/kg	ng/l	0.0151	23.3 U	ND	ND	ND	ND	0.021 U	0.025 U	0.024 U	0.021 U	ND	ND	ND	ND	764	0.011	ND		
Site 8: BP-Arco	ng/kg	ng/l	0.0071	5.3 U	ND	ND	ND	ND	0.077	0.016 J	0.015 U	0.017 U	ND	ND	ND	ND	316	0.017	ND	10th %-tile	ID
Site 11: Mar Com Marine	ng/kg	ng/l	0.0135	2.9 U	ND	ND	ND	ND	0.075 U	0.059 U	0.015 U	0.011 U	ND	ND	ND	ND	88	0.015	ND		
Site 13: Willamette Cove	ng/kg	ng/l	0.0290	4.8 UT	ND	ND	ND	ND	0.087 U	0.021 UJ	0.016 U	0.012 U	ND	ND	ND	ND	75	0.012	ND	Mean	ID
Site 17: Cascade General	ng/kg	ng/l	0.0119	2.6 U	ND	ND	ND	ND	0.036 U	0.019 UT	0.005 U	0.012 U	ND	ND	ND	ND	100	0.007	ND		
Site 17: Swan Is. Lagoon	ng/kg	ng/l	0.0167	7.0 U	ND	ND	ND	ND	0.093 J	0.069 U	0.007 U	0.007 UT	ND	ND	ND	ND	181	0.014	ND	90th %-tile	ID
Site 19: Gunderson	ng/kg	ng/l	0.0170	22.7 U	ND	ND	ND	ND	0.119 U	0.036 U	0.016 U	0.031	ND	ND	ND	ND	648	0.023	ND		
Site 20: Fireboat Cove	ng/kg	ng/l	0.0102	10.1 U	ND	ND	ND	ND	0.032 U	0.035 U	0.021 U	0.089	ND	ND	ND	ND	472	0.023	ND	Max	ID
Site 9: Gasco	ng/kg	ng/l	0.1060	83.6 U	ND	ND	ND	ND	0.010 U	0.340 J	0.058 U	0.114 J	ND	ND	ND	ND	383	0.048	ND		
Site 14: Arkema	ng/kg	ng/l	0.0199	71.4 U	ND	ND	ND	ND	0.010 UT	0.020 U	0.103	0.063 UJ	ND	ND	ND	ND	1,779	0.020	ND		
Total PCBs Congeners																					
Site 1: Evraz Oregon Steel	ug/kg	ug/l	0.0112	185 T	172	165	163	160	3.31 JT	1.72 T	0.66 JT	0.72 JT	3.67	3.93	4.34	4.30	14,727	1.282	4.06	Min	3.91
Site 3: Schnitzer	ug/kg	ug/l	0.0151	4,962 T	4,956	4,914	4,890	4,867	1.50 JT	10.57 T	6.03 JT	5.74 T	5.34	4.49	4.73	4.75	324,956	4.840	4.83		
Site 8: BP-Arco	ug/kg	ug/l	0.0071	7 JT	7	6	6	6	0.10 JT	0.04 JT	0.01 JT	0.01 JT	3.96	4.40	4.87	5.17	910	0.023	4.60	10th %-tile	3.97
Site 11: Mar Com Marine	ug/kg	ug/l	0.0135	25 JT	23	22	22	21	0.48 JT	0.24 JT	0.12 JT	0.12 JT	3.55	3.84	4.14	4.12	1,632	0.199	3.91		
Site 13: Willamette Cove	ug/kg	ug/l	0.0290	86 T	79	78	77	77	1.65 JT	0.28 JT	0.21 JT	0.06 JT	3.22	3.99	4.10	4.63	2,681	0.279	3.98	Mean	4.28
Site 17: Cascade General	ug/kg	ug/l	0.0119	47 JT	41	39	39	39	1.53 JT	0.44 T	0.07 JT	0.05 JT	3.35	3.88	4.66	4.82	3,314	0.220	4.18		
Site 17: Swan Is. Lagoon	ug/kg	ug/l	0.0167	107 T	103	97	96	95	1.01 JT	1.46 JT	0.24 T	0.14 T	3.79	3.60	4.38	4.60	5,838	0.473	4.09	90th %-tile	4.64
Site 19: Gunderson	ug/kg	ug/l	0.0170	2,371 JT	2,318	2,298	2,292	2,286	13.12 JT	4.98 JT	1.48 JT	1.59 JT	4.02	4.43	4.96	4.93	135,212	3.520	4.58		
Site 20: Fireboat Cove	ug/kg	ug/l	0.0102	851 T	779	749	742	740	17.88 JT	7.56 JT	1.66 JT	0.65 T	3.63	3.99	4.64	5.04	73,760	3.483	4.33	Max	4.83
Site 9: Gasco	ug/kg	ug/l	0.1060	95 JT	95	94	93	93	0.01 JT	0.11 JT	0.21 JT	0.13 JT	5.04	3.89	3.62	3.81	884	0.072	4.09		
Site 14: Arkema	ug/kg	ug/l	0.0199	1,013 JT	1,013	1,010	995	982	0.15 T	0.69 T	3.77 JT	3.27 JT	5.53	4.87	4.12	4.18	50,246	1.063	4.67		
Total Aroclors																					
Site 1: Evraz Oregon Steel	ug/kg	ug/l	0.0112	109	106	104	103	102	0.64	0.50	0.26	0.22	4.17	4.27	4.55	4.61	9,279	0.366	4.40	Min	4.32
Site 3: Schnitzer	ug/kg	ug/l	0.0151	4,520	4,510	4,488	4,462	4,453	2.56	5.48	6.45	2.22	5.07	4.73	4.66	5.12	296,567	3.763	4.90		
Site 6: Terminal 4	ug/kg	ug/l	0.0156	46	--	45.13	--	44.97	--	0.19	--	0.04	--	4.18	--	4.85	2,888	0.089	4.51	10th %-tile	4.37
Site 8: BP-Arco	ug/kg	ug/l	0.0071	10 UN	ND	ND	ND	ND	0.04	0.01 UN	0.01 UN	0.01 UN	ND	ND	ND	ND	661	0.009	ND		
Site 11: Mar Com Marine	ug/kg	ug/l	0.0135	10 UN	ND	ND	ND	ND	0.13	0.07	0.05	0.05	ND	ND	ND	ND	292	0.070	ND	Mean	4.55
Site 13: Willamette Cove	ug/kg	ug/l	0.0290	77	76	75	75	75	0.27	0.20	0.08	0.04 UN	3.99	4.11	4.52	> 5.11	2,588	0.095	4.44		
Site 17: Cascade General	ug/kg	ug/l	0.0119	50	49	48	48	48	0.30	0.17	0.04	0.04	4.14	4.39	5.06	5.06	4,039	0.088	4.66	90th %-tile	4.81
Site 17: Swan Is. Lagoon	ug/kg	ug/l	0.0167	69	68	66	66	65	0.22	0.39	0.10	0.08	4.26	4.01	4.60	4.68	3,967	0.163	4.39		
Site 19: Gunderson	ug/kg	ug/l	0.0170	1,358	1,348	1,341	1,336	1,334	2.52	1.66	1.28	0.56	4.50	4.68	4.79	5.15	78,812	1.315	4.78	Max	4.90
Site 20: Fireboat Cove	ug/kg	ug/l	0.0102	281	274	254	250	249	1.51	5.00	1.01	0.27	4.25	3.70	4.39	4.96	25,194	1.192	4.32		
Site 9: Gasco	ug/kg	ug/l	0.1060	120 UN	ND	ND	ND	ND	0.03 UN	0.05	0.10 UN	0.12	ND	ND	ND	ND	562	0.044	ND		
Site 14: Arkema	ug/kg	ug/l	0.0199	990 UN	ND	ND	ND	ND	0.90 UN	5.00 UN	15.00 UN	10.00 UN	ND	ND	ND	ND	23,371	2.549	ND		

Table 1-1
Summary of Bulk Sediment and Leachate Results, AOPC and Harbor-Wide Partitioning Coefficients

				Bulk Sediment Concentrations					SBLT Leachate Concentrations				LOG Kd/Koc (L/kg) [1][2]				AOPC Summary Statistics [3]			Harbor-Wide LOG Kd/Koc Summary Stats [5]	
	Sediment Unit	Leachate Unit	Fraction TOC	Initial Concentration	Cycle 1	Cycle 2	Cycle 3	Cycle 4	Cycle 1	Cycle 2	Cycle 3	Cycle 4	Cycle 1	Cycle 2	Cycle 3	Cycle 4	GeoMean Sediment[4]	GeoMean Leachate[4]	Average LOG Kd/Koc		
4,4'-DDD																					
Site 1: Evraz Oregon Steel	ug/kg	ug/l	0.0112	1.9 U	ND	ND	ND	ND	0.010 U	0.010 U	0.010 U	0.010 U	ND	ND	ND	ND	80	0.005	ND	Min	4.29
Site 3: Schnitzer	ug/kg	ug/l	0.0151	10.0 U	ND	ND	ND	ND	0.010 U	0.010 U	0.010 U	0.010 U	ND	ND	ND	ND	328	0.005	ND		
Site 6: Terminal 4	ug/kg	ug/l	0.0156	23.0 UJ	--	--	ND	--	--	--	0.004 J	--	--	--	ND	--	736	0.004	ND	10th %-tile	4.40
Site 8: BP-Arco	ug/kg	ug/l	0.0071	2.0 U	ND	ND	ND	ND	0.010 UJ	0.010 U	0.011 U	0.010 U	ND	ND	ND	ND	134	0.005	ND		
Site 11: Mar Com Marine	ug/kg	ug/l	0.0135	1.9 U	ND	ND	ND	ND	0.032 J	0.010 U	0.010 U	0.010 U	ND	ND	ND	ND	59	0.008	ND	Mean	5.11
Site 13: Willamette Cove	ug/kg	ug/l	0.0290	8.5 J	8.3	8.2	8.1	8.1	0.054 J	0.031 J	0.010 U	0.010 U	3.72	3.96	> 4.75	> 4.75	282	0.014	4.29		
Site 17: Cascade General	ug/kg	ug/l	0.0119	2.0 U	ND	ND	ND	ND	0.010 UJ	0.010 U	0.010 U	0.010 U	ND	ND	ND	ND	80	0.005	ND	90th %-tile	5.94
Site 17: Swan Is. Lagoon	ug/kg	ug/l	0.0167	1.9 U	ND	ND	ND	ND	0.011 U	0.010 U	0.010 U	0.010 U	ND	ND	ND	ND	54	0.005	ND		
Site 19: Gunderson	ug/kg	ug/l	0.0170	78.0 NJ	77.4	76.9	76.7	76.6	0.160 J	0.120	0.049	0.025	4.45	4.58	4.96	5.26	4,522	0.070	4.81	Max	6.22
Site 20: Fireboat Cove	ug/kg	ug/l	0.0102	85.0 J	85.0	84.9	84.9	84.8	0.010 U	0.010 U	0.010 U	0.010 U	> 6.22	> 6.22	> 6.22	> 6.22	8,328	0.005	6.22		
Site 9: Gasco	ug/kg	ug/l	0.1060	99.0 U	ND	ND	ND	ND	0.010 UJ	0.010 UJ	0.100 UJ	0.010 UJ	ND	ND	ND	ND	466	0.009	ND		
Site 14: Arkema	ug/kg	ug/l	0.0199	16,000	15,981	15,845	15,489	15,089	4.7	34.0	89.0	100.0	5.23	4.37	3.94	3.88	783,786	34.534	4.36		
4,4'-DDE																					
Site 1: Evraz Oregon Steel	ug/kg	ug/l	0.0112	1.9 U	ND	ND	ND	ND	0.010 U	0.010 U	0.010 U	0.010 U	ND	ND	ND	ND	80	0.005	ND	Min	4.59
Site 3: Schnitzer	ug/kg	ug/l	0.0151	10.0 U	ND	ND	ND	ND	0.040 U	0.010 U	0.010 U	0.032 U	ND	ND	ND	ND	323	0.009	ND		
Site 6: Terminal 4	ug/kg	ug/l	0.0156	16.0 UJ	--	--	ND	--	--	--	0.006 J	--	--	--	ND	--	511	0.006	ND	10th %-tile	ID
Site 8: BP-Arco	ug/kg	ug/l	0.0071	2.0 U	ND	ND	ND	ND	0.010 UJ	0.010 U	0.011 U	0.010 U	ND	ND	ND	ND	134	0.005	ND		
Site 11: Mar Com Marine	ug/kg	ug/l	0.0135	1.9 U	ND	ND	ND	ND	0.010 U	0.010 U	0.010 U	0.010 U	ND	ND	ND	ND	67	0.005	ND	Mean	5.56
Site 13: Willamette Cove	ug/kg	ug/l	0.0290	4.9 U	ND	ND	ND	ND	0.028 U	0.015 U	0.010 U	0.010 U	ND	ND	ND	ND	81	0.007	ND		
Site 17: Cascade General	ug/kg	ug/l	0.0119	2.0 U	ND	ND	ND	ND	0.010 UJ	0.010 U	0.010 U	0.010 U	ND	ND	ND	ND	80	0.005	ND	90th %-tile	ID
Site 17: Swan Is. Lagoon	ug/kg	ug/l	0.0167	1.9 U	ND	ND	ND	ND	0.011 U	0.010 U	0.010 U	0.010 U	ND	ND	ND	ND	54	0.005	ND		
Site 19: Gunderson	ug/kg	ug/l	0.0170	150	147	145	145	145	0.770	0.410	0.110	0.068 J	4.05	4.32	4.89	5.10	8,553	0.220	4.59	Max	6.52
Site 20: Fireboat Cove	ug/kg	ug/l	0.0102	170.0	170.0	169.9	169.9	169.8	0.010 U	0.010 U	0.010 U	0.010 U	> 6.52	> 6.52	> 6.52	> 6.52	16,662	0.005	6.52		
Site 9: Gasco	ug/kg	ug/l	0.1060	99.0 U	ND	ND	ND	ND	0.010 UJ	0.078 UJ	0.100 UJ	0.054 UJ	ND	ND	ND	ND	464	0.023	ND		
Site 14: Arkema	ug/kg	ug/l	0.0199	2,000 U	ND	ND	ND	ND	0.10 U	1.00 U	5.00 U	5.00 U	ND	ND	ND	ND	49,787	0.629	ND		
4,4'-DDT																					
Site 1: Evraz Oregon Steel	ug/kg	ug/l	0.0112	6.1 U	ND	ND	ND	ND	0.010 U	0.010 U	0.010 U	0.010 U	ND	ND	ND	ND	268	0.005	ND	Min	4.24
Site 3: Schnitzer	ug/kg	ug/l	0.0151	10.0 U	ND	ND	ND	ND	0.054 U	0.010 U	0.010 U	0.044 U	ND	ND	ND	ND	321	0.011	ND		
Site 6: Terminal 4	ug/kg	ug/l	0.0156	20.0 UJ	--	--	ND	--	--	--	0.003 UJ	--	--	--	ND	--	641	0.001	ND	10th %-tile	ID
Site 8: BP-Arco	ug/kg	ug/l	0.0071	2.0 U	ND	ND	ND	ND	0.010 UJ	0.010 U	0.011 U	0.010 U	ND	ND	ND	ND	134	0.005	ND		
Site 11: Mar Com Marine	ug/kg	ug/l	0.0135	4.2	4.0	4.0	3.9	3.8	0.039 J	0.022 NJ	0.019 J	0.010 U	3.89	4.12	4.18	> 4.76	291	0.017	4.24	Mean	4.42
Site 13: Willamette Cove	ug/kg	ug/l	0.0290	5.8	5.8	5.7	5.7	5.6	0.010 U	0.010 U	0.010 U	0.010 U	> 4.60	> 4.60	> 4.60	> 4.60	198	0.005	4.60		
Site 17: Cascade General	ug/kg	ug/l	0.0119	2.0 U	ND	ND	ND	ND	0.010 UJ	0.010 U	0.010 U	0.010 U	ND	ND	ND	ND	80	0.005	ND	90th %-tile	ID
Site 17: Swan Is. Lagoon	ug/kg	ug/l	0.0167	1.9 U	ND	ND	ND	ND	0.011 U	0.010 U	0.010 U	0.010 UJ	ND	ND	ND	ND	54	0.005	ND		
Site 19: Gunderson	ug/kg	ug/l	0.0170	20.0 U	ND	ND	ND	ND	0.034 U	0.031 U	0.010 U	0.010 U	ND	ND	ND	ND	581	0.009	ND	Max	4.60
Site 20: Fireboat Cove	ug/kg	ug/l	0.0102	19.0 U	18.7	18.2	18.1	18.0	0.081 U	0.120 U	0.029 U	0.015 U	ND	ND	ND	ND	894	0.023	ND		
Site 9: Gasco	ug/kg	ug/l	0.1060	99.0 U	ND	ND	ND	ND	0.010 UJ	0.010 UJ	0.100 UJ	0.010 UJ	ND	ND	ND	ND	466	0.009	ND		
Site 14: Arkema	ug/kg	ug/l	0.0199	29,000	28,999	28,983	28,915	28,791	0.21 J	4.00	17.00	31.00	6.84	5.56	4.93	4.67	1,453,369	4.587	5.50		

Table 1-1
Summary of Bulk Sediment and Leachate Results, AOPC and Harbor-Wide Partitioning Coefficients

	Sediment Unit	Leachate Unit	Fraction TOC	Bulk Sediment Concentrations					SBLT Leachate Concentrations				LOG Kd/Koc (L/kg) [1][2]				AOPC Summary Statistics [3]			Harbor-Wide LOG Kd/Koc Summary Stats [5]	
				Initial Concentration	Cycle 1	Cycle 2	Cycle 3	Cycle 4	Cycle 1	Cycle 2	Cycle 3	Cycle 4	Cycle 1	Cycle 2	Cycle 3	Cycle 4	GeoMean Sediment[4]	GeoMean Leachate[4]	Average LOG Kd/Koc		
Total DDx[6]																					
Site 1: Evraz Oregon Steel	ug/kg	ug/l	0.0112	6.1 UN	ND	ND	ND	ND	0.010 UN	0.010 UN	0.010 UN	0.010 UN	ND	ND	ND	ND	268	0.005	ND	Min	4.23
Site 3: Schnitzer	ug/kg	ug/l	0.0151	10.0 UN	ND	ND	ND	ND	0.054 UN	0.010 UN	0.010 UN	0.044 UN	ND	ND	ND	ND	321	0.011	ND		
Site 6: Terminal 4	ug/kg	ug/l	0.0156	23.0 UN	ND	ND	ND	ND	--	--	0.011	--	--	--	ND	--	734	0.011	ND	10th %-tile	4.32
Site 8: BP-Arco	ug/kg	ug/l	0.0071	2.0 UN	ND	ND	ND	ND	0.010 UN	0.010 UN	0.011 UN	0.010 UN	ND	ND	ND	ND	134	0.005	ND		
Site 11: Mar Com Marine	ug/kg	ug/l	0.0135	6.1	5.8	5.7	5.6	5.5	0.076	0.032	0.029	0.010 UN	3.75	4.12	4.15	> 4.91	417	0.024	4.23	Mean	4.87
Site 13: Willamette Cove	ug/kg	ug/l	0.0290	16.8	16.5	16.3	16.2	16.2	0.073	0.044	0.010 UN	0.010 UN	3.89	4.11	> 5.05	> 5.05	562	0.017	4.53		
Site 17: Cascade General	ug/kg	ug/l	0.0119	2.0 UN	ND	ND	ND	ND	0.010 UN	0.010 UN	0.010 UN	0.010 UN	ND	ND	ND	ND	80	0.005	ND	90th %-tile	5.64
Site 17: Swan Is. Lagoon	ug/kg	ug/l	0.0167	1.9 UN	ND	ND	ND	ND	0.011 UN	0.010 UN	0.010 UN	0.010 UN	ND	ND	ND	ND	54	0.005	ND		
Site 19: Gunderson	ug/kg	ug/l	0.0170	238.0	234.2	232.0	231.4	231.0	0.947	0.546	0.164	0.098	4.16	4.40	4.92	5.14	13,656	0.302	4.66	Max	6.06
Site 20: Fireboat Cove	ug/kg	ug/l	0.0102	264.5	264.2	263.7	263.6	263.5	0.081 UN	0.120 UN	0.029 UN	0.015 UN	> 5.81	> 5.64	> 6.25	> 6.54	25,894	0.023	6.06		
Site 9: Gasco	ug/kg	ug/l	0.1060	99.0 UN	ND	ND	ND	ND	0.010 UN	0.078 UN	0.100 UN	0.054 UN	ND	ND	ND	ND	464	0.023	ND		
Site 14: Arkema	ug/kg	ug/l	0.0199	46,000					4.96	38.05	108.50	133.50	5.67	4.78	4.32	4.23	2,287,107	40.662	4.75		

Notes:
[1] Partitioning of metals is expressed as Kd; Partitioning of organics is expressed as Koc.
[2] If leachate is not always detected, Kd/Koc values are based on 1/2 the detection limit for nondetects.
[3] GeoMean sediment concentrations are carbon normalized for organic compounds.
[4] GeoMean concentrations are based on 1/2 the detection limit for nondetects.
[5] Sites 9 and 14 are excluded from Harbor-wide summary statistics.
[6] Total DDx is defined as the sum of 4,4'-DDT, 4,4'-DDD, and 4,4'-DDE.

Outlier concentration excluded (EX) from Kd/Koc calculations due to mass balance violations and/or anomalous and unconfirmed leachate results
NC = Not calculated because chemical of concern is not detected in any leachate cycles
ND = Not calculated because chemical of concern is not detected in bulk sediment
ED = Not calculated because of elevated detection limit in leachate
ID = Insufficient data; less than 3 valid data pairs
> = Kd/Koc value may be higher than indicated due to undetected leachate concentrations

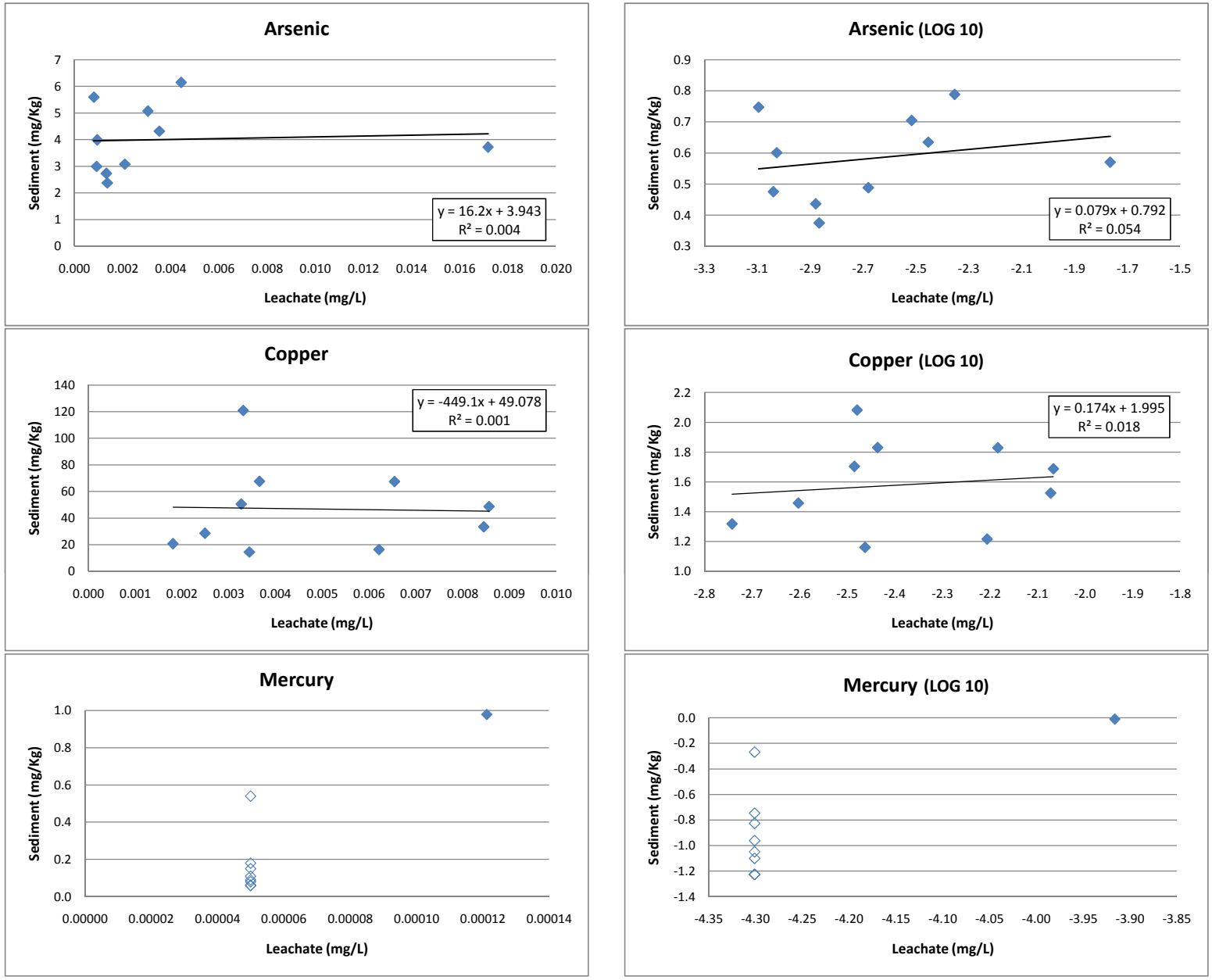
Table 1-2
Compilation of Log Partitioning Coefficients (Log Kd/Log Koc) for T4 CDF Confined Sediments and Berm

		LEACHING COEFFICIENTS FOR CONFINED SEDIMENTS [SBLT RESULTS]											PARTITIONING COEFFICIENTS FOR CDF BERM							
		Harbor-Wide Summary Statistics of Log Kd/Log Koc Values [Method 1]						Linear Isotherm Model [Method 3]		Freundlich Isotherm Model [Method 4]			Literature Values [RI Table E6]			LWG Water Column Data				
		Number Data Pairs	Min	10th Percentile	Mean	90th Percentile	Max	LOG Regression Slope	Regression Coefficient [r^2]	Freundlich Coefficient [K_f]	Freundlich Slope [1/n]	Regression Coefficient [r^2]	Min	Mean	Max	Number Data Pairs	Min	Mean	Max	St Dev
Arsenic	**Kd**	10	2.34	3.01	3.25	3.65	3.84	PC	0.004	PC	PC	0.054	1.6	2.4	4.3	74	3.39	4.34	4.85	0.23
Copper	**Kd**	10	3.42	3.58	3.95	4.30	4.56	PC	0.001	PC	PC	0.018	0.7	3.5	6.2	92	3.94	4.93	5.44	0.28
Mercury	**Kd**	1	Insufficient Data					Insufficient Data		Insufficient Data			3.8	4.9	6.0	Insufficient Data				
Benzo(a)pyrene	**Koc**	10	4.42	4.72	5.18	5.48	7.01	PC	-0.158	PC	PC	0.055	5.68	6.01	6.67	10	7.08	7.73	8.5	0.49
Naphthalene	**Koc**	9	4.22	4.26	4.97	5.58	5.81	PC	-0.763	PC	PC	0.019	3.12	3.30	3.53	3	4.93	5.31	5.79	0.44
Bis(2-ethylhexyl)phthalate	**Koc**	5	4.20	4.30	4.64	5.08	5.43	PC	-1.022	PC	PC	0.005	3.52	7.42	9.52	7	5.72	6.35	6.7	0.36
PCB-077	**Koc**	8	4.15	4.21	4.43	4.67	4.92	4.56	0.964	4.44	1.16	0.921	5.52	6.39	6.66	43	6.13	6.75	7.85	0.4
PCB-106 & 118	**Koc**	9	4.07	4.08	4.36	4.85	4.86	4.83	0.977	4.32	1.04	0.882	6.13	6.69	7.29	48	6.23	6.75	7.77	0.32
PCB-126	**Koc**	7	3.99	4.11	4.36	4.61	4.85	4.80	0.918	4.68	1.35	0.951	6.27	6.57	6.88	6	6.58	6.89	7.22	0.27
PCB-169	**Koc**	0	Insufficient Data					Insufficient Data		Insufficient Data			7.26	7.18	7.49	Insufficient Data				
Total PCB Congeners	**Koc**	9	3.91	3.97	4.28	4.64	4.83	4.67	0.777	4.31	1.12	0.888	Not Evaluated			Not Evaluated				
Total PCB Aroclors	**Koc**	8	4.32	4.37	4.55	4.81	4.90	4.86	0.931	4.62	1.16	0.943	5.96*	6.39*	7.59*	Not Evaluated				
4,4'-DDD	**Koc**	3	4.29	4.40	5.11	5.94	6.22	PC	-0.984	PC	PC	0.003	5.10	5.95	6.22	32	5.39	6.32	7.44	0.62
4,4'-DDE	**Koc**	2	4.59	ID	5.56	ID	6.52	Insufficient Data		Insufficient Data			4.81	6.78	6.84	53	5.72	6.60	7.36	0.31
4,4'-DDT	**Koc**	2	4.24	ID	4.42	ID	4.60	Insufficient Data		Insufficient Data			5.34	6.61	6.80	31	5.98	6.89	7.72	0.43
Total DDx	**Koc**	4	4.23	4.32	4.87	5.64	6.06	PC	-0.378	PC	PC	0.247	5.08**	6.44**	6.62**		5.69**	6.60**	7.51**	

Notes:
Partitioning coefficients for organics are carbon normalized (Koc); metals are not (Kd)
PC = Regression parameters not reported due to poor correlation
ID = Insufficient Data (less than 3 valid data pairs)
* Geometric mean of Aroclor-1254 and -1260
** Geometric mean of 4,4'-DDD, -DDE, and -DDT

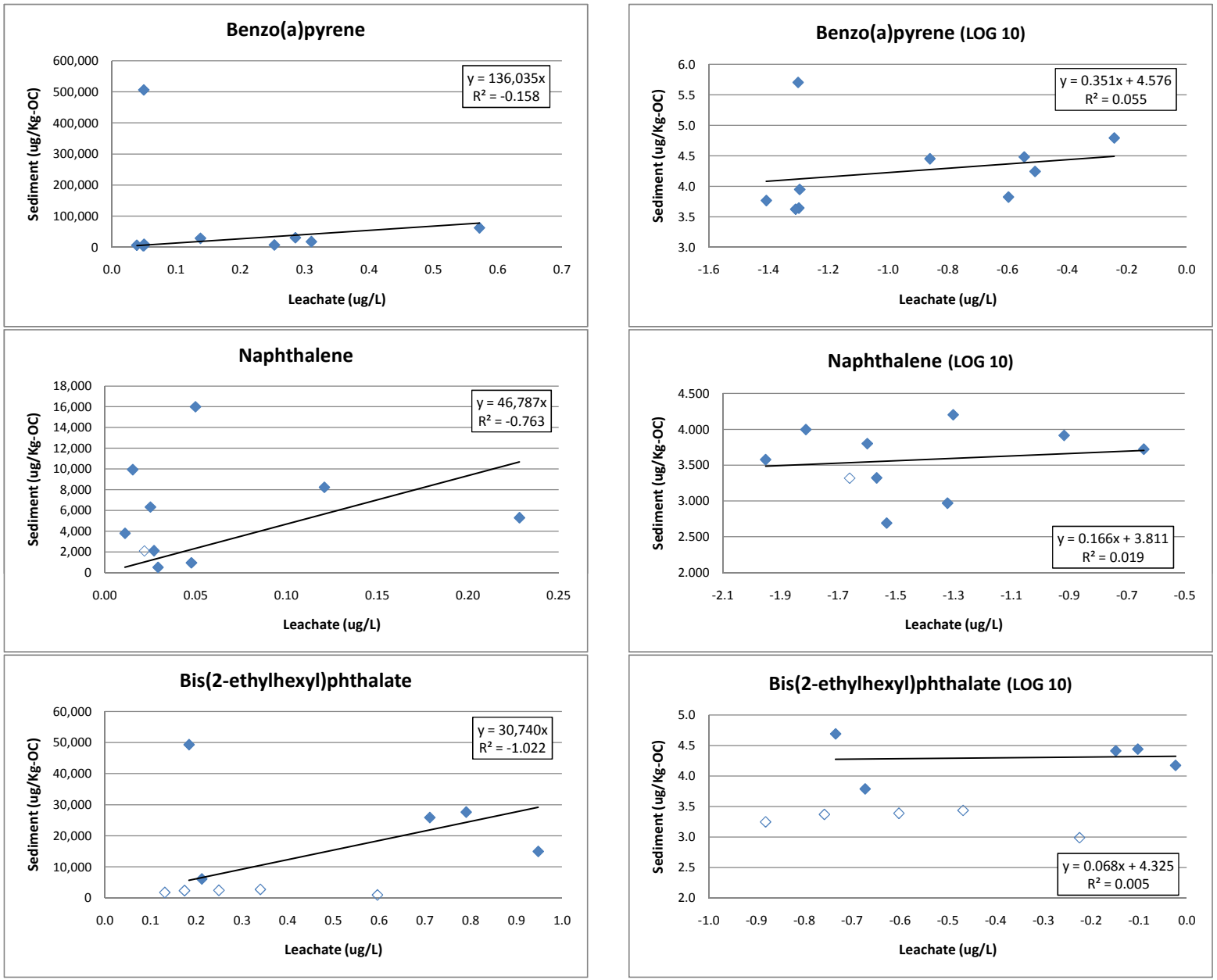
Recommended Log Kd/ Log Koc values for confined sediments
Recommended Log Kd/ Log Koc values for CDF berm

Figure 1-1
Linear and Log (Freundlich) Regressions of Harbor-Wide Partitioning Data



Key:
- Valid AOPC sediment-leachate data pair
- Invalid data pair excluded from regression model

Figure 1-1
Linear and Log (Freundlich) Regressions of Harbor-Wide Partitioning Data



Key:
- ◆ Valid AOPC sediment-leachate data pair
- ◇ Invalid data pair excluded from regression model

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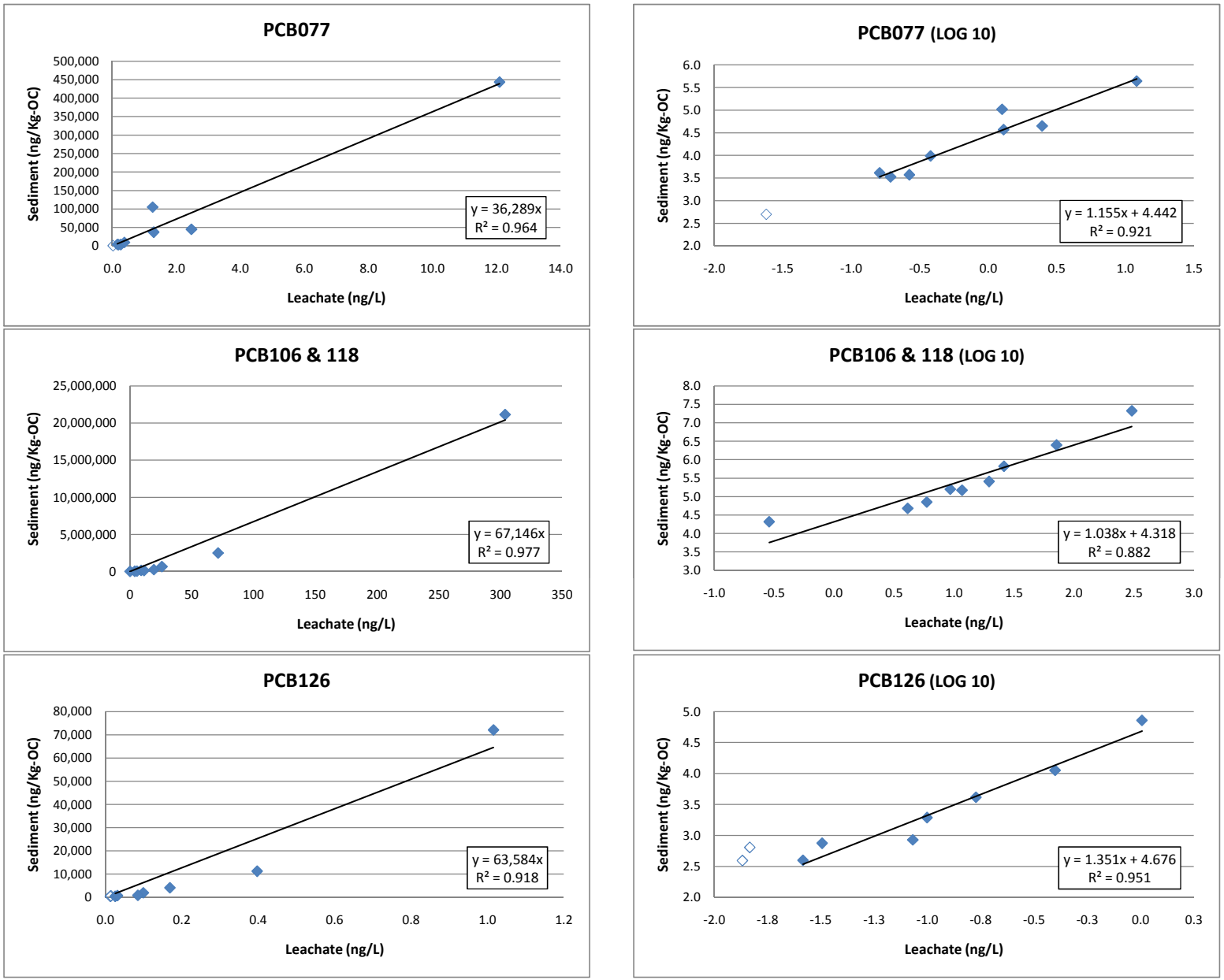
Linear and Log (Freundlich) Regressions of Harbor-Wide Partitioning Data



Key:
- ◆ Valid AOPC sediment-leachate data pair
- ◇ Invalid data pair excluded from regression model

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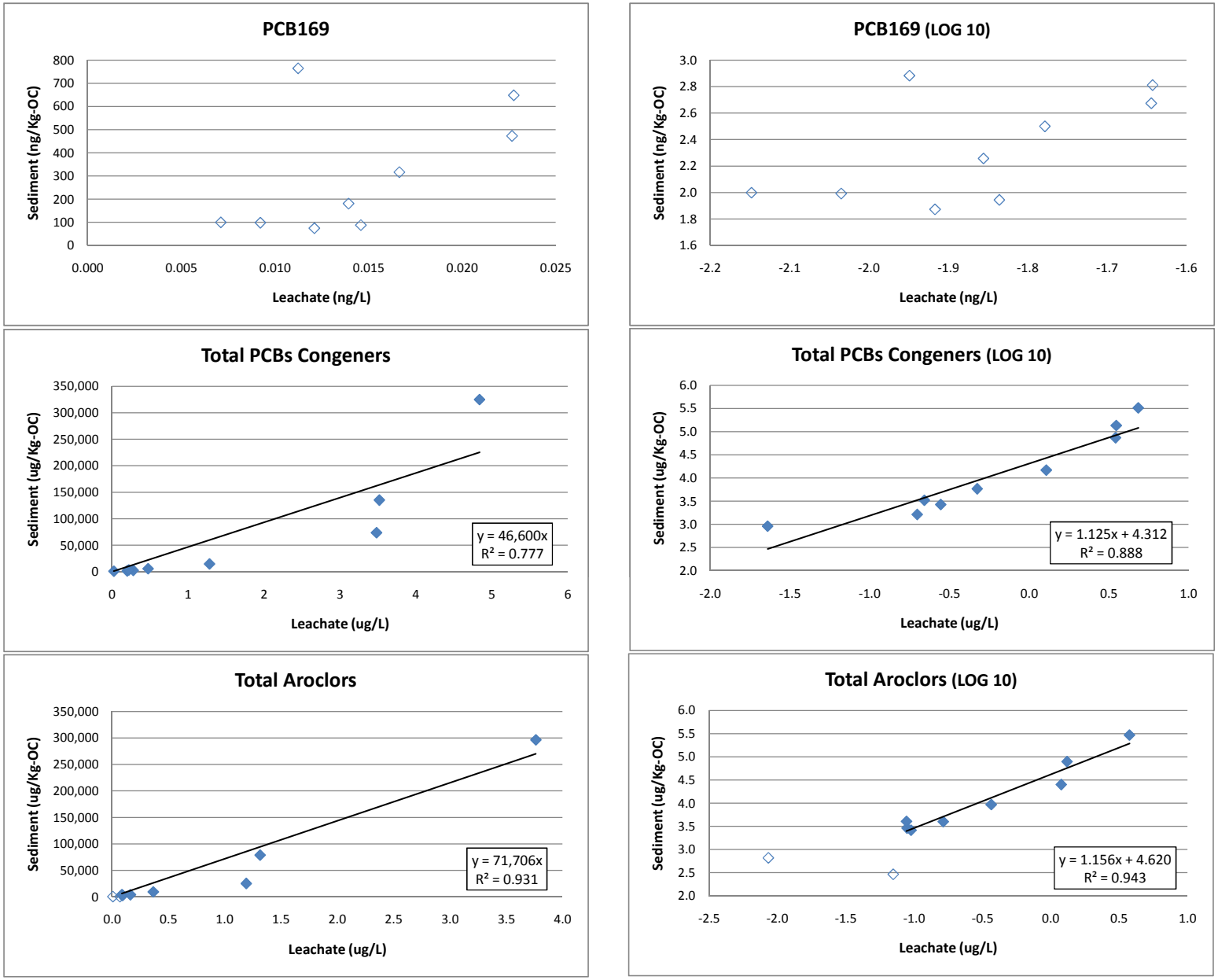
Linear and Log (Freundlich) Regressions of Harbor-Wide Partitioning Data



Key:
- ◆ Valid AOPC sediment-leachate data pair
- ◇ Invalid data pair excluded from regression model

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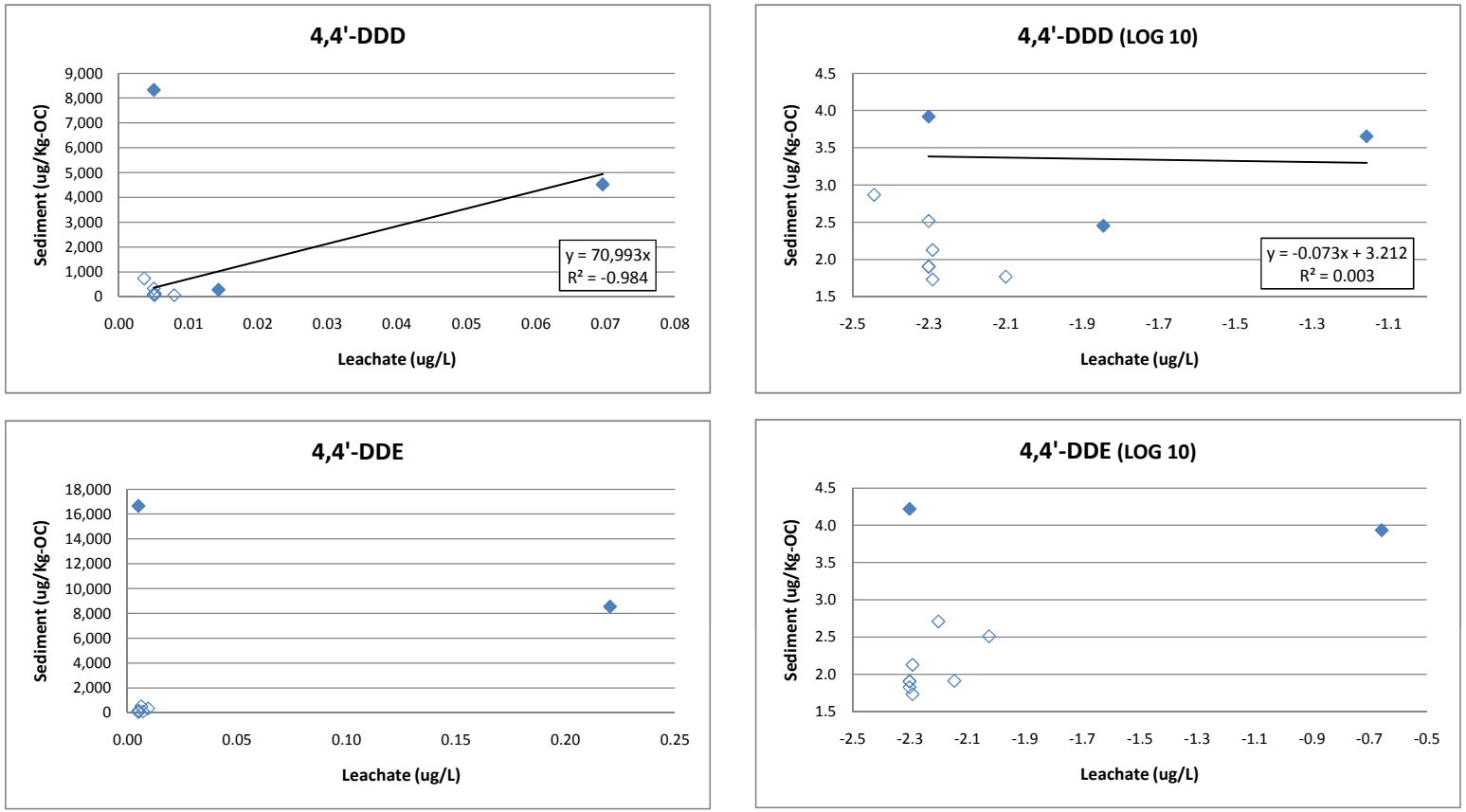

Key:
- ◆ Valid AOPC sediment-leachate data pair
- ◇ Invalid data pair excluded from regression model

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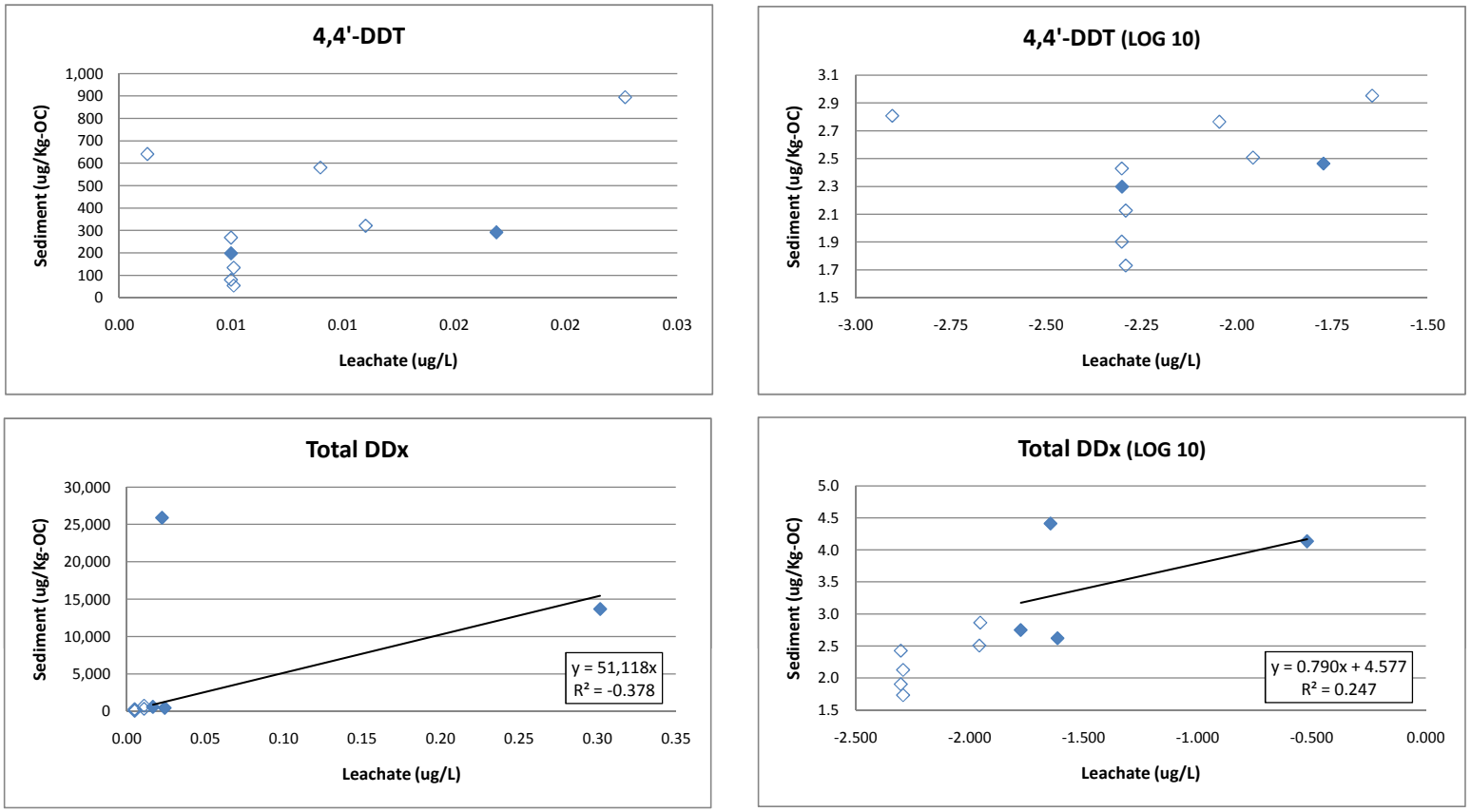
Linear and Log (Freundlich) Regressions of Harbor-Wide Partitioning Data



Key:
- ◆ Valid AOPC sediment-leachate data pair
- ◇ Invalid data pair excluded from regression model

ATTACHMENT 2

ANCHOR QEA

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TECHNICAL MEMORANDUM

To:	Kelly Madalinski and Krista Koehl, Port of Portland	**Date:**	May 19, 2010
From:	Todd Thornburg, Anchor QEA Pete Townsend, NewFields	**Project:**	050332-01
Re:	Response to EPA Comments on Groundwater Model Input Parameter Memorandum, Port of Portland Terminal 4 Confined Disposal Facility		

This memorandum provides responses to the U.S. Environmental Protection Agency's (EPA's) comments on the Port of Portland's (Port's) Groundwater Model Input Parameter Memorandum. The Memorandum was submitted to EPA on April 1, 2010, and EPA comments were subsequently received by the Port on April 19, 2010. EPA comments are reprinted below in *italicized* font, and Port responses follow in normal font.

Based on the responses in this memorandum, the Groundwater Model Input Parameter Memorandum will be updated and provided to EPA as an appendix to the Terminal 4 (T4) Confined Disposal Facility (CDF) 60 percent design report when that report is submitted.

GENERAL COMMENTS

1. Please identify the name and type of the base model in QEA-FATE, such as Modflow, a finite element model.

We will clarify that QEA-FATE is a finite difference code that simulates hydrodynamics, sediment transport, and contaminant fate and transport within a linked framework. It is based on EPA's EFDC code for hydrodynamics and transport in the water column, and also includes modeling of the sediment bed. The contaminant fate and transport code has its roots in another EPA-supported model, WASP. A finite difference approach is used to calculate transport processes within the bed (advection, diffusion, partitioning) much like a MODFLOW/MT3D model, but it also simulates bioturbation as well as changes in bed structure due to deposition and erosion. Further details on QEA-FATE model structure will be provided as part of the Portland Harbor Superfund Site Feasibility Study (FS).

2. *Please revise the memorandum to include a new section listing the key processes that the model incorporates in calculating future concentrations. What attenuation mechanisms are included for metals? for organics? Does the model conserve mass in the sediment? Does it consider ultimate sorption capacity in the berm organic fraction? EPA is not looking for an extensive treatise on modeling, but rather a short bullet list of items to aid in understanding how the input parameters are used.*

The memorandum will be revised as requested. The primary attenuation mechanisms in the berm are the same for both metals and organics; these include advection and dispersion, adsorption to matrix materials, mixing with regional groundwater and incident rainwater, and surface water intrusion. For organics, model scenarios will also be run with and without biodegradation. Conservation of mass is a fundamental model assumption. A linear adsorption isotherm is assumed.

3. *Please revise the memorandum to include a new section explaining how results will be presented. Where will results be calculated (berm face, mid berm)? Will berm and sediment bulk contaminant and groundwater isopleth concentrations be presented?*

The memorandum will be revised as requested. Groundwater concentrations will be modeled and presented at three observation points in the berm—one in the inner berm, one in the middle of the berm, and one at the point of discharge to the river. The primary graphical representation of model output will be a series of breakthrough curves of groundwater concentrations over time at these three observation points for the duration of the long-term modeling period. Groundwater isopleths (concentration distributions in berm cross-section) will be presented for a few critical model scenarios to illustrate the preferential transport pathways and geochemical gradients within the berm. The presentation of model output will be similar to that shown in the short-term groundwater modeling memorandum (NewFields 2007). Bulk sediment concentrations will not be mapped because they change very little over time.

4. *Per prior correspondence from the Port, EPA understands that the Port will manage the CDF filling events to ensure that no overflow or "weir" type discharge occurs. Please confirm.*

Yes, the Port will manage the CDF filling event to ensure that no weir overflow occurs.

SPECIFIC COMMENTS

5. *(Page 4) Metals: Please explain why cadmium and lead will be omitted from the modeling analysis.*

The main reason cadmium and lead are omitted from the modeling analysis is because the focus of the modeling effort has shifted from a T4-centric analysis (as per the 2006 Design Analysis Report; Anchor 2006) to a more inclusive Portland Harbor analysis, and cadmium and lead are not high-priority constituents of concern (COCs) for Portland Harbor. Although cadmium and lead were originally identified as COCs for T4 sediments, T4 sediments are estimated to comprise less than 15% of the total capacity of the CDF. Earlier modeling runs showed predicted concentrations of cadmium and lead were well below chronic water quality criteria, and these metals are not listed as COCs for fish consumption in the Joint Source Control Strategy. Therefore, we believe it is more appropriate to focus on Portland Harbor COCs that will occupy a majority of the CDF capacity and, in particular, bioaccumulative COCs like DDx and polychlorinated biphenyls (PCBs).

6. *(Page 6) Please confirm that the QEA-FATE model will be looking at homologs for PCBs, rather than total PCBs.*

It is our understanding that the current plans for the Portland Harbor FS are to model several different PCB homolog groups (tri-, tetra-, penta-, hexa-, and hepta-chlorinated homologs), which account for 90 percent of the total PCB mass on average. Each homolog group will be modeled separately, then summed and proportionately scaled to calculate a Total PCB concentration. By comparison, for the T4 CDF we are proposing to model Total PCBs plus a high-priority congener (PCB-126).

7. *(Page 6) Short-Term Groundwater Model (A): EPA does not agree that the short-term model can be deferred. The intent of the short-term model is twofold: 1) to determine if contaminant breakthrough will occur during CDF filling events, and 2) to provide the "starting condition" for the long-term model. EPA agrees that the short-term model can be omitted; no sediments are added to the CDF via hydraulic dredging method. However, if the Port is still considering hydraulic dredging to fill the CDF, then the modeling should reflect this approach as it has the potential to cause substantially higher concentrations in the long-term model. Additionally, the short-term model would need to include confirmation or revision of the 4/30/07 memorandum on Short-Term CDF Hydraulic Boundary Condition.*

The short-term modeling effort needs to coordinate with the 60% design to ensure the berm inner face provides the sediment filtration function assumed in the model.

As discussed in our April 28, 2010 meeting, we have agreed to defer any further work on the short-term model until it has been determined that hydraulic dredging is a feasible and cost-effective removal technology for T4 or other sediments. Existing short-term modeling runs using mutually agreed-upon input parameters have already demonstrated that groundwater exit concentrations are orders of magnitude below relevant water quality criteria (see NewFields memorandum dated July 30, 2007). These model scenarios are environmentally conservative because they did not take into account the fact that some of the most highly contaminated sediment at T4 was subsequently removed during the Phase I Removal Action. In addition, basic contaminant transport calculations indicate that the short-term effect of pre-loading the berm for long-term model simulations is not significant. This conclusion is based on the following: (1) contaminant source concentrations for the long-term model (i.e., sequential batch leachate test [SBLT] results) are in every case higher than source concentrations for the short-term model (i.e., modified elutriate test [MET] results) for all of the CDF COCs (see table below); and (2) the short-term model puts a hydraulic gradient across the berm that is about 5 times higher than the long-term gradient, for a period of approximately 1 month. As a result, even if the short-term source concentrations were as high as the long-term source concentrations, which they are not, the effect of pre-loading the berm would be about a 5-month head start on a 475-year simulation (i.e., a negligible effect). Nevertheless, the Port agrees to update the short-term model if and when hydraulic dredging is determined to be a cost-effective remedial technology for T4.

Comparison of Elutriate and Leachate Concentrations

Chemical Parameter	Short-Term Elutriate Concentration (µg/L)	Long-Term Leachate Concentration (µg/L)	Ratio Leachate-to-Elutriate
Copper	6	8	1.3
Naphthalene	<0.10	0.07	1.4
Benzo(a)pyrene	0.10	0.23	2.3
Total DDx	0.012	0.058	4.8
Total PCBs	0.07	0.87	13.0

8. *(Page 6) Short-Term Groundwater Model (B): This table presents a summary of the output of the short-term model for copper, lead, total PCBs, and total DDx with minimal explanation of their derivation. It is not clear how these constituents were selected for this model, why lead was added to the list presented on page 4, and why other constituents were not included. If it is appropriate to look at lead here, why is it not a COC for the groundwater modeling?*

We refer to the NewFields memorandum dated July 30, 2007, and supporting documentation, for a more detailed description of short-term model structure, input parameters, and results. The COCs selected for the short-term model were those chemicals that exceeded their chronic water quality criteria in the T4 MET (Anchor and Palermo 2007). Lead was not carried forward because it is not a high-priority COC for Portland Harbor (see also response to Comment No. 5).

9. *(Page 8) Long-Term Groundwater Model Duration: The design seismic return period is a reasonable starting point for a modeling timeframe; however, please verify that peak concentrations have occurred and have fully transported through the berm by the end of the modeling timeframe. If not, the modeling timeframe should be extended to at least 2 times the period needed to obtain the peak. A longer time period would aid in understanding whether long-term declines occur slowly or rapidly.*

Based on earlier modeling work, if biodegradation is not considered, we do not expect to see a peak in the breakthrough curve for most of the COCs, but rather an asymptotic approach to a maximum concentration at long time periods. Because the COCs are generally very hydrophobic, and groundwater residence time is relatively long, in the absence of biodegradation there is little change in contaminant mass over time in the CDF, and the source material approximates an infinite source. In contrast, inclusion of biodegradation in the model is expected to show a rise to a peak concentration and then a subsequent decline as the source material slowly degrades over time. The selected modeling timeframe is expected to be sufficiently long to allow groundwater exit concentrations to stabilize near their asymptotic limit in the absence of biodegradation, and to characterize the peak and decay in groundwater concentrations when biodegradation is included.

10. *(Page 9) First Partial Paragraph: The use of the term "harbor-wide" is confusing. In Table A-1, it is referring to the 10 AOPCs with sediment that may be disposed in the CDF, but it could also be construed to mean all data from Portland Harbor. If it is the latter, how*

does the organic carbon in the representative sites differ from harbor-wide? Is it more appropriate to use OC values from sediments likely to be disposed in the CDF (e.g., the 10 AOPCs)?

It will be clarified that "harbor-wide," in the context of the Groundwater Model Input Parameter Memorandum, refers to the sediment or leachate quality of the 10 areas of potential concern (AOPCs) being evaluated for placement in the CDF (i.e., those AOPCs for which leaching tests were performed, excluding Gasco and Arkema).

11. *(Page 9) Initial Source Concentrations: How was it determined that geometric mean, arithmetic mean, and 90th percentile are appropriate for "minimum, average, and maximum" concentrations in leachate? Why is a maximum value not used for maximum? The definitions of these terms should also be provided in Table 3 to avoid confusion in the future.*

Additional clarification will be provided in the revised memorandum. Because we are modeling a mixture of sediment and leachate characteristics from a variety of different AOPCs, an average concentration (i.e., arithmetic mean) is the appropriate statistic to characterize the source strength of this material. On the other hand, it would not be appropriate to assume that all of the material in the CDF was equivalent to the maximum concentration of any one individual AOPC. Ideally, an upper confidence limit on the arithmetic mean would be used to define the maximum source concentration for model sensitivity analysis. However, confidence limits are often difficult to calculate with lognormal data, especially if the data include undetected concentrations. Therefore, we selected a nonparametric statistic (90th percentile) to define a "worst case" upper-bound source concentration. These are all commonly used statistics with standard definitions, and are consistent with the statistics used to define harbor-wide source characteristics in previous work (see Portland Harbor Stats Summary, dated June 11, 2007).

12. *(Page 9) Partitioning Coefficients: Please support the statement that source concentrations and partitioning coefficients are covariant with data. If they do not covary, values for sediments should include a range, particularly given the variability of partitioning coefficients for Total DDx and Total PCB Aroclors presented in Attachment A that may be dependent on the mixture of isomers at a given site.*

These parameters are covariants by definition, because Kd is the ratio of sediment to leachate concentration. For a given sediment concentration, as the leachate concentration decreases, the Kd increases proportionately. To evaluate a range in both

values will introduce unnecessary noise and inflated estimates of uncertainty. For example, consider two data pairs: one with 100 parts per million (ppm) sediment and 1 ppm leachate, and another with 1,000 ppm sediment and 10 ppm leachate. Both data pairs have Kd values of 100. But if we mix and match the sediment and leachate data indiscriminately, we can calculate erroneous Kd values ranging from 10 (100/10) to 1,000 (1,000/1). This is not an accurate representation of the leaching behavior.

13. *(Page 11) Comparison with Other Region 10 Sites (first paragraph): Please state in what manner the effect of salinity has on the partitioning behavior of metals as compared to freshwater (e.g., reduce it or increase it).*

It is not possible to make such a generalization because the effects of saltwater on metal partitioning are complex. The complexity derives from the fact that marine sediment is leached with freshwater in the Puget Sound tests (mimicking upland groundwater intrusion into formerly marine sediments). These conditions create transient effects in metals leachability—the so-called "salt washout" effect. We will make note of this effect and provide a reference for more detailed discussion.

14. *(Page 11) SBLT Testing. Please discuss how the colloidal material in the SBLT leachate affects the assumption of 0.5% colloidal material passing through the berm as was assumed in the prior short-term modeling analysis.*

The SBLT indicates that clays and colloids are present in the dredged material, consistent with the assumption used in the short-term model. It is difficult to draw any further comparisons from these data, however, because of fundamentally different test conditions—the SBLT leachate water is filtered through a 2-dimensional, 1-micron glass-fiber filter, whereas the short-term condition represents groundwater transport through a 3-dimensional, 200- to 300-foot-wide sand and gravel berm, based on MET results. The assumption of 0.5 percent colloidal transport in the short-term model represents the best estimate of this process based on the experience and professional judgment of Mike Palermo (Anchor and Palermo 2007).

15. *Table 3 (A), Biodegradation Rates: EPA directs the Port to complete the groundwater modeling without consideration of biodegradation in sediment fill or groundwater as the base case. EPA agrees the Port can complete an alternative "sensitivity analysis" that considers more rapid biodegradation rates, such as values listed in the "average" column. Sean Sheldrake's July 18, 2007, email to Ann Summers concluded: EPA's overall conclusion is*

that "In the absence of convincing field studies indicating degradation rates in sediment in conditions similar to those that will occur in the CDF, EPA suggests that assuming infinite half-life values is the appropriate conservative approach for PCBs and DDX. EPA requests that the proposed half-lives for PAHs be re-evaluated considering applicable field studies and considering expected in-situ conditions in the T4 CDF."

As discussed in the April 28, 2010 meeting, the Port will plan to run comparative model scenarios with and without biodegradation.

16. *Table 3 (B): The Port should consider incorporating a factor of safety into the initial sediment and pore water concentrations so that this modeling effort may be useful for the future as appropriate for evaluating sediment acceptance, and to establish a conservative analysis. See related comment regarding Table 4.*

The initial porewater concentrations and sediment-water partitioning coefficients for potential Portland Harbor source materials are well characterized, based on representative SBLT testing of the most significant AOPCs following an EPA-approved Field Sampling Plan (LWG 2008). As part of model sensitivity analysis, modeling will be performed using 90th percentile leachate concentrations, which represents an extremely conservative analysis of the most contaminated 10 percent of the potential source material. Additional model conservatism is introduced by: (1) use of leachate values that are likely biased high by suspended sediments due to an inefficient laboratory filtration step, resulting in partitioning coefficients that are one or more orders of magnitude lower than corresponding literature values; and (2) evaluation of 475-year model timeframes with no biodegradation. In consideration of the above, the Port believes the model already establishes a conservative analysis.

17. *Table 3 (C): Please confirm average Kd for copper (quarry spall) per EPA 2005 Table 3.*

The copper values are confirmed. The 1st percentile is estimated at 2.33 standard deviations (SD) below the median (median = 2.7; SD = 0.6). This equates to 10^[2.7-(2.33*0.6)], which is approximately 20. The minimum value is $10^{0.1}$, which is approximately 1.

18. *Table 3 (D): Please explain how calculating partitioning coefficients as averages of the four cycles and 10 sites in Table A-1 is a reasonable approximation for the CDF.*

The rationale for calculating partitioning coefficients using averages of the four test cycles is described in Attachment A – *SBLT Partitioning Calculations* (pp. 5 to 8). Alternative calculation methods are also reviewed and compared. Averaging across the 10 AOPC sites is appropriate because the sediment from different sites will be mixed during placement, and groundwater particles will be exposed to sediment from different sites during transport through the CDF. In the future, more specific placement and layering scenarios may be explored in the groundwater model, but currently there is not enough information on the relative volumes and sequencing of sites to evaluate AOPC-specific filling scenarios.

19. *Table 3 (D[i]): With regard to the cycle data, please identify the pore water volume ratios for the SBLT tests. How long would it take to flush these pore volume ratios through the CDF sediment fill? EPA recommends using the first cycle data as the initial source concentration.*

We will clarify that each cycle of the SBLT is extracted from a slurry of 4 parts water to 1 part sediment by weight, as per standard U.S. Army Corps of Engineers protocol (USACE 2003). These tests are batch leachate extractions, rather than column tests, so they are designed to estimate partitioning coefficients but are not easily interpreted in terms of pore volume elutions in the CDF. For reference, the groundwater travel times through the CDF are estimated at less than 20 years to greater than 100 years, with higher travel times toward the upper back part of the CDF.

As described in Attachment A, Method No. 2 (p. 6), there are no consistent trends in leachate quality over time in the SBLT tests, and given the negligible amount of mass that is removed from the sediment during each leaching cycle, the cycles essentially behave as four replicate measurements. As a result, the first cycle data may be about average in some cases, or randomly higher or lower than average in other cases. Therefore, an average of the four replicate cycles provides a more accurate measurement of the leachate strength, and is less affected by random laboratory variability.

20. *Table 3 (D[ii]): With regard to averaging the SBLT data over the sites, does this imply equal volumes of dredged material will be accepted from each site? Consider estimating dredged volumes from each site and calculating a volume weighted average.*

Yes, the current assumption is that each AOPC contributes an equal volume of material to the CDF. We agree that volume-weighting the AOPCs is a good idea. However, it is

our understanding that estimates of AOPC-specific remediation volumes are not yet available from the Portland Harbor FS process.

21. *Table 4(A): Please compare the bulk sediment concentrations in Table 4 to those listed in the iAOPC Steps 1 and 2 table prepared by the Port during previous design work, and adjust the model starting conditions appropriately. Many of the concentrations in the SBLT tests appear to be lower than previously calculated values. For example, iAOPC average BaP concentration is 1,555 ug/kg, whereas the bulk sediment concentration for BaP in Table 4 is 990 ug/kg. EPA understands that the LWG could not, with certainty, collect SBLT samples at locations where concentrations would be average or above average at each site. However, this creates a need to "adjust" the data to reflect the likelihood that the potential dredged sediment may have higher concentrations on average than reflected in the SBLT tests. Use of 95% upper confidence interval values may be appropriate. EPA desires that the groundwater modeling for the 60% design be reasonably worst case so as to demonstrate the feasibility of the CDF.*

The mean harbor-wide sediment concentrations compare reasonably well between the current (2010) and earlier (2007) estimates, as shown in the table below. The two estimates are within a factor of two of each other. Note that the current harbor-wide concentration for PCBs is two times higher than the 2007 estimate, and DDx estimates are extremely close. The differences that are observed are not surprising considering that the earlier 2007 estimates were likely biased by targeted sampling designs, and no spatial weighting of the mean was performed to remove such biases. The 2010 means were derived from systematic sampling of the extent and depth of potential remediation volumes in the AOPCs, and are therefore a more accurate and reliable estimate of the quality of the dredged material being considered for placement in the CDF, compared to the 2007 database queries. In addition, during model sensitivity analysis, 90th percentile leachate concentrations will be evaluated, representing a rather extreme worst-case scenario. In consideration of the above, the Port does not believe any “adjustments” of the source material concentrations are warranted.

Comparison of Mean Harbor-Wide Bulk Sediment Concentrations

Chemical	Units	SBLT Mean 2010	RI Mean 2007
Copper	mg/kg	47	79
Total PCBs	µg/kg	650	330
DDx	µg/kg	57	63
Benzo(a)pyrene	µg/kg	990	1,560
Naphthalene	µg/kg	89	160

22. *Table 4 (B): What do the values in this comparison table represent? Are these means? Ranges would be helpful as well.*

We will clarify that the bulk sediment concentrations for Portland Harbor listed in Table 4 are mean concentrations for the 10 AOPCs. However, the bulk sediment concentrations for the other sites are based on analysis of a single bulk composite sample that was subjected to a pancake column leachate test; therefore, a range cannot be provided for bulk sediment. For leachate results, the 90th percentile concentration is presented in Table 4, which provides information on the critical upper end of the concentration range.

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ATTACHMENT 3

Port of Portland

TERMINAL 4 PHASE II

CDF 60 Percent Design Approach Meeting with EPA
Wednesday April 28, 2010
1:00 – 3:00 PM (Pacific)

ATTENDEES

In Person:
Sean Sheldrake, EPA
Kristine Koch, EPA
Ken Fellows, Parametrix
Kelly Madalinski, Port of Portland
Krista Koehl, Port of Portland
Tom Schadt, Anchor QEA
John Verduin, Anchor QEA
Todd Thornburg, Anchor QEA
Ben Hung, Anchor QEA
Cy Young, ODSL
Brian Cunninghame, Warm Springs Tribe

Via Teleconference:
Rene Fuentes, EPA
Chip Humphrey, EPA
Jim Anderson, ODEQ
Tom Gainer, ODEQ
Erin Madden, Cascadia Law
Jennifer Peers, Stratus
Genevieve Angle, NOAA
Sheila Fleming, Ridolfi

MEETING SUMMARY

PROCESS OVERVIEW

The goals of the September 1, 2010 CDF design submittal include maintaining consistency with the harbor-wide feasibility study process while providing information to allow EPA to make remedial decisions within harbor-wide context. Finalization of the T4 CDF design and construction and other cleanup efforts at T4 will not take place until after the Portland Harbor ROD.

The CDF feasibility, cost, and protectiveness evaluation will be based on EPA-specified CDF performance standards and the LWG response on clarifying EPA performance standards. The September 1 CDF design submittal will also consist of additional evaluations (e.g., biodegradation rates). However, proposing alternative performance standards and assumptions will not be the focus of the T4 CDF design submittal, as that analysis will be performed in the context of the harbor-wide FS.

Port of Portland

TERMINAL 4 PHASE II

CDF 60 Percent Design Approach Meeting with EPA
Wednesday April 28, 2010
1:00 – 3:00 PM (Pacific)

CDF DESIGN LEVEL CLARIFICATIONS

On February 18, 2010, EPA issued CDF performance standards to the Lower Willamette Group (LWG) for use in the development and evaluation of alternatives in the Portland Harbor Feasibility Study. LWG provided a response on April 14, 2010 clarifying the EPA performance standards. Several of the EPA standards were characterized as design level issues. The Port identified six design level issues requiring further clarification from EPA on how to address in the T4 60 percent design submittal. Below are the specific issues and resolution of those issues based on the meeting with EPA.

- **Short term water quality impact duration during hydraulic dredging of the CDF** (Performance Standard #22 in LWG Table [*EPA February 18, 2010 CDF Performance Standards Comments and LWG April 14, 2010 Responses*]).

  Resolution: This EPA standard defines the duration for short-term water quality impacts as the period from the beginning of the fill activity until the water level in the CDF reduces to within 0.1-foot of the water level in the river. EPA confirmed that this standard is meant to define the duration for short-term water quality model predictions in the event of hydraulic dredging and filling. EPA stated and acknowledged that some other metric could be used to define the duration for short-term water quality model predictions, including "asymptotic run-out to steady state," for instance. The Port and EPA agreed that a tolerance greater than 0.1-foot (like 1-foot) or other metric (such as a narrative metric) could reasonably be used to define the short-term water quality impact duration in the event of hydraulic dredging, considering the 1 to 2-foot diurnal tidal swings in the river. The Port and EPA also discussed offloading of barges with a high-solids pump using make-up water from within the CDF, and it was acknowledged that the head difference in the pond created by this scenario would not be significant.

- **Physically closing any hydraulic connection or notch** (Performance Standard #23 in LWG Table).

Resolution: EPA confirmed that the definition of hydraulic connection in this standard is related to a surface water connection through a notch in the berm or discharge over a weir, not groundwater or surface water moving through the berm. If the design included barges moving through a notch in the berm to bottom-dump material, the notch would need to be closed between filling seasons.

- **No installation of piles in contaminated sediment zone requirement** (Performance Standard #29 in LWG Table).

  Resolution: EPA indicated that while this performance standard states that installation of piles driven through the contaminated sediment zone may not be performed, EPA is open to reviewing the use of piles and not mandating an outright prohibition. EPA suggested that the O&M plan may contain a set of procedures that would be followed to provided justification and appropriate analysis for use of piles. The Port and EPA agreed that, for the purposes of the T4 CDF design, this performance standard could be amended to read: Installation of piles driven through the contaminated sediment zone is not allowed *without further analysis and EPA approval.*

- **Stormwater discharges/infiltration into fill** (Performance Standard #26 and #29 in LWG Table).

  Resolution: Performance Standard #26 states that "stormwater discharges or infiltration into the CDF is not allowed." Performance Standard #29 relates to implementing institutional controls, including the requirement to "prevent stormwater infiltration into the CDF and CDF buffer zone." EPA indicated that these performance standards may be viewed in the same way as the performance standard related to pile installation in the contaminated sediment zone, i.e., evaluation of stormwater infiltration facilities would require further analysis and EPA approval. In general, EPA prefers to prevent, or at least minimize, stormwater discharges and infiltration into the CDF and CDF buffer zone. It was clarified that the primary concern was deliberate infiltration of stormwater into the ground surface in an engineered

stormwater management facility, and not the incidental infiltration of rainfall on a pervious surface (i.e. passive infiltration). EPA is willing to review analysis of various amounts of discharges/infiltration and sensitivity of modeled groundwater concentrations to this parameter. The Port indicated it is planning to run model scenarios with both pervious and impervious (i.e. pavement) covers. EPA stated that a component of their concern related to the fact that stormwater would be oxygenated and therefore leaching characteristics given this additional flow may be different than leaching characteristics for groundwater only. DEQ stated that infiltration of stormwater in general does not seem like a major design issue, given that the CDF is designed as a "flow-through" facility, unless the geochemical impact of oxygenated water is significant or the stormwater itself was contaminated. To summarize, EPA is interested in understanding whether this is a sensitive design parameter, and passive infiltration may be acceptable.

- **Utility conduits within 500 feet of the CDF** (Performance Standard #8 in LWG Table).

  Resolution: The performance standard includes identifying, removing, or modifying utilities trenches, storm drain lines, and other conduits within 500 feet of the CDF. The performance standard applies to all utilities. EPA stated that they did not have a specific reference for the 500-foot offset distance (referred to as the CDF buffer), although they indicated some of their performance standards were borrowed from a review of solid waste landfill regulations. It was clarified that utilities needed to be identified and evaluated, but not necessarily "removed or modified", depending on the evaluation. The key concern for EPA, generally, is that utility conduits may provide preferential pathways for groundwater exiting the CDF. To address these concerns, the Port may review existing and planned utility conduits to determine whether there is a potential for these preferential pathways to occur. The majority if not all of the utility conduits are expected to be located at elevations above the design elevation for the contaminated fill zone, in which case a preferential pathway for groundwater exiting the CDF would not be of concern.

Port of Portland

TERMINAL 4 PHASE II

CDF 60 Percent Design Approach Meeting with EPA
Wednesday April 28, 2010
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- **Imported fill criteria** (Performance Standard #25 in LWG Table).

  Resolution: Specific acceptance criteria have not been established by EPA for the Portland Harbor. However, based on previous discussions EPA considers the narrative standard developed for the McCormick and Baxter sediment cap to be the default acceptance criteria for the T4 Site. The Port noted that this standard is for an in-water sediment cap, and the fill above the contaminated fill zone in the CDF is not an in-water sediment cap. As such, different acceptance criteria may be both appropriate and protective of human health, including trench workers at the terminal, and the aquatic receptors in the river. EPA agreed and stated that the Port may perform evaluations of CDF performance, using the CDF groundwater model, based on different acceptance criteria in addition to the default acceptance criteria, to determine exiting groundwater COC concentration sensitivity to this parameter.

DISCUSSION OF EPA COMMENTS ON GROUNDWATER INPUT MEMO

The Port will provide responses to EPA comments within 30 days of receipt of the EPA comments. The responses will be substantive enough for EPA to understand how the Port is moving forward with the groundwater modeling effort. The Groundwater Input Memo will be updated and provided to EPA as an appendix to the CDF 60% Design Report when that report is submitted.

The Port provided rationale to EPA for omitting any further short-term water quality modeling evaluation as part of the CDF 60% Design submittal. The Port's rationale was based on the following: (1) it is likely that Phase 2 dredging at T4 will be mechanical, not hydraulic; (2) if the CDF is sited elsewhere in the harbor, hydraulic dredging at T4 will not likely be feasible; (3) short-term modeling was already performed using a conservatively large hydraulic dredging rate and duration (memo dated 7/30/07) and it was shown that groundwater exit concentrations were orders of magnitude below water quality criteria; and (4) hydrogeologic analysis of source concentrations and hydraulic gradients

indicates the "pre-loading" effect in the berm will be insignificant compared to long-term contaminant transport processes. The Port will provide this rationale in the response to comments on the Groundwater Input Memo. EPA stated that they accept the Port's determination to omit any further short term modeling work from the groundwater modeling approach based on the rationale provided. However, if hydraulic dredging ends up being proposed at T4, then the Port will need to update the short term modeling evaluation as part of those subsequent design submittals.

NEXT STEPS

The Port and EPA will continue to confer as needed to enable the design process to progress on schedule. The Port will provide responses to EPA comments on the Groundwater Input Memo as described above. The Port will forward the most up-to-date schedule to EPA. The next major deliverable will be the Groundwater Results Memo.

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TECHNICAL MEMORANDUM

To:	Kelly Madalinski, Port of Portland Krista Koehl, Port of Portland	**Date:**	October 5, 2010; Revised June 15, 2011 *(Updated August 8, 2011)*
From:	Pete Townsend, NewFields Todd Thornburg, Anchor QEA	**Project:**	050332-01
Re:	Long-Term Groundwater Modeling Results Memorandum Port of Portland Terminal 4 Confined Disposal Facility		

INTRODUCTION

This memorandum presents the results of groundwater modeling for the Terminal 4 confined disposal facility (T4 CDF). Modeling was performed to estimate groundwater chemical concentrations exiting the T4 CDF for evaluation of long-term protection of water quality in the Willamette River.

This memorandum is organized as follows:

- Modeling Approach
- Model Design and Setup
- Model Input Parameters
- Model Calibration
- Model Results and Predictions
- Conclusions

MODELING APPROACH

Visual Modflow (Version 2009.1 Pro, Build: 4.4.0.156; Waterloo Hydrogeologic, Inc.) was used for model construction, execution, and visualization. All groundwater flow simulations were performed with MODFLOW-2000 (Harbaugh et al. 2000). MODFLOW-2000 is a

three-dimensional, block centered finite difference code capable of simulating steady-state and transient flow conditions. MODFLOW-2000 can simulate time-varying boundary conditions and heterogeneous aquifer properties.

Contaminant transport simulations were performed with MT3DMS (Zheng and Wang 1999). MT3DMS uses the flow solution provided by MODFLOW-2000. MT3DMS can simulate changes in concentrations of miscible contaminants in groundwater considering advection, dispersion, diffusion, and some basic chemical reactions, including biodegradation, with various types of boundary conditions and external sources or sinks. This approach is consistent with previous modeling work on the T4 CDF, which also used versions of MODFLOW and MT3D, including modeling work performed as part of the previous 60 Percent Design (Anchor 2006) and Engineering Evaluation/Cost Analysis (EE/CA; BBL 2005).

The MODFLOW/MT3DMS model simulates leaching of chemicals from contaminated dredged sediment placed in the CDF, and subsequent transport of chemicals through the CDF, the underlying aquifer, and the berm, toward the Willamette River. The following contaminant transport and attenuation processes are included in the model:

- Groundwater advection and dispersion
- Mixing of leachate with incident rainfall above and regional groundwater below
- Adsorption and desorption of contaminants onto berm and aquifer matrix materials
- Biodegradation of contaminants

MODEL DESIGN AND SETUP

This section provides a brief review of site hydrogeology and a description of the model structure, grid design, boundary conditions, and simulation period.

Site Hydrogeology

The T4 hydrogeology is summarized in Appendix D of the EE/CA report and presented in detail in the T4 characterization report (BBL 2004). BBL (2005) summarized the geologic stratigraphy adjacent to and beneath the proposed CDF; the stratigraphy consists of the following:

- Upland fill material, consisting of medium to fine sand ranging in thickness from about 5 to 40 feet
- Unconsolidated Alluvial Deposits, consisting of fine sand west of the former shoreline, and interbedded layers of gravel, sand, silt, and clay to the east of the former shoreline, ranging in thickness from 120 to 160 feet
- Troutdale Gravel, encountered at an elevation of approximately -114 to -168 feet Columbia River Datum (CRD)

The regional groundwater flow direction is toward the Willamette River. In nearshore locations, groundwater in the upland fill material and the Unconsolidated Alluvial Deposits is in direct hydraulic connection with the river, and groundwater elevations respond to changes in river stage. The alignment of the CDF is coincident with the general groundwater flow direction.

Model Structure

To estimate concentrations of groundwater chemicals of concern (COCs) at the outer edge of the CDF berm, a two-dimensional (2-D) cross-sectional model was aligned with the critical groundwater flow path through the center of the CDF. The 2-D model structure is shown on Figure 1. The key hydrologic units of the 2-D model include:

- Berm Fill (import sand and gravel comprising the core of the CDF berm)
- Training Dikes (quarry spalls comprising the outer walls of the berm)
- Sediment Fill (contaminated dredged material from Portland Harbor, and the source of contaminants through leaching)
- Imported Fill (imported cover material comprising the unsaturated zone above the Sediment Fill, with physical/chemical characteristics similar to the Berm Fill)
- Aquifer (existing strata at T4 below and adjacent to the CDF; predominantly sand with interbedded silt and clay layers associated with undifferentiated upland fill and Unconsolidated Alluvial Deposits).

Model Grid Design

Figure 1B shows the model grid. The model domain extends 900 feet along the centerline of the CDF. Vertically, the model extends from elevation -65 to +32 feet National

Geodetic Vertical Datum (NGVD). The bottom of the CDF (i.e., the top of the Aquifer) is at elevation -35 feet NGVD, and the top of the CDF (i.e., the base of the Imported Fill) is at elevation +9.5 feet NGVD. The model is discretized into 278 columns and 61 layers. Layer thicknesses range from approximately 1 to 5 feet. Column widths range from approximately 2 to 8 feet. The finest grid spacing is placed over the contact between the contaminated sediment and the berm material, because there are steep gradients in both physical properties (e.g., permeability) and geochemical properties (e.g., partitioning coefficients, leaching potential) across this interface.

Boundary Conditions

The hydrologic boundary conditions are shown on Figure 1C. The Willamette River is represented by constant head cells. River stage information was obtained from the U.S. Geological Survey National Streamflow Information Program, station number 14211720 (Morrison Bridge in Portland, Oregon). Statistics for the stream gage are as follows:

- Mean annual elevation = 7.4 feet NGVD
- Mean monthly low elevation (September) = 4.5 feet NGVD
- 10-year monthly low elevation = 3.8 feet NGVD (based on the 10th percentile of mean monthly Portland Harbor river elevations during September)

Transient river stages were used in model calibration. The transient boundary is comprised of both seasonal and diurnal tidal fluctuations. Figure 2 shows the superposition of the mean daily river stage (i.e., the mean annual hydrograph) and a typical diurnal tidal cycle.

The head of the CDF is represented by constant head cells. Average groundwater elevations in this area are based on measurements from monitoring wells MW-09 and MW-10 (BBL 2005). A mean annual water level elevation (13.3 feet NGVD) was calculated from measurements between September 2004 and September 2005.

A “no-flow” condition was specified along the upriver and downriver boundaries of the modeling domain (i.e., the sides of the 2-D cross section), since these boundaries are aligned parallel to the groundwater flow direction.

Recharge through the Import Fill is a function of annual precipitation, evaporation, transpiration, ground slope, and grain size of the soils. Man-made surface structures, such as roads, pavement, buildings, and drainage systems, also affect recharge. BBL (2005) used the Hydrologic Evaluation of Landfill Performance (HELP) model (Schroeder et al. 1994) to estimate recharge rates at 22.3 and 0.92 inches per year (in/year) for unpaved and paved conditions, respectively. The current model simulations assume an unpaved condition.

Regarding the geochemical boundary conditions, the upstream groundwater concentrations in the regional aquifer and the concentrations in the recharge water are assumed to be zero. The source concentrations in the contaminated sediment fill are initialized based on leaching test results (see the Groundwater Model Input Parameter Memorandum; Anchor QEA and NewFields 2010), then the source concentrations decrease as contaminants are released over time. For most of the hydrophobic COCs being evaluated in the absence of biodegradation, however, the contaminant reduction rates are so slow that the contaminated sediment fill essentially behaves as an infinite source over the design period of the CDF.

Simulation Period

Groundwater model simulations were run for a minimum of 475 years, except for the model simulation involving naphthalene, which peaked and declined much more quickly than the other constituents (see Model Results and Predictions, below). The 475-year simulation period coincides with the longest applicable engineering design standard being applied to the CDF. The design seismic event, corresponding to a 10 percent probability of exceedance in 50 years, or a return period of 475 years, is the longest applicable design standard. Selection of a 475-year simulation period, therefore, reflects consistency between the physical design life of the CDF (e.g., its hydrodynamic or geotechnical stability) and the chemical isolation life of the CDF. For most COCs, model simulations were extended to periods of 1,000 years for informational purposes, to better characterize the shape of the prediction curves.

MODEL INPUT PARAMETERS

Groundwater model input parameters, including COCs, physical and hydraulic properties of CDF building materials, leachate concentrations in the contaminated sediment, chemical partitioning coefficients, and biodegradation rates, are summarized in this section (see Tables 1 and 2). A more detailed discussion of model input parameters and supporting rationale is presented in the Groundwater Model Input Parameter Memorandum.

Constituents of Concern

The following COCs were evaluated in the model:

- Copper
- Naphthalene
- Benzo(a)pyrene
- DDx (sum of DDT, DDD, and DDE)
- Total polychlorinated biphenyls (PCBs)

Material and Hydraulic Properties

Material and hydraulic properties were established for the CDF building materials, including the Sediment Fill (contaminated dredged sediment from Portland Harbor), Imported Fill (cover material), Berm Fill (sand and gravel), and Training Dikes (quarry spalls), as well as the surrounding Aquifer material (alluvial sand and silt). Material and hydraulic input parameters, and their supporting data and rationale, are summarized in Table 1.

Geochemical Properties

Geochemical input parameters (source concentrations, partitioning coefficients, and biodegradation rates), and their supporting data and rationale, are summarized in Table 2 and discussed below.

Initial Leachate Concentrations. Sequential batch leachate test (SBLT) data from Portland Harbor provide an estimate of the porewater concentrations that are expected to equilibrate with contaminated sediments in the T4 CDF. These data are used to initialize the source concentrations in the CDF. The source concentrations represent the potential

for COCs to be mobilized in groundwater as the COCs move through the CDF (undergoing fate and transport processes) toward the river. The geometric mean, arithmetic mean, and 90th percentile leachate concentrations from Portland Harbor SBLT results (excluding leachate results from areas of potential concern [AOPCs] 9 and 14; see Attachment 1 of the Groundwater Model Input Parameter Memorandum) provide the minimum, average, and maximum source concentrations, respectively, for setting the initial conditions in the long-term groundwater model. The initial source concentrations for the various groundwater COCs are compiled in Table 2.

Initial Concentrations in Other Materials. The initial concentrations in the Aquifer, Imported Fill, and Berm Fill are assumed to be zero.

Partitioning Coefficients in Dredged Sediment. The ratio of the bulk sediment concentration to the SBLT leachate concentration is used to develop site-specific partitioning coefficients for contaminated sediment placed in the CDF. The partitioning coefficient describes how readily contaminants are desorbed from the sediments, dissolved in groundwater, and made available for transport through the CDF. The derivation of partitioning coefficients from SBLT tests on bulk sediment from Portland Harbor AOPCs is presented in Attachment 1 of the Groundwater Model Input Parameter Memorandum. Geometric mean partitioning coefficients for the various groundwater COCs are compiled in Table 2.

Partitioning Coefficients in Berm. The physical properties, source characteristics, and thermodynamic conditions in the berm are fundamentally different from those in the contaminated sediment fill material. Applicable partitioning coefficients for metals in the berm were established in NewFields and Anchor (2007). Partitioning coefficients for organic constituents in the berm are adopted from the Lower Willamette Group (LWG) Remedial Investigation Report (LWG 2009, Table E6). In most cases, the partitioning coefficients were adopted from the LWG compilation of literature values, with outliers removed, and are consistent with the partitioning coefficients proposed for use in the QEA-FATE model for the Portland Harbor Superfund site. The minimum Koc value for DDx was adjusted based on site-specific analysis of dissolved and particulate monitoring data in the Willamette River, with one outlier removed.

Biodegradation Rates. Published biodegradation rates were compiled and evaluated for use in the T4 CDF model. It is expected that anaerobic degradation processes will prevail in the confined contaminated sediments, whereas aerobic degradation processes will be more important in the berm. For all constituents, zero degradation (i.e., infinite half life) was evaluated as a worst-case and base case scenario. The long-term model evaluation also includes scenarios with conservatively protective biodegradation rates from the lower end of published literature values, (i.e., slow rates), with particular emphasis on field studies. Because of the long time period of the model simulations, biodegradation is likely to be an important process for contaminant attenuation in the CDF (USACE 1996; M. Palermo pers. comm. 2010). Conservatively slow biodegradation rates (expressed as half lives, in days) are presented in Table 2, along with supporting literature citations. In Table 2, an infinite half life (i.e., zero degradation) represents the "maximum" value assumed in the model, and conservatively long half lives (i.e., slow degradation rates) represent the "central" values.

Evaluation Criteria

Risk-Based Criteria. Model predicted concentrations in groundwater are compared to the following risk-based criteria (see Table 3):

- Chronic Water Quality Criteria (WQC)
- Fish Consumption Criteria
- Drinking Water Maximum Contaminant Levels (MCLs)

The chronic WQC for copper, DDx, and Total PCBs are from Oregon Table 33A (ODEQ 2005), which is also consistent with the U.S. Environmental Protection Agency (USEPA) National Recommended Water Quality Criteria (USEPA 2010); the chronic criteria for naphthalene and benzo(a)pyrene are from USEPA guidance (USEPA 2003). Human health criteria for fish consumption are from the National Recommended Water Quality Criteria (USEPA 2010). Human health criteria for drinking water are the USEPA MCLs (USEPA 2009).

Background and Technology Limits. In addition to risk-based criteria, upstream background concentrations and analytical reporting limits were also considered in the

evaluation, because it is impracticable to control groundwater concentrations below the ambient upstream concentrations in the river, and compliance decisions cannot reliably be made at concentrations below the limits of analytical technology. High-volume surface water samples were used to define upstream background water quality (LWG 2009, Table 7.4-4). Analytical reporting limits were derived from the Quality Assurance Project Plan for the Round 3A stormwater sampling event based on standard sample volumes (LWG 2007).

Observation Points. Model observation points were selected to characterize model output concentrations at designated locations along the berm face where groundwater exits to the river. Three observation points were considered in this evaluation:

- Peak "centerline" concentrations within surficial CDF berm material
- Spatially averaged concentrations within surficial CDF berm material
- Spatially averaged concentrations in receiving water near point of discharge

Model output concentrations for the observation points within the CDF berm are derived from the last tier of cells in the model adjacent to the river boundary. The observation points along the last tier of model cells are shown in Figure 3 (red dots); these cells are directly adjacent to the boundary condition cells representing the Willamette River. The CDF berm observation points do not include the riprap layer placed on the outside face of the berm. Because the width and thickness of the terminal model cells are approximately 2 feet, and the reported concentrations represent the average concentration for the entire cell, the mid-point of the observation is located about 1 foot below the berm face (excluding the riprap layer).

The centerline concentration is the peak concentration in the last tier of model cells fronting the river. Typically, the centerline concentration occurs at a relatively shallow depth in the saturated part of the berm, near the center of the upper training dike. The spatially averaged groundwater exit concentration is the arithmetic mean concentration of 22 observation points along the cross-section of the berm interface, from elevation -35 feet NGVD (base of the CDF) to elevation +7.4 feet NGVD (mean river stage). Spatial averaging was only performed vertically along the berm interface. No spatial averaging

was performed horizontally (parallel to the river) because the 2-D cross-sectional model assumes a uniform concentration distribution along the third dimension.

For Total PCBs and DDx, an additional observation point 10 centimeters (cm) above the berm face was modeled to characterize the degree of mixing in the receiving water immediately after groundwater exits the berm. Such an observation point might represent, for example, the quality of the interstitial water in a riprap armor layer placed over the berm face, which includes a significant amount of mixing with river water.

MODEL CALIBRATION

The seasonal and tidal variations in the Willamette River stage result in river water moving into and out of the berm during high and low tides, and during seasonal high and low river stages, respectively. These periodic reversals in groundwater flow direction increase the mechanical mixing of groundwater in the berm. Following the USEPA-approved model calibration procedure for the T4 CDF (NewFields 2007a), the effect of a transient river boundary was approximated using an effective dispersion factor in the transport simulations. The calibration of effective dispersion was updated to match the current model structure and hydraulic conductivity values of the hydrogeologic units. The use of a calibrated effective dispersion value in a steady-state flow field greatly simplifies the modeling calculations, whereas the computational time required to simulate a transient boundary with twice-daily tides for 475 years is unmanageable.

To calibrate the effective dispersion, a transport simulation is performed using a transient flow field and transient boundary at the Willamette River. The transient boundary consists of the average annual hydrograph (compilation of mean daily river stages) superimposed with typical diurnal tidal variations, as shown in Figure 2. A conservative (non-attenuating and non-reactive) contaminant source is assigned to the Sediment Fill at concentration of 1 (i.e., 100 percent). Dispersivity is set to a small value (2.0 feet) over the entire model domain. The transient model is then run until peak concentrations are observed at the berm-river interface. To finalize the calibration process, the model is run again using a steady-state flow field with the same conservative contaminant source. A constant head boundary condition is assigned at the river boundary, represented by the long-term average

river stage (7.44 feet). Dispersivity for the berm materials is then adjusted (calibrated) in the steady-state flow field case until the peak concentrations match the transient case.

Figure 4 shows the arrival curve for the conservative tracer for the transient model, with centerline concentrations ranging from 0.02 and 0.12 (2 to 12 percent of the source concentration) after arrival of the tracer at the river interface. The long-term average concentration from the transient model (0.08, or 8 percent) provides the target concentration for estimating the effective dispersivity in the steady-state model. As shown in Figure 4, increasing dispersivity results in earlier arrival times and smaller peak concentrations. A dispersivity factor of 6.5 feet provided the best approximation of the long-term average concentration in the transient model. It should be noted that the steady-state approximation of the transient boundary condition generates an arrival curve that is accelerated by about a factor of two (i.e., arriving in about 200 days in the steady-state simulation compared to 400 days in the transient simulation). In this respect, the use of a steady-state approximation is conservative (i.e., protective).

MODEL RESULTS AND PREDICTIONS

Groundwater Flow and Residence Time in the CDF

Groundwater transport pathways and residence times in the contaminated sediments are shown on Figure 5. Transport pathways are dominated by downward vertical flow through the contaminated sediment toward the underlying aquifer and laterally into the berm. This results from mounding of infiltrated rainwater at the contact between the Sediment Fill and the Imported Fill, near elevation +9.5 feet NGVD. Once groundwater leaves the CDF, it flows horizontally toward the river in the underlying aquifer, and then upwells into the berm and training dikes along the contact with the contaminated sediments.

The groundwater residence time in the contaminated sediments varies from less than 20 years along the front and bottom of the CDF, to greater than 200 years at the upper rear of the CDF (Figure 5). As a result, contaminated sediments in the upper rear of the CDF are likely to have less effect on groundwater exit concentrations.

Long-Term Groundwater Quality

Figures 6A through 6E present the predicted groundwater exit concentrations for copper, naphthalene, benzo(a)pyrene, DDx, and Total PCBs, respectively. In all cases but naphthalene, the model simulation period was projected out to 1,000 years to define the shape of the concentration trends. This is more than two times longer than the longest applicable engineering design standard for the CDF (i.e., 475-year return period for the seismic design standard). Prediction curves are presented for the peak centerline concentration, as well as the spatially averaged concentration for the last row of cells in the berm. For DDx and Total PCBs, an additional observation point 10 cm above the berm face was modeled to characterize incipient mixing in the receiving water immediately after groundwater exits the berm (see Figures 6D and 6E). Such an observation point might represent, for example, the quality of the interstitial water in a riprap armor layer placed over the berm face, which includes a significant amount of mixing with river water.

Initial leachate concentrations are plotted on the charts, along with chronic WQC, maximum contaminant levels (MCLs), and fish consumption criteria, as appropriate. In addition, the region at or below analytical reporting limits is shaded in gray, and the region at or below ambient background concentrations is shaded in yellow. For relevant organic COCs, model predictions are presented both with and without biodegradation. The cross-sectional contaminant distributions at 475 years for DDx and Total PCBs are presented in Figures 7A and 7B, respectively.

Copper (Figure 6A). Centerline copper concentrations are below both chronic WQC and upstream background concentrations during the entire 1,000-year model prediction period of the CDF. Therefore, no adverse effects are predicted for copper.

Naphthalene (Figure 6B). Centerline naphthalene concentrations are well below the chronic guideline during the entire 1,000-year model prediction period of the CDF. This was anticipated prior to conducting the model simulation since the initial leachate concentration was already below this criterion. Naphthalene concentrations are also predicted to remain below the analytical reporting limit. Therefore, no adverse effects are predicted for naphthalene.

It should be noted that the naphthalene prediction curves reach their maximum concentration at the berm face within years, rather than decades or centuries as is more typical of the other COCs, because naphthalene has a much lower partitioning coefficient and is, therefore, more mobile. As a result, model predictions for naphthalene were terminated early (i.e., after 20 years), because groundwater concentrations had already reached their maximum value and were declining.

Benzo(a)pyrene (Figure 6C). The benzo(a)pyrene centerline concentration remains well below the chronic guideline, and the spatially averaged concentration remains well below the MCL and fish consumption criteria during the entire 1,000-year model prediction period of the CDF. The model predicted concentrations are also below the analytical reporting limit. Therefore, no adverse effects are predicted for benzo(a)pyrene. For comparison, model predictions using a conservative biodegradation rate (41-year half life) are also presented; when biodegradation is included, benzo(a)pyrene results are many orders of magnitude below WQC.

DDx (Figure 6D). The DDx centerline concentration remains well below the chronic WQC, and the spatially averaged concentration remains well below the fish consumption criteria during the entire 1,000-year model prediction period of the CDF. The model predicted concentrations are also below the analytical reporting limit. Therefore, no adverse effects are predicted for DDx. For comparison, model predictions using a conservative biodegradation rate (90-year half life) are also presented; when biodegradation is included, DDx results are many orders of magnitude below WQC.

Significantly more attenuation will be caused by rapid initial mixing in the receiving water immediately after groundwater exits the berm, because the groundwater seepage rate (8.9 E-7 meters per second [m/sec]) is approximately 50,000 times slower than the ambient river current velocity (5 E-2 m/sec). Using a simple groundwater-surface water mixing calculation, the effect of the CDF groundwater discharge on receiving water concentrations at 10 cm from the berm face is determined to be imperceptible. This distance could conceivably represent the quality of interstitial water in the riprap armor layer placed over the berm face. As shown on Figure 6D, there is no discernible change

in the ambient background concentration in the river as a result of groundwater discharge from the CDF. At Year-475, for example, the background concentration at 10 cm from the berm face is predicted to increase by only 0.0001 percent. Negligible receiving water effects would similarly be expected for other COCs as well, including Total PCBs, as discussed below.

Total PCBs (Figure 6E). Total PCB centerline concentrations remain well below the chronic WQC during the entire 1,000-year model prediction period of the CDF. Similarly, spatially averaged concentrations remain well below the MCL during the entire 1,000-year model prediction period. Spatially averaged Total PCB concentrations remain below both the upstream background concentration and the analytical reporting limit for 500 to 600 years, although concentrations eventually rise above these levels at very long time periods.

Spatially averaged Total PCB concentrations are predicted to reach the fish consumption criterion (6.4 E-5 micrograms per liter [µg/L]) at approximately 500 years. However, model predictions using a conservatively slow biodegradation rate (60-year half life) indicate Total PCB concentrations are orders of magnitude below all WQC at all times, including the fish consumption criterion. With a biodegradation half life as long as 205 years (i.e., more than three times the recommended literature value of 60 years), the Total PCB concentrations in groundwater exiting the berm are not predicted to exceed the fish consumption criterion.

In consideration of upstream background concentrations, analytical reporting limits, and conservative biodegradation processes, no adverse water quality effects are predicted for Total PCBs.

Significantly more attenuation will be caused by rapid initial mixing in the receiving water immediately after groundwater exits the berm, because the groundwater seepage rate (8.9 E-7 m/sec) is approximately 50,000 times slower than the ambient river current velocity (5 E-2 m/sec). Simple mixing calculations were performed to estimate water concentrations at 10 cm from the berm face, as described above for DDx. This distance could conceivably represent the quality of interstitial water in the riprap armor layer

placed over the berm face. As shown on Figure 6E, there is no discernible change in the ambient background concentration in the river as a result of groundwater discharge from the CDF. At Year-475, for example, the background concentration is predicted to increase by only 0.01 percent.

Sensitivity Analysis

Model sensitivity analysis was conducted to determine which input parameters have the greatest effects on model predictions, and the relative range of those effects. Estimated minimum and maximum values for evaluating sensitivity were provided in the Groundwater Model Input Parameter Memorandum, and are reprinted in Tables 1 and 2.

Initial Sensitivity Analysis. Total PCBs and DDx were the COCs selected for the initial assessment of model sensitivity. The following parameters were evaluated:

- Sediment Fill Permeability
- Sediment Fill Source Concentration (Total PCBs and DDx)
- Berm Permeability
- Berm Fraction Organic Carbon [foc]
- Berm Partitioning Coefficient [Koc] (Total PCBs and DDx)

Results of the initial sensitivity analysis are presented in Table 4. Results include the predicted concentrations for the minimum, central tendency, and maximum value scenarios, as measured after a 475-year model prediction period. Results are presented for both the centerline concentration and the spatially averaged concentration. The geometric deviation, or multiplier (plus or minus), from the central tendency scenario is also tabulated.

In some cases, model results were not particularly sensitive to the designated ranges in input parameter values. Model results varied by less than plus 2.4 times the base case concentration as a result of variability in sediment fill permeability, berm permeability, and berm foc. An increase in the berm permeability did not cause a corresponding increase in predicted concentrations, but in contrast, a reduction in the berm permeability resulted in substantially lower predicted concentrations at the berm face (minus 16x).

A moderate degree of sensitivity was observed for sediment fill source concentrations (i.e., leachate concentrations). Model predictions varied by up to plus 2.5 times and minus 4.1 times the base case concentration as a result of variability in the source strength of PCBs and DDx. The sensitivity of the model to source concentrations is explored further in the next section.

A higher degree of sensitivity was observed for berm Koc values; in particular, significantly higher concentrations were observed for Total PCBs (plus 35x) and DDx (plus 287x) after a 475-year model prediction period when minimum Koc values were applied. These results show that minimum Koc values accelerate the arrival time of the contaminants at the berm face, and maximum Koc values retard the arrival time. Other lines of evidence, however, indicate that such low Koc values are not representative of Portland Harbor sediments, and the central Koc values selected for the T4 CDF base case simulations are appropriate. These other lines of evidence include partitioning coefficients calculated from Willamette River surface water data (i.e., particulate and dissolved fractions), and partitioning coefficients calibrated as part of the QEA-FATE modeling effort (Kevin Russell pers. comm. 2010). For example, the calibrated Log Koc values for the QEA-FATE model for DDx (geometric mean of DDD, DDE, and DDT isomers) and PCBs (geometric mean of tetra- through hepta-homolog groups) are 6.3 and 6.5 liters per kilogram (L/kg), respectively, which compare very well with the T4 CDF base case values of 6.4 and 6.4 L/kg, respectively (see Table 2). The sensitivity of the model to Koc values is explored further in the next section.

The most sensitive input parameter is the biodegradation rate (Table 4). Considering the long model simulation periods of the CDF (i.e., up to 1,000 years), even very slow biodegradation rates can have a profound effect on model results, as is clearly illustrated in Figure 6. By assuming zero biodegradation, predicted concentrations of Total PCBs and DDx after a 475-year model prediction period may be overestimated by one to two orders of magnitude (i.e., potential overprediction of 230x and 40x for Total PCBs and DDx, respectively, on a spatially averaged basis).

Supplemental Sensitivity Analysis. USEPA requested that additional sensitivity analyses be conducted to further assess the robustness of the CDF groundwater model predictions. Supplemental sensitivity analyses were focused on variability in source concentrations and berm Koc values, because model results were found to be moderately to highly sensitive to these input parameters in the initial sensitivity analysis. For these follow-up analyses, the COC list was expanded to include an assessment of copper and benzo(a)pyrene predictions, as well as DDx and Total PCBs.

A matrix summarizing the scenarios that were evaluated in the supplemental sensitivity analysis is presented in Table 5. The variability in source concentrations and Kd (or Koc) values, including minimum, central tendency, and maximum values, was assessed for all four COCs. The range of source concentrations is based on the 50th and 90th percentile values of the Portland Harbor leaching test data, and the range of Koc values is based on minimum and maximum values reported in the literature with outliers removed in some cases (see Table 2). A conservatively slow biodegradation rate was assumed in all scenarios.

The results of the supplemental sensitivity analysis are shown in Table 6 and Figures 8A through 8D. The model results were much more sensitive to variability in Koc values compared to source concentrations. In all scenarios and for all COCs, the model-predicted peak concentrations were below all applicable WQC. These results demonstrate that model predictions are robust to input parameter assumptions and provide another line of evidence to support a conclusion of no adverse long-term water quality effects.

Mass Loading Estimates

Mass loadings for the T4 CDF were calculated and compared to mass loadings from other sources in Portland Harbor, including upstream, stormwater, atmospheric, and groundwater sources, as well as inputs from in situ contaminated sediments in Portland Harbor via porewater advection and resuspension (LWG 2009, Table 6.1-11). The magnitude of the CDF mass loadings in comparison to other sources provides another line of evidence to assess the potential impacts of the CDF on the water quality in the river.

The CDF mass loadings for Total PCBs and DDx are summarized in Table 7 and Figure 9. Figure 9 shows the annualized mass loadings (kg/yr) over time in groundwater exiting the CDF, as well as the cumulative percent of the initial CDF contaminant mass that enters the river (kg). These estimates show that the annual mass loadings of Total PCBs and DDx from the CDF constitute a negligible percentage of the upstream background load entering Portland Harbor (0.0003 and 0.00001 percent, respectively) after a 475-year model prediction period. Similarly, they constitute a negligible percentage of the existing load from in situ contaminated sediments in Portland Harbor (0.007 and 0.001 percent, respectively) at the end of the model prediction period. In other words, dredging the contaminated sediments in the Harbor and placing them in the CDF is expected to result in greater than 99.99 percent reduction in the mass loadings of PCBs and DDx to the river. In addition, a negligible percentage of the initial contaminant mass of PCBs and DDx in the CDF is predicted to enter the river by the end of the model prediction period (approximately 0.0002 and 0.0001 percent of the initial mass, respectively). (Note that these results are based on the assumptions used in the modeling study, and in particular do not include consideration of sediment from AOPCs 9 or 14). Although this analysis is specific to dredging and confined disposal, it is expected that reductions in mass loadings relative to current conditions would also be realized for other remedial technologies, such as capping.

CONCLUSIONS

The following conclusions are indicated by the modeling results:

- Groundwater transport pathways are dominated by downward vertical flow through the contaminated sediment toward the underlying aquifer and laterally into the berm.
- The groundwater residence time in the contaminated fill material varies from less than 20 years along the front and bottom of the CDF, to greater than 200 years at the upper rear of the CDF. Therefore, contaminated sediments in the upper rear of the CDF are likely to have less effect on groundwater exit concentrations.
- During the entire model prediction period of 1,000 years, the centerline and spatially averaged concentrations of all COCs remained below their respective evaluation criteria—including chronic WQC, fish consumption criteria, and drinking water MCLs—under the base case scenario of no biodegradation, with only one exception. The fish consumption criterion for Total PCBs was reached at approximately 500

years. However, model predictions using a conservatively slow biodegradation rate (60-year half life) indicate Total PCB concentrations are orders of magnitude below the fish consumption criterion, as well as all other WQC, at all times. In addition, groundwater exit concentrations for copper, DDx, and Total PCBs remained below Portland Harbor upstream background concentrations, and all organic COCs remained below analytical reporting limits for at least 500 years.

- When conservatively slow rates of biodegradation are incorporated into model simulations for organic compounds, spatially averaged concentrations at the end of a 475-year model prediction period are reduced by orders of magnitude (e.g., 40x reduction for DDx, 230x reduction for Total PCBs, and even greater reductions for benzo[a]pyrene).
- Model sensitivity analysis was conducted to assess the robustness of the model predictions. The model was not overly sensitive to variations in sediment fill permeability, berm permeability, and berm organic carbon content. The model showed moderate sensitivity to dredged sediment leachate concentrations, and high sensitivity to berm Koc values and biodegradation rates. Copper, benzo(a)pyrene, DDx, and Total PCBs were subjected to a more detailed sensitivity analysis regarding initial leachate concentrations and Kd (or Koc) values under a conservatively slow biodegradation rate. In 15 sensitivity scenarios, none of the analyses were predicted to exceed any applicable WQC.
- The estimated annual mass loadings of Total PCBs and DDx from the CDF at the end of a 475-year model prediction period constitute a negligible percentage of the upstream load to Portland Harbor, as well as a negligible percentage of the existing load from in situ contaminated sediments in the Harbor. Dredging the contaminated sediments in the Harbor and placing them in the CDF is expected to result in greater than 99.99 percent reduction in the mass loading of PCBs and DDx to the river (excluding consideration of sediment from AOPCs 9 and 14).
- Based on the groundwater modeling results, the CDF as designed will be effective in controlling leachate and protective of water quality in the Willamette River.
- Additional modeling may need to be conducted during the remedial design of specific AOPC dredging actions, when more is known about which AOPCs are intended for placement in the CDF, and the details of their placement sequence. Ten of the high-priority AOPCs in Portland Harbor were evaluated in this memorandum and were

shown to be protective of water quality in the river; therefore, it is expected that subsequent modeling efforts will be focused on AOPCs with above-average leachate concentrations. In addition, some AOPCs may have additional contaminants beyond those evaluated in this memorandum that may need to be reviewed before those sediments are accepted for placement in the CDF.

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Attachments

Attachment 1	Port of Portland Response to EPA Comments on T4 CDF Long-Term Groundwater Modeling Results Memorandum
Attachment 2	Terminal 4 Phase II CDF 60 Percent Design Approach Meeting Summary
Attachment 3	USEPA CDF Performance Standards

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TABLES

Table 1
Physical and Hydraulic Properties of CDF Materials

Material	Units	Model Input Values for Base Case and Sensitivity Analysis			Data Source/Rationale
		Min.	Central	Max.	
Sediment Fill					
Fraction organic carbon	-	0.010	0.015	0.018	LWG (2009), Measured pH bulk sediment: 10% / Average / 90%
Porosity	-	-	0.35	-	Anchor (2006)
Hydraulic conductivity	ft/d	0.00017	0.00085	0.0028	Anchor (2007a); Consolidation tests from T4 and Region 10
Bulk density	g/cm^3	-	1.3	-	BBL (2005; Table 4-4); Consolidation tests from T4
Imported Fill					
Fraction organic carbon	-	0.0005	0.0006	0.0007	Anchor (2007b), Measured import from local quarries
Porosity	-	-	0.30	-	Anchor (2006)
Hydraulic conductivity	ft/d	-	28	-	Freeze and Cherry (1979; Table 2.2); clean sand
Bulk density	g/cm^3	-	2.0	-	Holz and Kovacs (1981; Table 2-1)
Berm Fill					
Fraction organic carbon	-	0.0005	0.0006	0.0007	Anchor (2007b), Measured import from local quarries
Porosity	-	-	0.30	-	Anchor (2006)
Hydraulic conductivity	ft/d	30	280	450	Hazen's approximation based on gradation specification for Select Fill
Bulk density	g/cm^3	-	2.0	-	Holz and Kovacs (1981; Table 2-1)
Dispersion - Horizontal	-	-	40	-	Anchor (2006); NewFields (2007a): Dynamic model calibration
Dispersion - Vertical	-	-	0.4	-	Anchor (2006); NewFields (2007a): Dynamic model calibration
Training Dikes					
Fraction organic carbon	-	-	0.00006	-	Assumed 10 percent of Berm Fill value
Porosity	-	-	0.30	-	Anchor (2006)
Hydraulic conductivity	ft/d	-	2,800	-	Freeze and Cherry (1979; Table 2.2); clean gravel
Bulk density	g/cm^3	-	2.2	-	Holz and Kovacs (1981; Table 2-1)
Aquifer					
Fraction organic carbon	-	-	0.003	-	BBL (2005); Average measured value in Slip 1 aquifer material
Porosity	-	-	0.30	-	Anchor (2006)
Hydraulic conductivity (K)	ft/d	-	65	-	Hart Crowser (2000); Pumping test results, as reported in BBL (2005)
Bulk Density	g/cm^3	-	2.0	-	Holz and Kovacs (1981; Table 2-1)

"Base case" input values used in Figures 6A through 6E

Table 2
Geochemical Properties of Chemicals of Concern

Material	Units	Model Input Values for Base Case and Sensitivity Analysis			Data Source/Rationale
		Min.	Central	Max.	
Initial Source Concentrations in Contaminated Sediment Pore Waters					
Copper	µg/L	4	8	14	LWG (2009); Geometric Mean, Arithmetic Mean, and 90th Percentile of SBLT results
Naphthalene	µg/L	0.04	0.07	0.15	LWG (2009); Geometric Mean, Arithmetic Mean, and 90th Percentile of SBLT results
Benzo(a)pyrene	µg/L	0.12	0.23	0.52	LWG (2009); Geometric Mean, Arithmetic Mean, and 90th Percentile of SBLT results
Total DDX	µg/L	0.014	0.058	0.076	LWG (2009); Geometric Mean, Arithmetic Mean, and 90th Percentile of SBLT results
Total PCB Aroclors	µg/L	0.22	0.87	2.17	LWG (2009); Geometric Mean, Arithmetic Mean, and 90th Percentile of SBLT results
Metal Partitioning Coefficient [Kd]					
Copper [Sediment]	L/kg	-	8,900	-	Anchor QEA and Newfields (2010); LWG (2009); Geometric Mean of AOPCs
Copper [Berm, Cap]	L/kg	100	165	-	NewFields (2007b)
Copper [Quarry Spall]	L/kg	1	20	-	USEPA (2005; Table 3); Minimum and 1st Percentile Kd
Log Organic Partitioning Coefficient [Koc] - Sediment					
Naphthalene	Log L/kg-OC	-	4.97	-	Anchor QEA and Newfields (2010); LWG (2009); Geometric Mean of AOPCs
Benzo(a)pyrene	Log L/kg-OC	-	5.18	-	Anchor QEA and Newfields (2010); LWG (2009); Geometric Mean of AOPCs
Total DDX	Log L/kg-OC	-	4.87	-	Anchor QEA and Newfields (2010); LWG (2009); Geometric Mean of AOPCs
Total PCB Aroclors	Log L/kg-OC	-	4.86	-	Anchor QEA and Newfields (2010); LWG (2009); Linear Isotherm Model
Log Organic Partitioning Coefficient [Koc] - Berm					
Naphthalene	Log L/kg-OC	3.12	3.30	3.53	LWG RI Report Table E6 (2009)
Benzo(a)pyrene	Log L/kg-OC	5.68	6.01	6.67	LWG RI Report Table E6 (2009)
Total DDX	Log L/kg-OC	5.69	6.44	6.62	LWG RI Report Table E6 (2009); Geometric Mean of DDT, DDE, and DDD
Total PCB Aroclors	Log L/kg-OC	5.96	6.39	7.59	LWG RI Report Table E6 (2009); Geometric Mean of Ar-1254 and Ar-1260
Biodegradation Half Life in Sediment [Anaerobic]					
Naphthalene	days	-	1,100	Infinite[1]	Central value = 95% UCL from Bach et al. (2005); Coates et al. (1996a, 1996b, 1997); Chang et al. (2001); Heitkamp & Cerniglia (1987); Rothermich et al. (2002)
Benzo(a)pyrene	days	-	15,000	Infinite[1]	
Total DDX	days	-	33,000	Infinite[1]	Eganhouse et al. (2000a, 2000b)
Total PCB Aroclors	days	-	22,000	Infinite[1]	Magar et al. (2005); van Dort et al. (1997); Mackay et al. (1994); Davis (2004)

Notes: [1] Infinite half life corresponds to zero biodegradation

"Base case" input values used in Figures 6A through 6E

Table 3
Groundwater Evaluation Criteria

Criteria (µg/L)	Copper	Naphthalene	Benzo(a)pyrene	DDx	Total PCBs
Chronic WQC[1]	2.7	194	0.96	0.001	0.014
Drinking Water MCL[2]	1,300	N/A	0.2	N/A	0.5
Fish Consumption Criteria[3]	N/A	N/A	0.018	0.00022	6.4E-05
Upstream Background[4]	3.1	0.024	0.0005	0.00059	3.9E-04
Analytical Reporting Limit[5]	0.1	0.02	0.02	0.00050	2.0E-04

Notes:

1. Copper, DDx, and Total PCBs from ODEQ 2005, Table 33A, www.deq.state.or.us/wq/rules/div041/table33a.pdf and USEPA 2010, National Recommended Water Quality Criteria, www.epa.gov/waterscience/criteria/wqctable; Criteria for naphthalene and benzo(a)pyrene from USEPA 2003.
2. USEPA 2009, www.epa.gov/safewater/contaminants/index.html
3. USEPA 2010, National Recommended Water Quality Criteria, www.epa.gov/waterscience/criteria/wqctable
4. LWG 2009, Portland Harbor Draft RI Report, Table 7.4-4.
5. LWG 2007, Round 2 QAPP, Addendum 8, Table 3-2, for all constituents except Total PCBs; Total PCBs based on 90th percentile laboratory blank contamination levels (using LWG 2009 data).

N/A = Not applicable

Table 4
Results of Initial Sensitivity Analysis of Model Input Parameters

A. CENTERLINE CONCENTRATION

		Concentration at 475 yr (µg/L)			Geometric Deviation	
		MIN	CENTRAL (BASE)	MAX	Plus /	Minus
Physical Properties - PCBs						
Sediment Fill	Hydr. Cond.	2.6E-04	2.8E-04	3.5E-04	1.3 X	1.1 X
Berm	foc	6.7E-04	2.8E-04	1.2E-04	2.4 X	2.4 X
Berm	Hydr. Cond.	1.8E-05	2.8E-04	2.3E-04	0.8 X	15.8 X
Geochemical Properties - PCBs						
Sediment Fill	Source Conc.	7.1E-05	2.8E-04	7.0E-04	2.5 X	4.0 X
Berm	Koc	9.8E-03	2.8E-04	5.3E-17	35 X	5.E+12 X
Geochemical Properties - DDx						
Sediment Fill	Source Conc.	2.1E-06	8.7E-06	1.2E-05	1.3 X	4.1 X
Berm	Koc	2.5E-03	8.7E-06	5.9E-07	287 X	15 X
Biodegradation		MIN	CENTRAL	MAX (BASE)		
PCBs		N/M	1.2E-06	2.8E-04	N/A	233 X
DDx		N/M	2.3E-07	8.7E-06	N/A	38 X

B. SPATIAL AVERAGE CONCENTRATION

		Concentration at 475 yr (µg/L)			Geometric Deviation	
		MIN	CENTRAL (BASE)	MAX	Plus /	Minus
Physical Properties - PCBs						
Sediment Fill	Hydr. Cond.	6.6E-05	7.2E-05	9.1E-05	1.3 X	1.1 X
Berm	foc	1.7E-04	7.2E-05	3.0E-05	2.4 X	2.4 X
Berm	Hydr. Cond.	4.6E-06	7.2E-05	5.6E-05	0.8 X	15.7 X
Geochemical Properties - PCBs						
Sediment Fill	Source Conc.	1.8E-05	7.2E-05	1.8E-04	2.5 X	4.0 X
Berm	Koc	2.8E-03	7.2E-05	1.2E-17	39 X	6.E+12 X
Geochemical Properties - DDx						
Sediment Fill	Source Conc.	5.3E-07	2.3E-06	2.9E-06	1.3 X	4.3 X
Berm	Koc	7.4E-04	2.3E-06	1.5E-07	322 X	15 X
Biodegradation		MIN	CENTRAL	MAX (BASE)		
PCBs		N/M	3.1E-07	7.2E-05	N/A	232 X
DDx		N/M	5.7E-08	2.3E-06	N/A	40 X

Notes:
N/A = Not applicable
N/M = Scenario was not modeled

Table 5
Supplemental Sensitivity Analysis Matrix

COC/Sensitivity Scenario	Values for Supplemental Sensitivity Analysis									
	Initial Source Concentrations in Sediment Pore Waters µg/L			Metal Partitioning Coefficient [Kd] L/kg						
	Min.	Central	Max.		Min.	Central	Max.	-	-	-
Copper	**4**	**8**	**14**	**[Sediment]**	**-**	**8,900**	**-**	**-**	**-**	**-**
				[Berm, Cap]	**100**	**165**	**-**	**-**	**-**	**-**
				[Quarry Spall]	**1**	**20**	**-**	**-**	**-**	**-**
Cu_Src_max	-	-	X		-	X	-	-	-	-
Cu_Src_min	X	-	-		-	X	-	-	-	-
Cu_Kd_min	-	X	-		X	-	-	-	-	-
				Log Organic Partitioning Coefficient [Koc] Log L/kg-OC				Biodegradation Half Life [Anaerobic] Days		
	Min.	Central	Max.		Min.	Central	Max.	Min.	Central	Max.
Benzo(a)pyrene	**0.12**	**0.23**	**0.52**	**Berm, Cap, Spall**	**5.68**	**6.01**	**6.67**	**470**	**15,000**	**Infinite**
BaP_Src_max	-	-	X		-	X	-	-	X	-
BaP_Src_min	X	-	-		-	X	-	-	X	-
BaP_Koc_max	-	X	-		-	-	X	-	X	-
BaP_Koc_min	-	X	-		X	-	-	-	X	-
				Log Organic Partitioning Coefficient [Koc] Log L/kg-OC				Biodegradation Half Life [Anaerobic] Days		
	Min.	Central	Max.		Min.	Central	Max.	Min.	Central	Max.
DDx	**0.014**	**0.058**	**0.076**	**Berm, Cap, Spall**	**5.69**	**6.44**	**6.62**	**11,000**	**33,000**	**Infinite**
DDX_Src_max	-	-	X		-	X	-	-	X	-
DDX_Src_min	X	-	-		-	X	-	-	X	-
DDX_Koc_max	-	X	-		-	-	X	-	X	-
DDX_Koc_min	-	X	-		X	-	-	-	X	-
				Log Organic Partitioning Coefficient [Koc] Log L/kg-OC				Biodegradation Half Life [Anaerobic] Days		
	Min.	Central	Max.		Min.	Central	Max.	Min.	Central	Max.
Total PCBs	**0.22**	**0.87**	**2.17**	**Berm, Cap, Spall**	**5.96**	**6.39**	**7.59**	**-**	**22,000**	**Infinite**
PCB_Src_max	-	-	X		-	X	-	-	X	-
PCB_Src_min	X	-	-		-	X	-	-	X	-
PCB_Koc_max	-	X	-		-	-	X	-	X	-
PCB_Koc_min	-	X	-		X	-	-	-	X	-

Table 6
Results of Supplemental Sensitivity Analysis of Model Input Parameters

	Peak Concentration	Basis	Years to Peak[1]
Copper			
Chronic Criterion	2.7		
Upstr. Background	3.1		
Central Estimate	1.2	Centerline	464
Source - Min	0.6	Centerline	464
Source - Max	2.1	Centerline	464
Kd - Min	1.8	Centerline	330
Kd - Max	N/M	N/M	N/M
Benzo(a)pyrene			
Fish Consumption Crit.	1.8E-02		
Upstr. Background	5.0E-04		
Analyt. Reporting Lmt.	2.0E-02		
Central Estimate	1.6E-06	Spatial Avg.	275
Source - Min	8.3E-07	Spatial Avg.	275
Source - Max	3.6E-06	Spatial Avg.	275
Koc - Min	3.4E-05	Spatial Avg.	190
Koc - Max	2.4E-11	Spatial Avg.	475
DDx			
Fish Consumption Crit.	2.2E-04		
Upstr. Background	5.9E-04		
Analyt. Reporting Lmt.	5.0E-04		
Central Estimate	5.8E-08	Spatial Avg.	475
Source - Min	1.4E-08	Spatial Avg.	475
Source - Max	7.5E-08	Spatial Avg.	475
Koc - Min	5.0E-05	Spatial Avg.	260
Koc - Max	1.5E-09	Spatial Avg.	475
Total PCBs			
Fish Consumption Crit.	6.4E-05		
Upstr. Background	3.9E-04		
Analyt. Reporting Lmt.	2.0E-04		
Central Estimate	3.1E-07	Spatial Avg.	475
Source - Min	7.7E-08	Spatial Avg.	475
Source - Max	7.6E-07	Spatial Avg.	475
Koc - Min	3.9E-05	Spatial Avg.	303
Koc - Max	< 1.0E-30	Spatial Avg.	475

Notes:

[1] Maximum of 475 years is reported if peak concentration is not achieved by that time

N/M = Scenario was not modeled

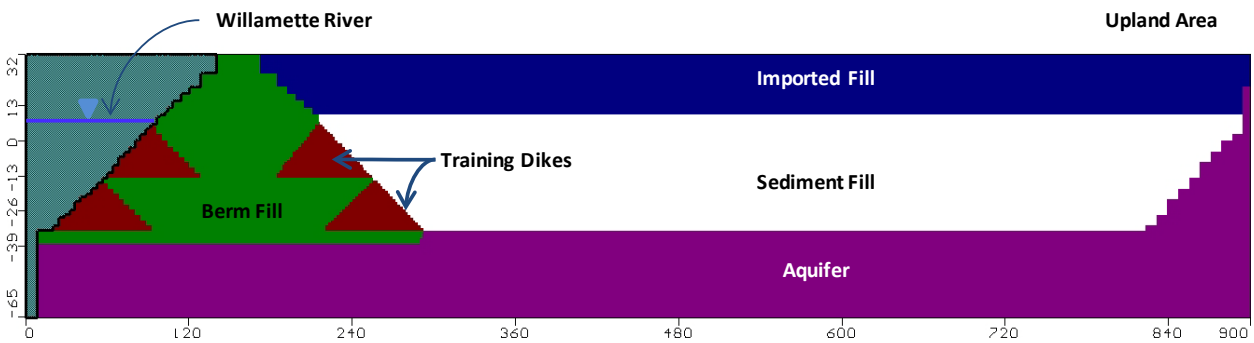
Table 7
Comparison of Portland Harbor and T4 CDF Mass Loadings

	Annual Load (kg/yr)	
Portland Harbor Mass Load	**Total PCBs**	**DDx**
Upstream	4.71	7.53
Stormwater	2.03	0.40
Atmospheric	0.63	0.17
Groundwater	0.00	0.02
Sediment (subsurface)	0.08	0.02
Sediment (surface)	0.12	0.01
TOTAL	**7.57**	**8.15**
T4 CDF Mass Load		
CDF Mass Load @ 475 years	1.4E-05	4.1E-07
Percent of Upstream Load	0.0003%	0.00001%
Percent of Sediment Load	0.007%	0.001%

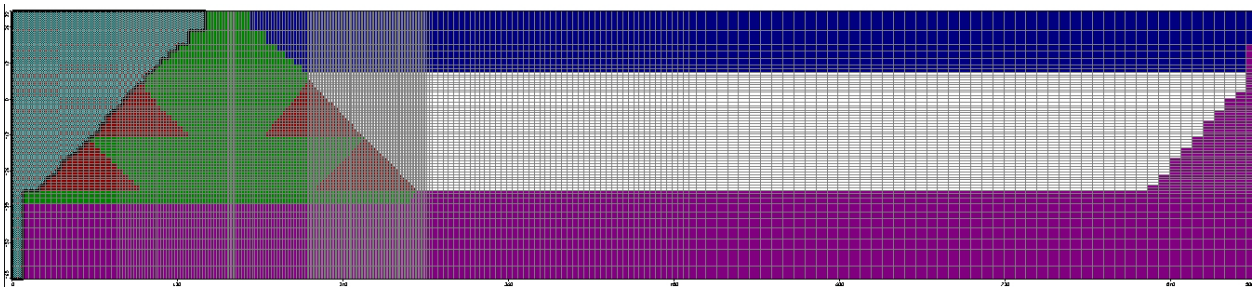
Note:

Estimated T4 CDF mass loads do not include sediments from AOPC 9 (Gasco) or AOPC 14 (Arkema).

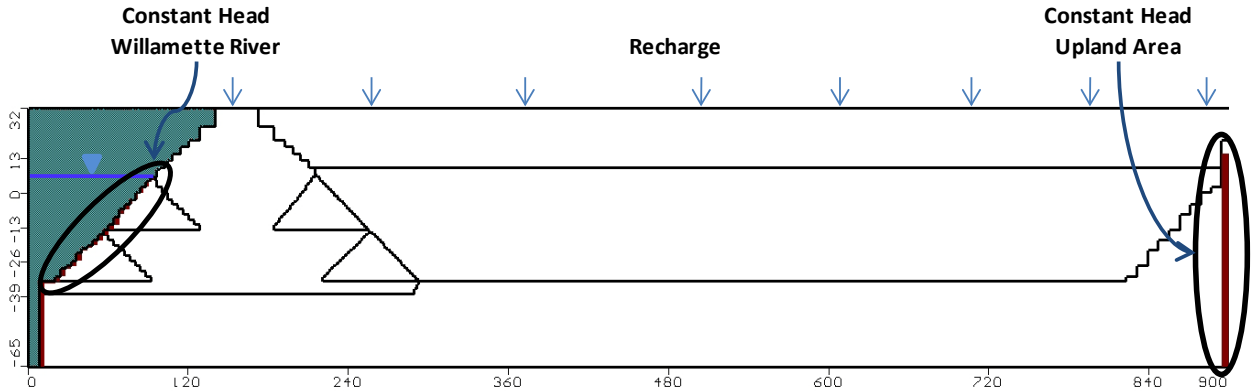
FIGURES



A. Key Hydrogeologic Units



B. Model Grid



C. Boundary Conditions

Figure 1
Model Structure
Long-Term Groundwater Modeling Results Memorandum
Port of Portland Terminal 4 Confined Disposal Facility

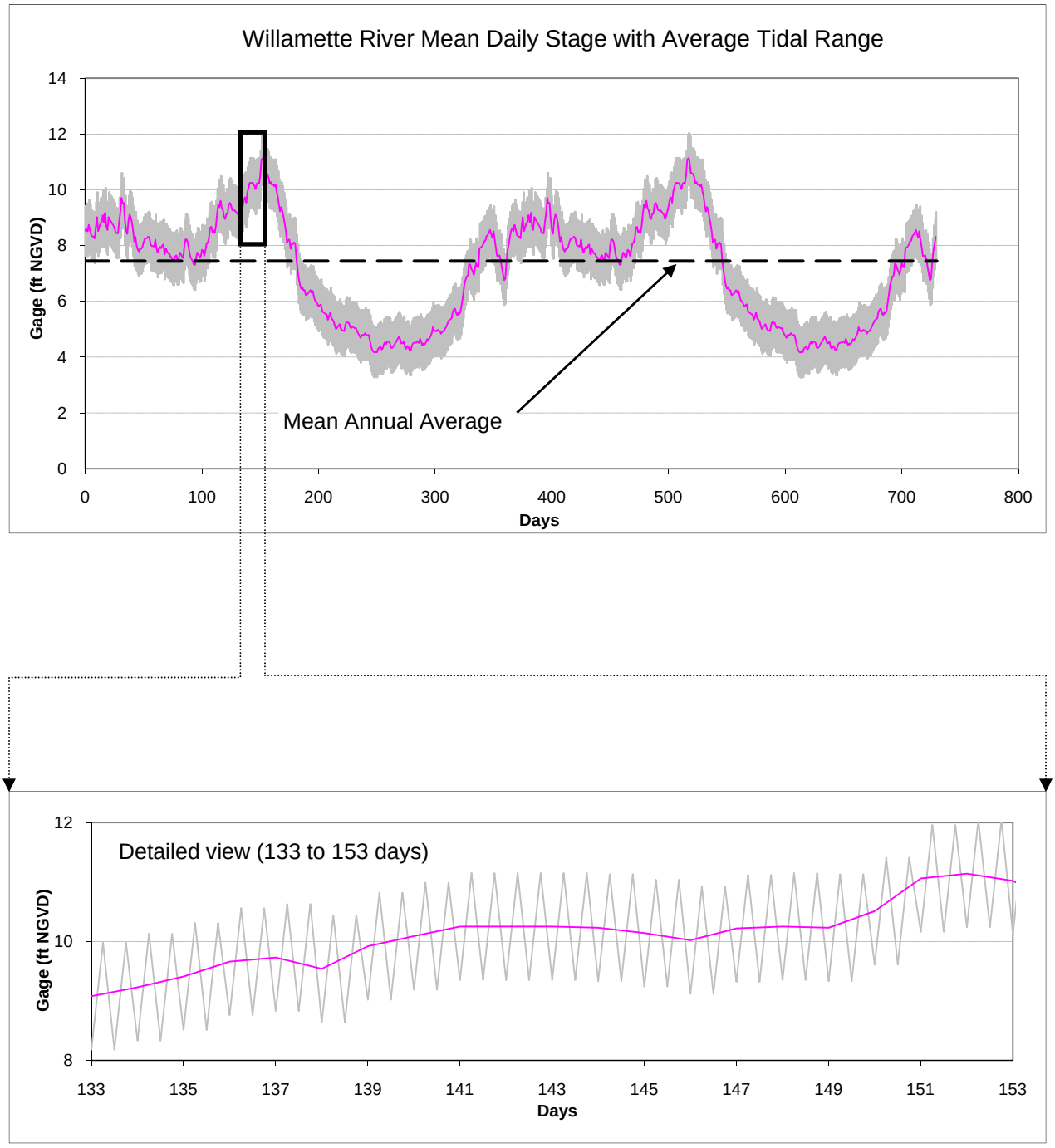


Figure 2

Willamette River Seasonal and Diurnal Tidal Fluctuations
Long-Term Groundwater Modeling Results Memorandum
Port of Portland Terminal 4 Confined Disposal Facility

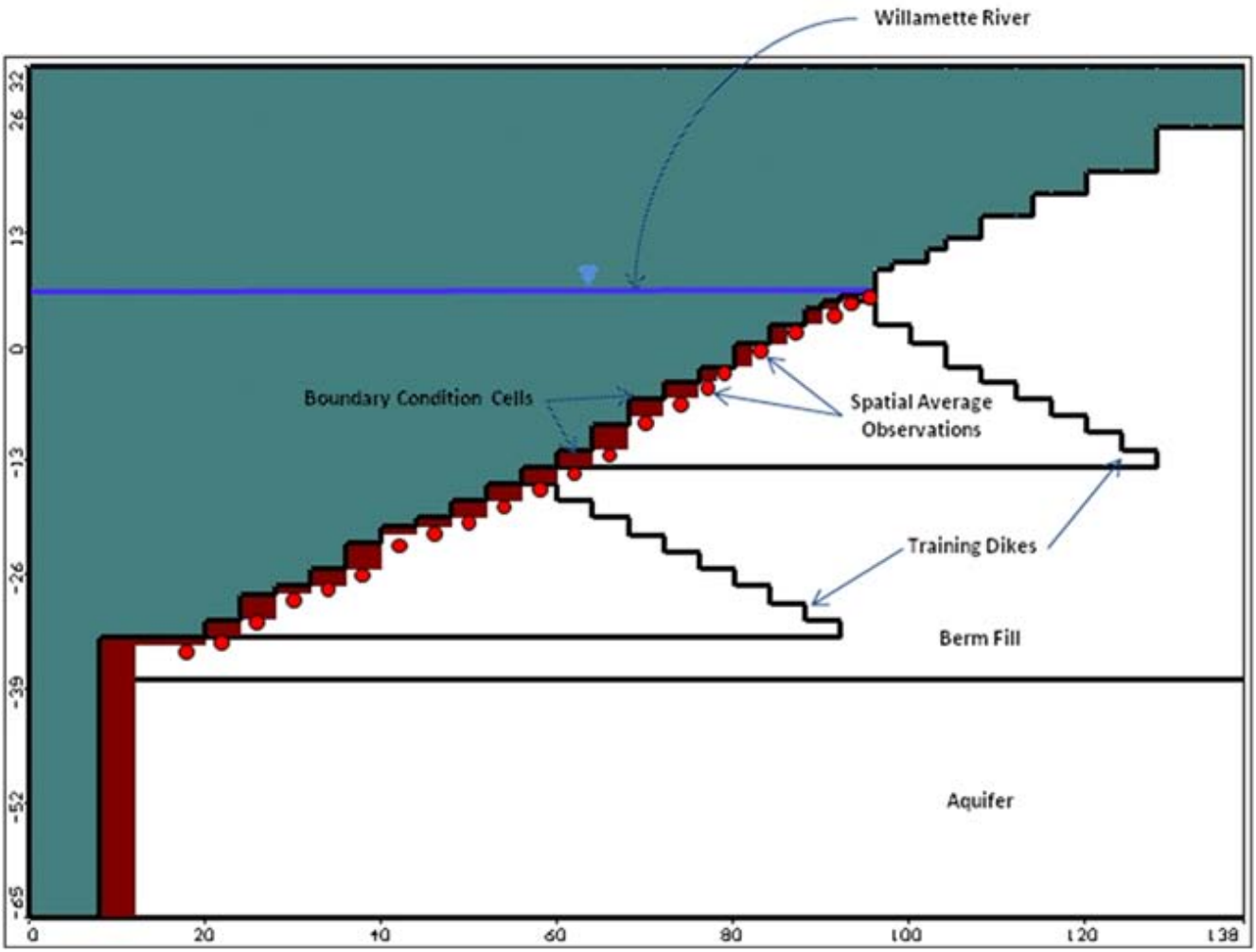


Figure 3
Detail of Model Domain at Berm Interface
Long-Term Groundwater Modeling Results Memorandum
Port of Portland Terminal 4 Confined Disposal Facility

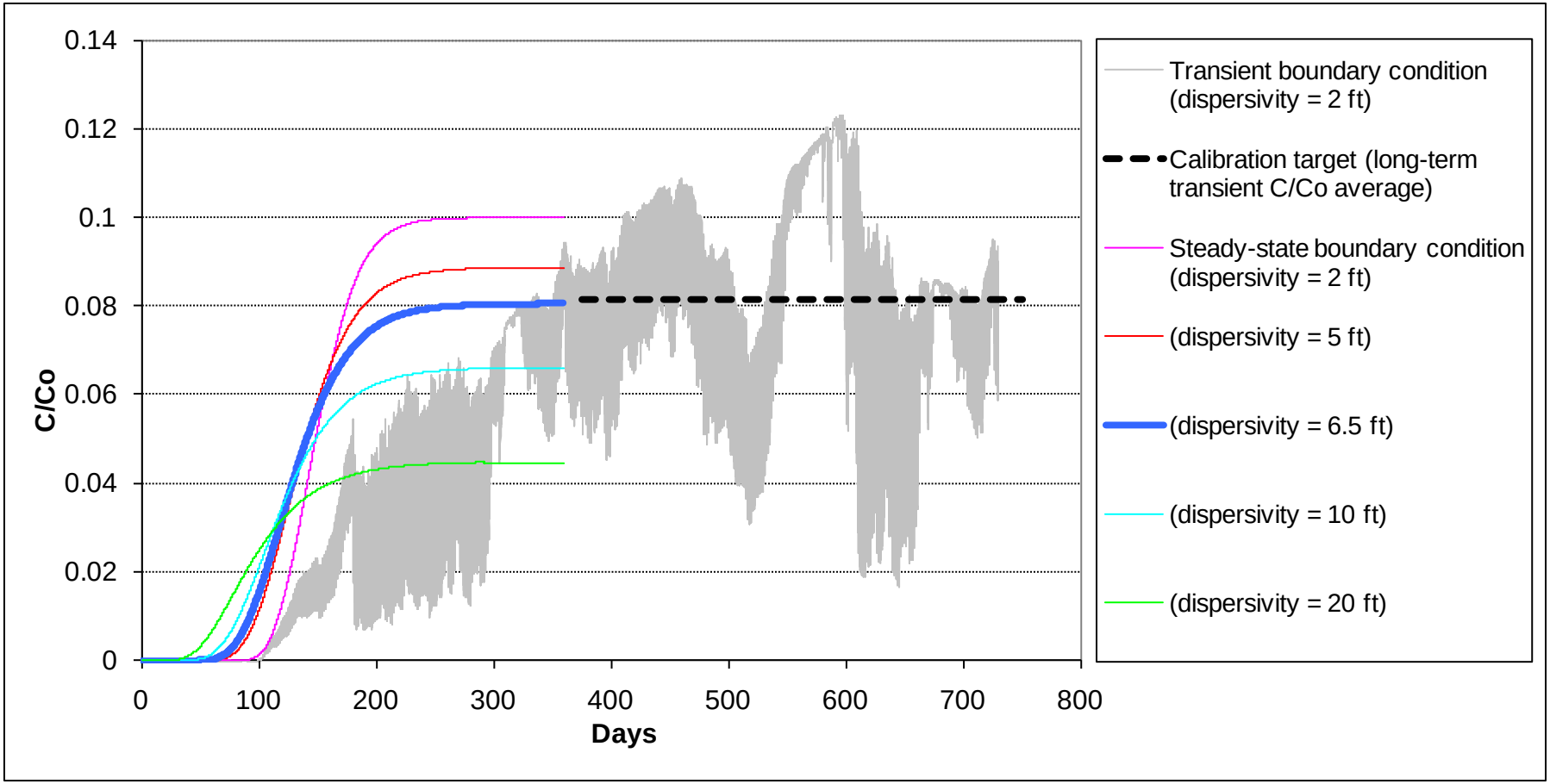
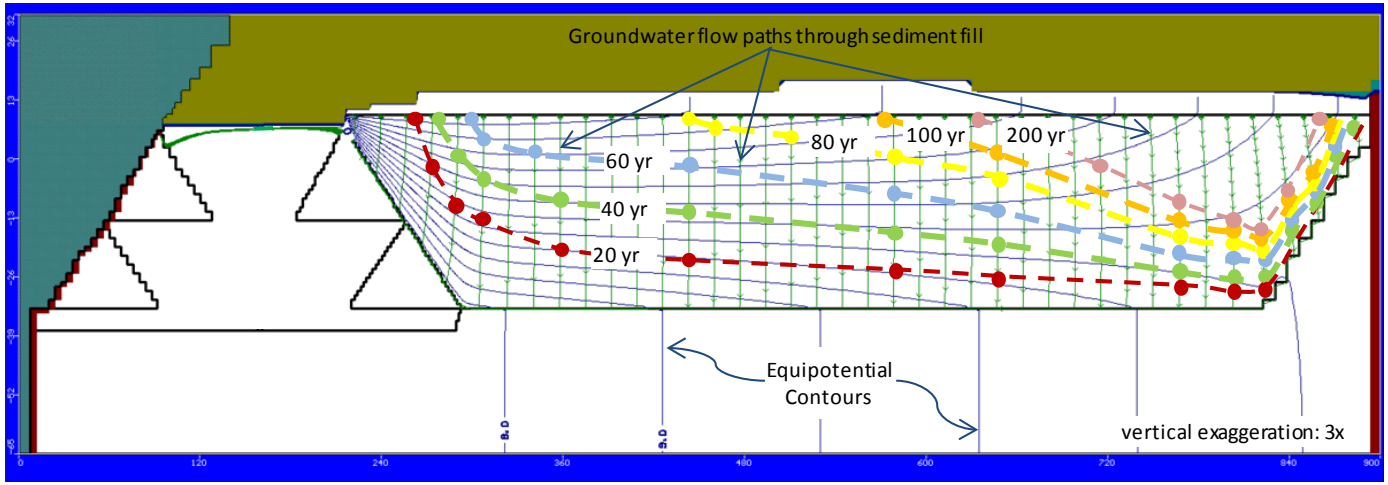
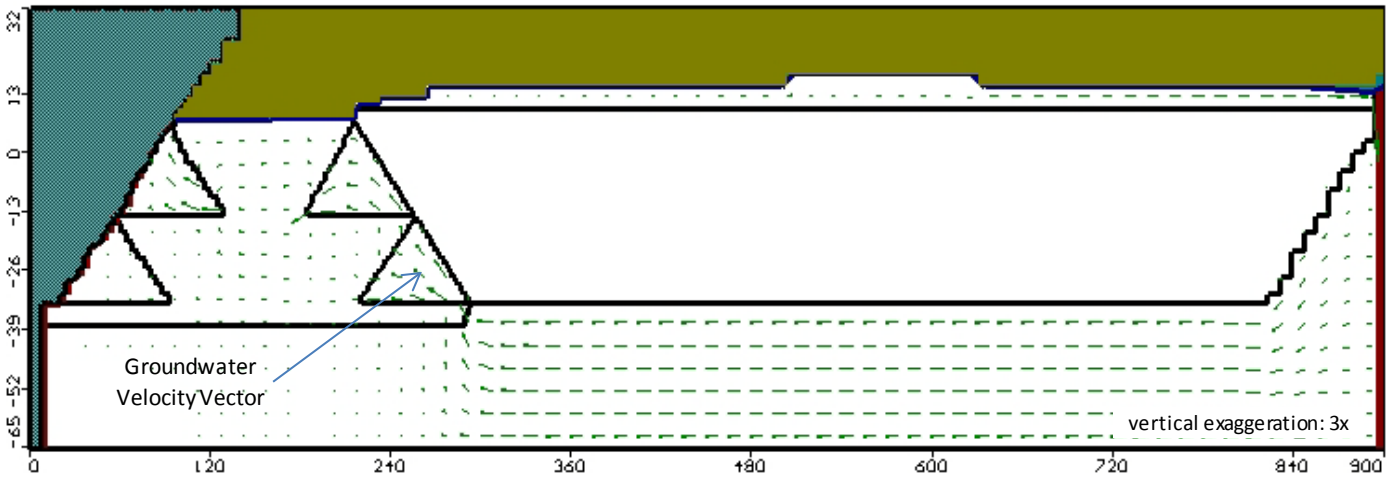


Figure 4
Effective Dispersion Calibration
Long-Term Groundwater Modeling Results Memorandum
Port of Portland Terminal 4 Confined Disposal Facility

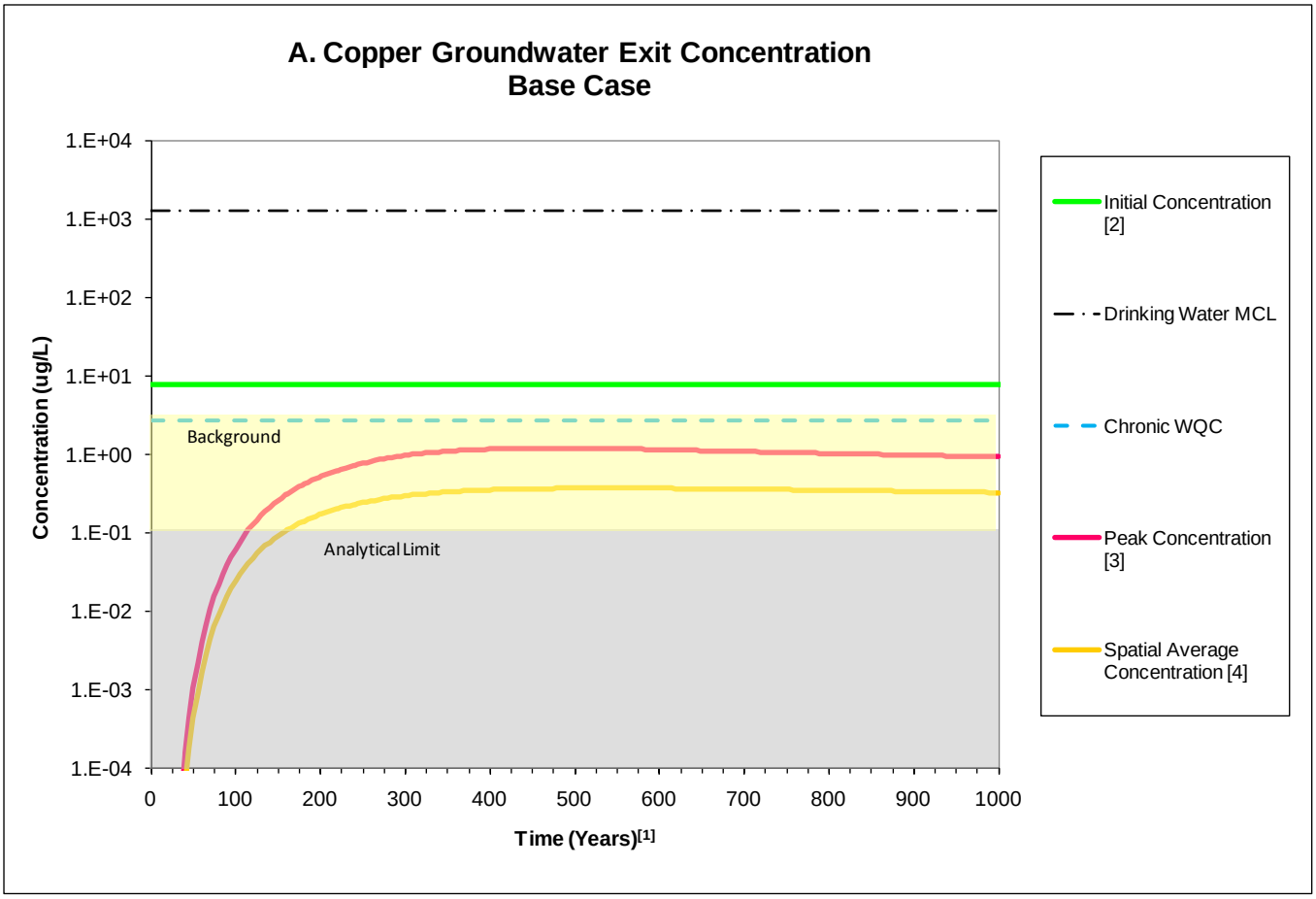


A. Groundwater Flow Paths and Residence Times



B. Groundwater Velocity Vectors

Figure 5
CDF Groundwater Flow Characteristics
Long-Term Groundwater Modeling Results Memorandum
Port of Portland Terminal 4 Confined Disposal Facility



Notes:

Groundwater observation point is the predicted concentration in last model cell adjacent to river boundary, approximately one foot below the berm face.

[1] Time zero refers to the time when CDF construction is complete. It may take up to 4 to 6 years to fill and cover the CDF.

[2] Initial Concentration = sediment leachate concentration in CDF estimated using SBLT test results; see Appendix A and Table 6-7.

[3] Peak Concentration = peak contaminant concentration in groundwater exiting the CDF berm.

[4] Spatial Average Concentration = average contaminant concentration in groundwater exiting the CDF berm averaged vertically over the CDF berm face.

Figure 6

Model Predictions

Long-Term Groundwater Modeling Results Memorandum

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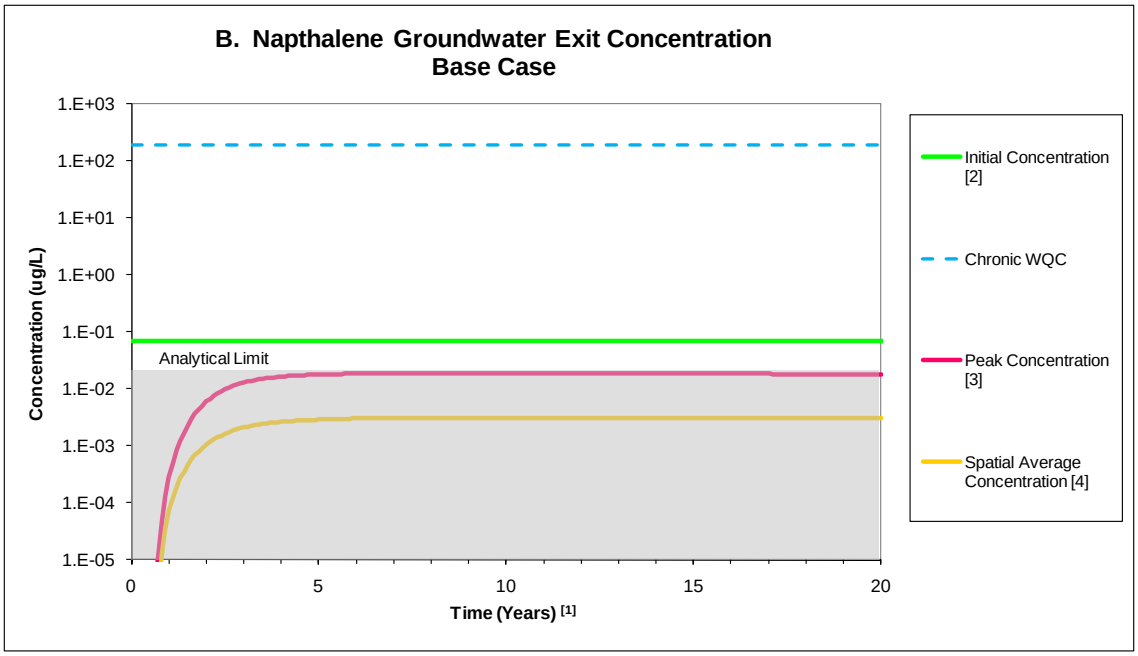

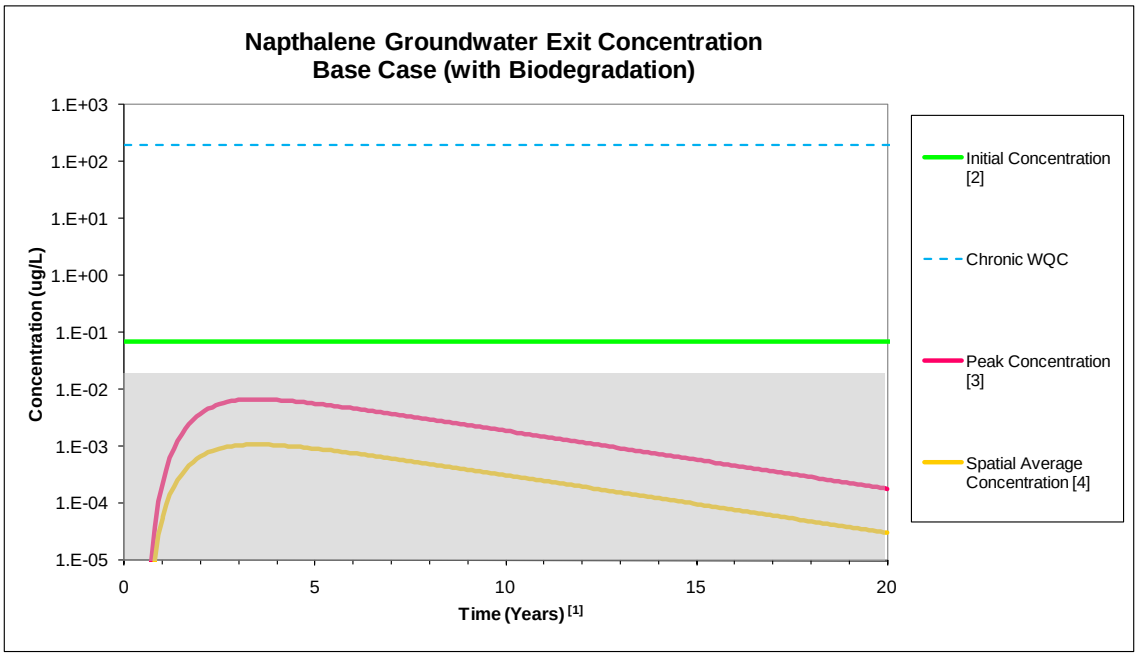

Notes:

Groundwater observation point is the predicted concentration in last model cell adjacent to river boundary, approximately one foot below the berm face.

Naphthalene predictions were terminated early after it was observed that exit concentrations had peaked and were subsequently declining.

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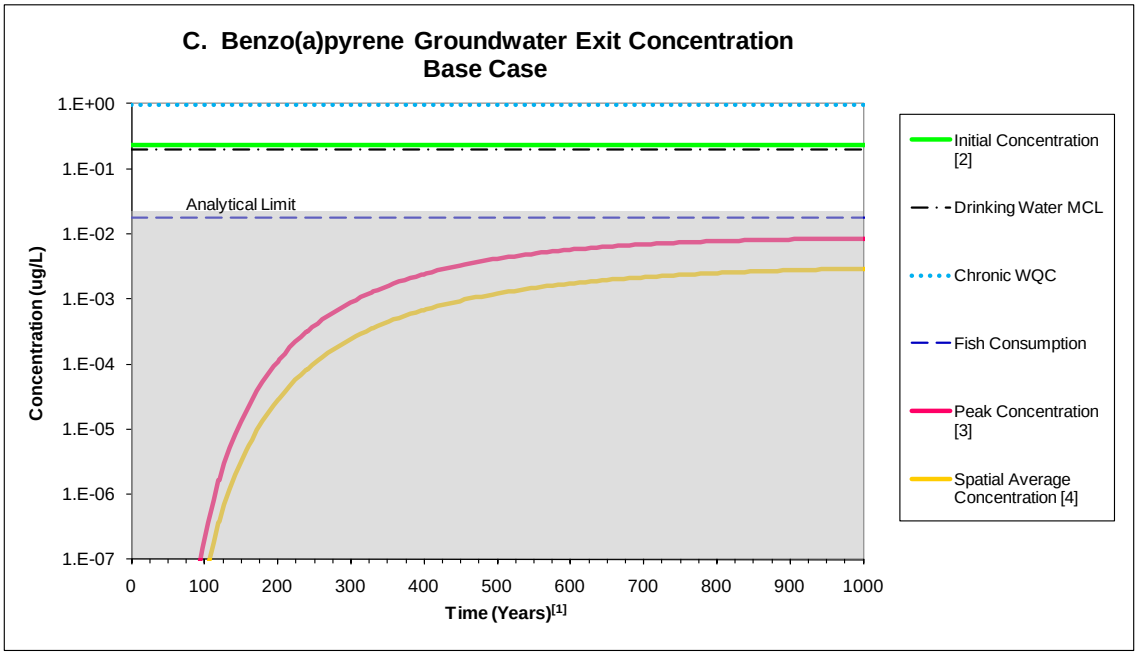
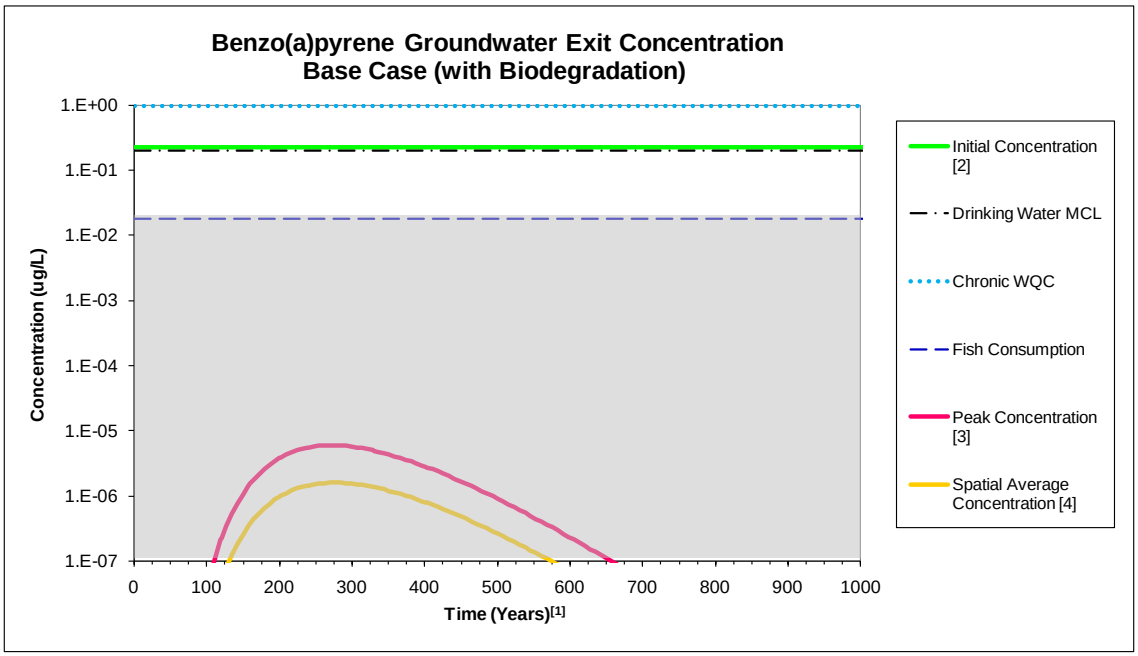
Long-Term Groundwater Modeling Results Memorandum

Port of Portland Terminal 4 Confined Disposal Facility





Notes:

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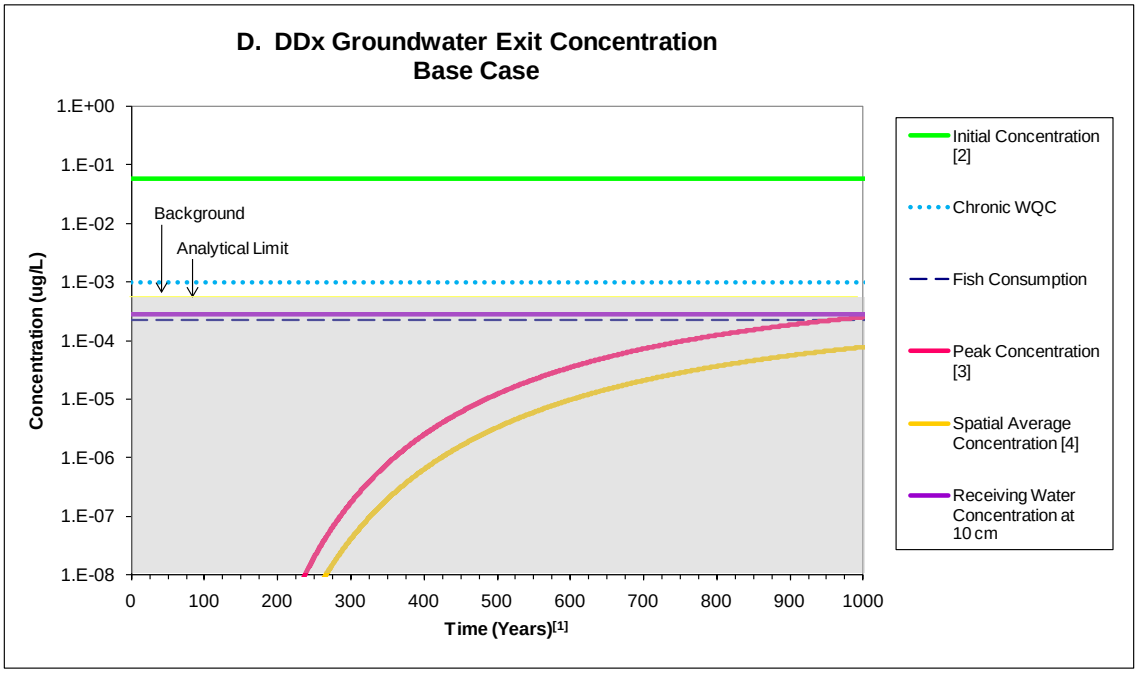
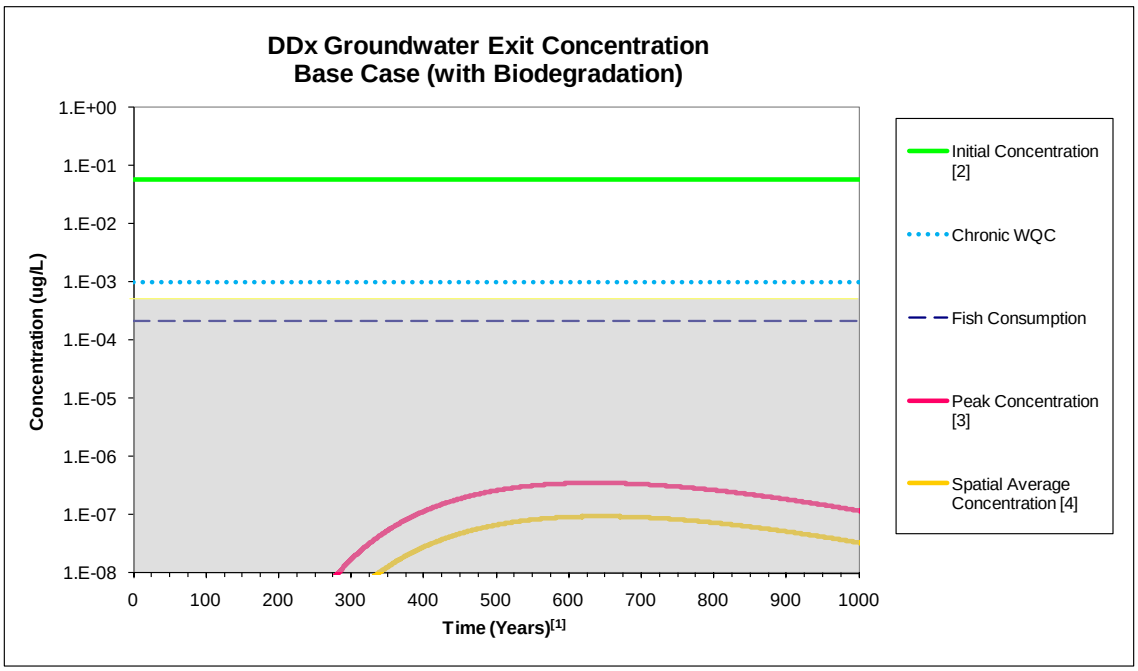
Figure 6

Model Predictions

Long-Term Groundwater Modeling Results Memorandum

Port of Portland Terminal 4 Confined Disposal Facility





Notes:

Groundwater observation point is the predicted concentration in last model cell adjacent to river boundary, approximately one foot below the berm face.

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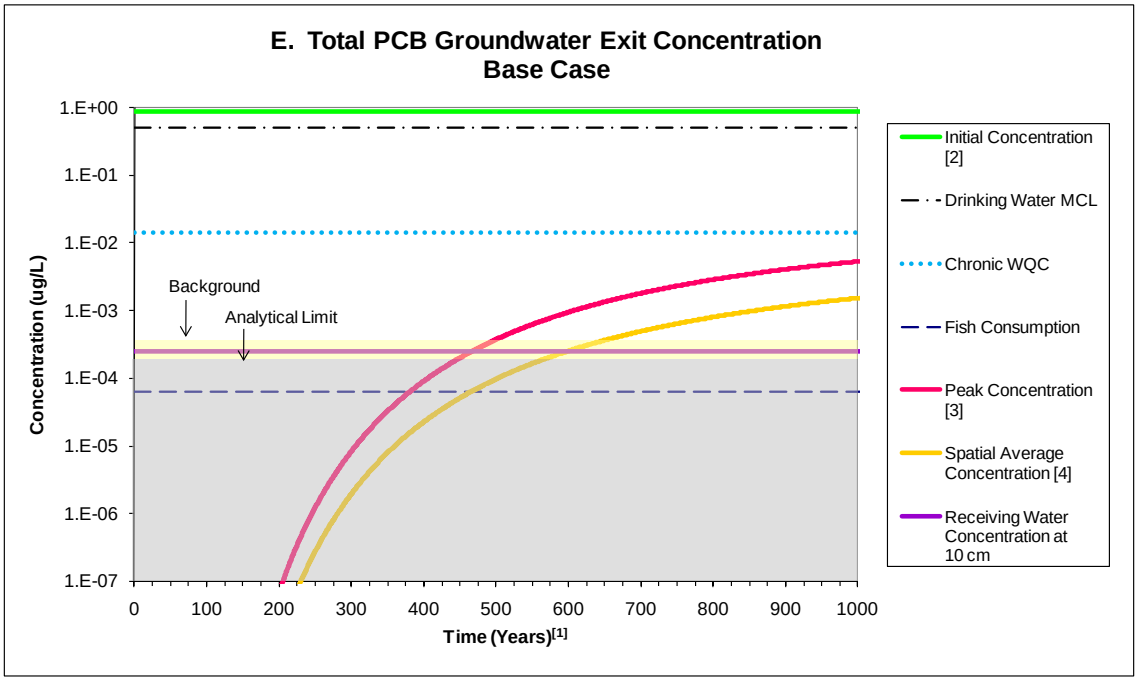
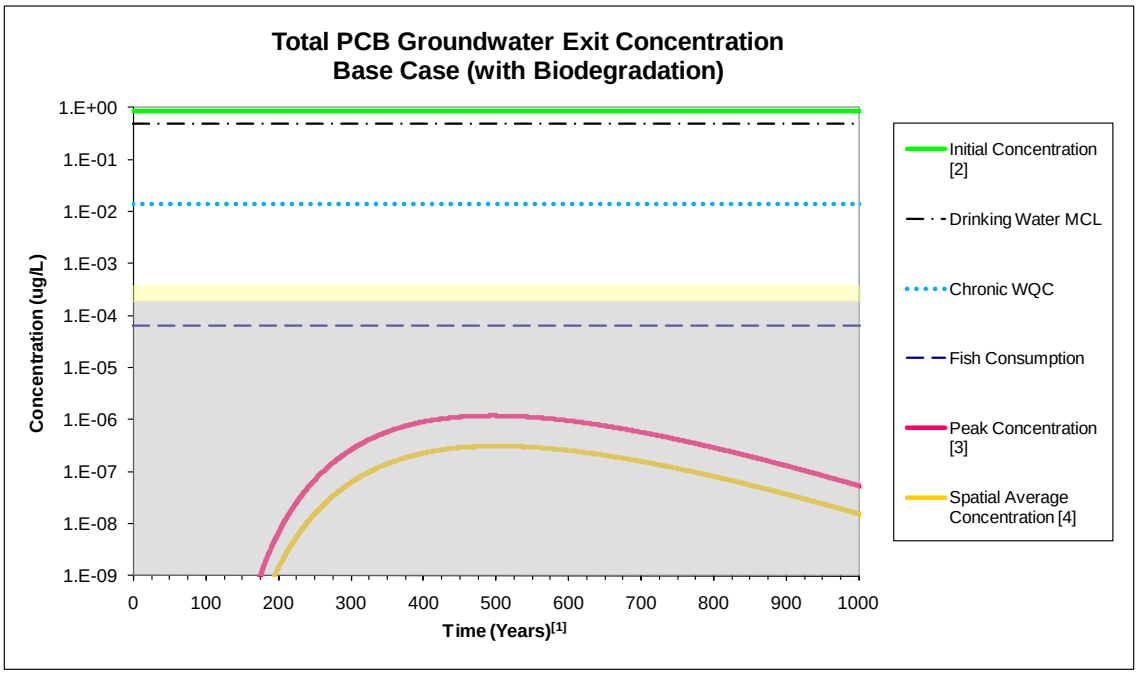
Figure 6

Model Predictions

Long-Term Groundwater Modeling Results Memorandum

Port of Portland Terminal 4 Confined Disposal Facility





Notes:

Groundwater observation point is the predicted concentration in last model cell adjacent to river boundary, approximately one foot below the berm face.

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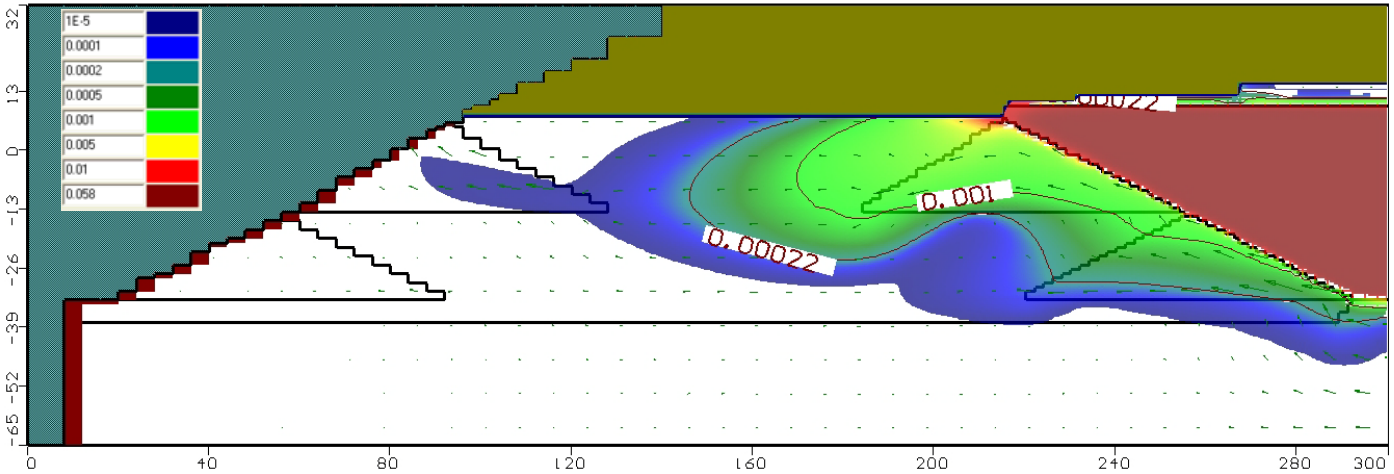
Figure 6

Model Predictions

Long-Term Groundwater Modeling Results Memorandum

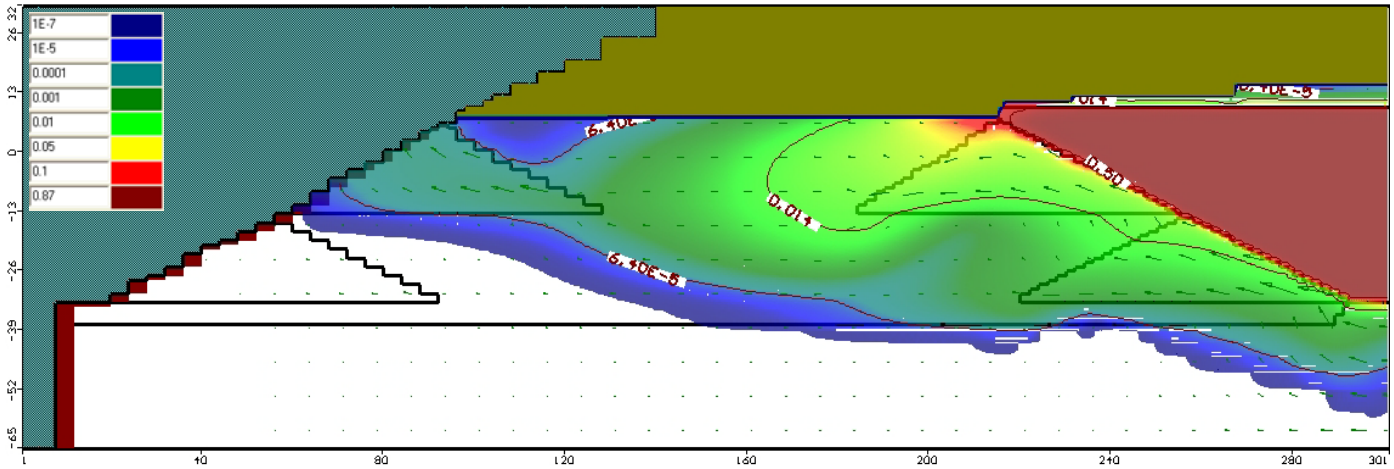
Port of Portland Terminal 4 Confined Disposal Facility

DDx at 475 years (in µg/L)



A. DDx

Total PCBs at 475 years (in µg/L)



B. Total PCBs

Figure 7
Contaminant Distributions at 475 Years
Long-Term Groundwater Modeling Results Memorandum
Port of Portland Terminal 4 Confined Disposal Facility

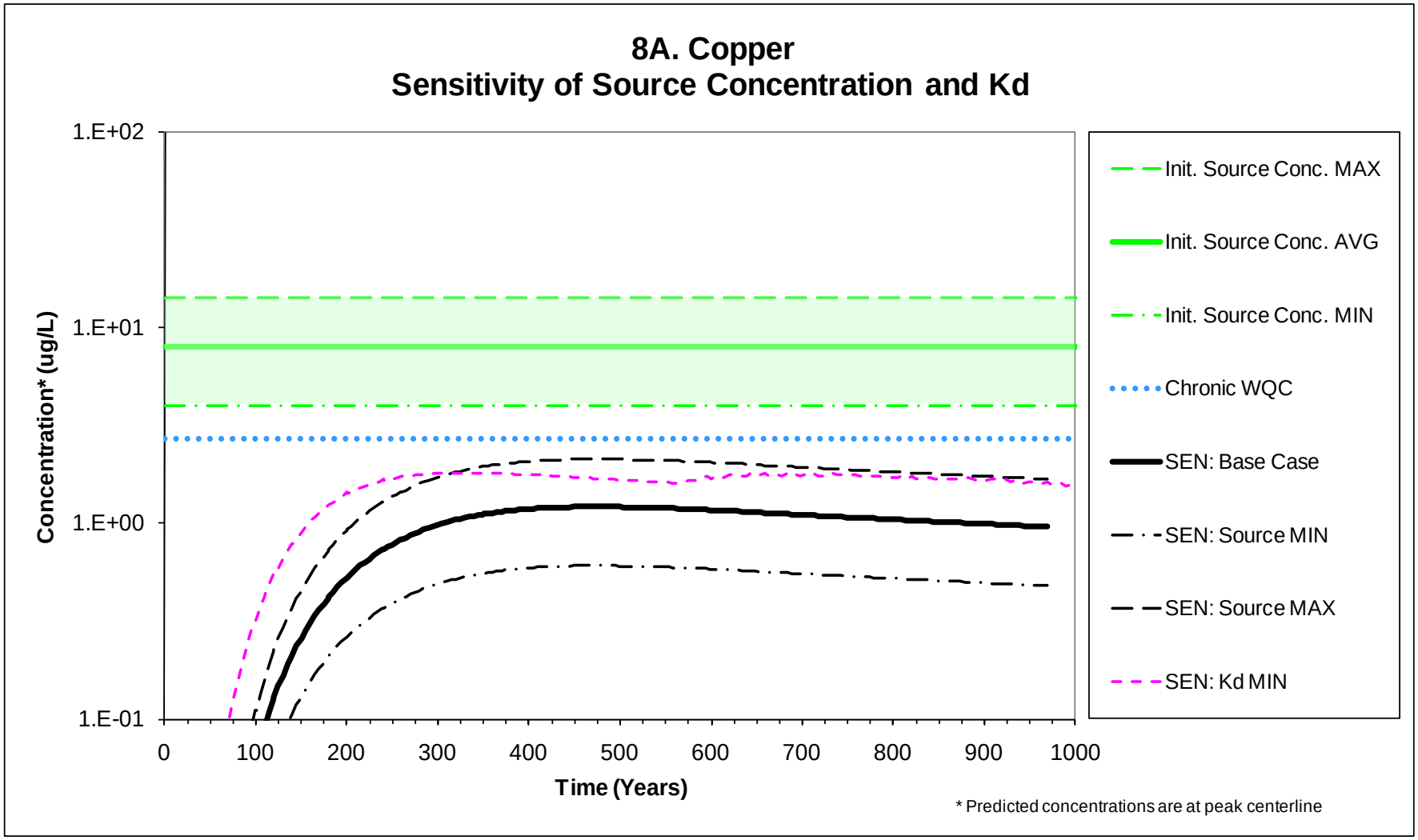
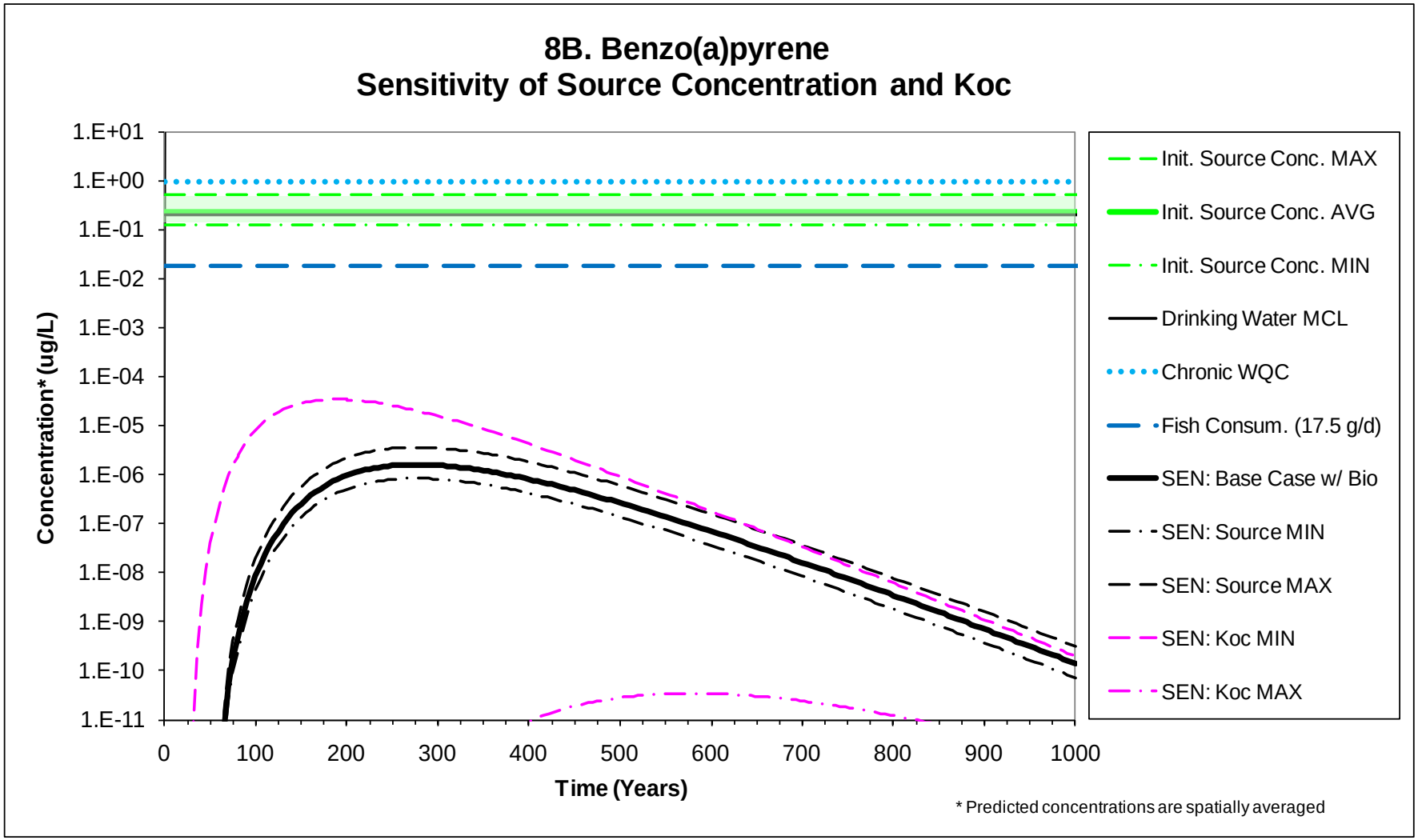


Figure 8
Sensitivity of Groundwater Exit Concentrations
Long-Term Groundwater Modeling Results Memorandum
Port of Portland Terminal 4 Confined Disposal Facility



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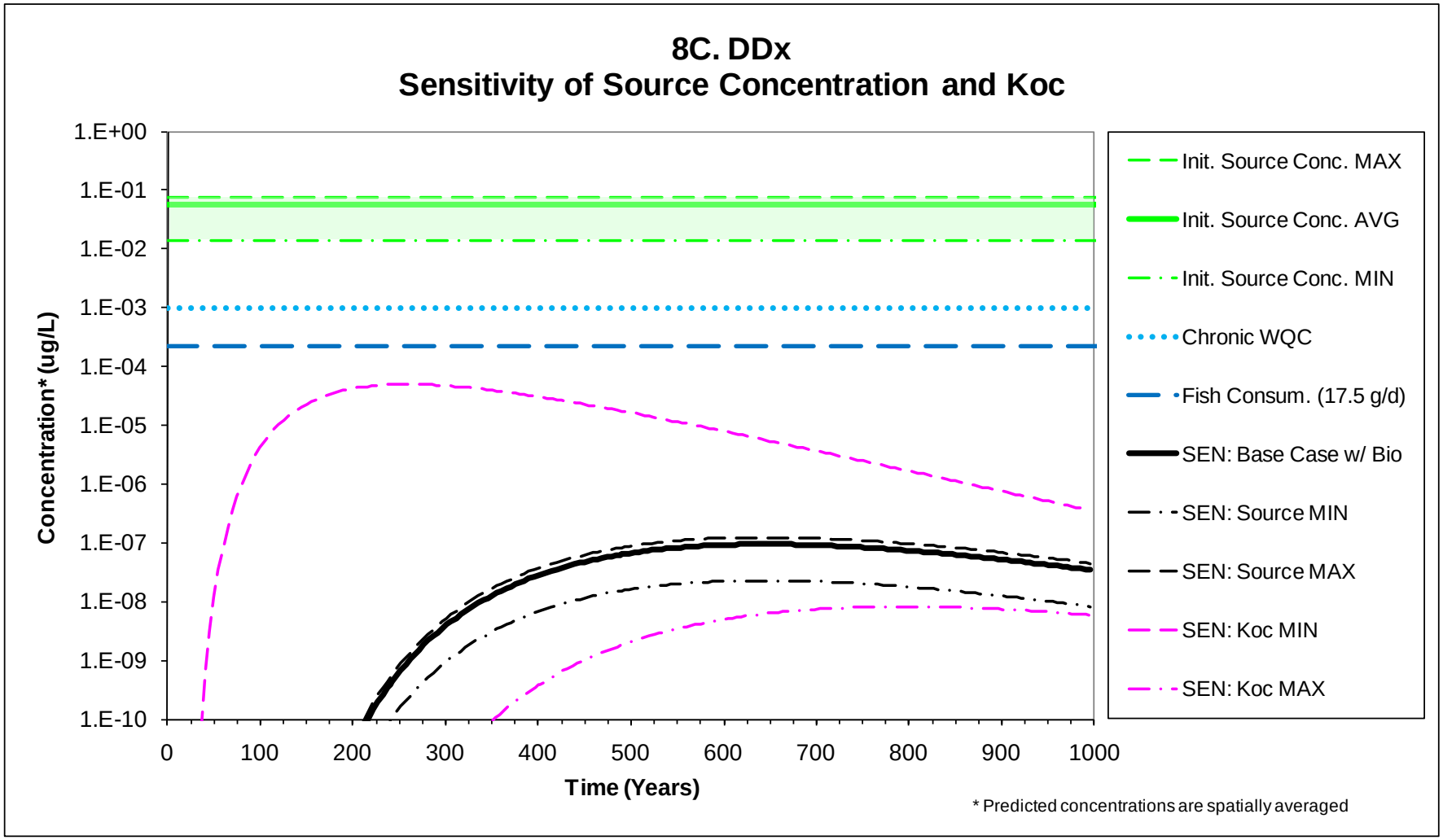

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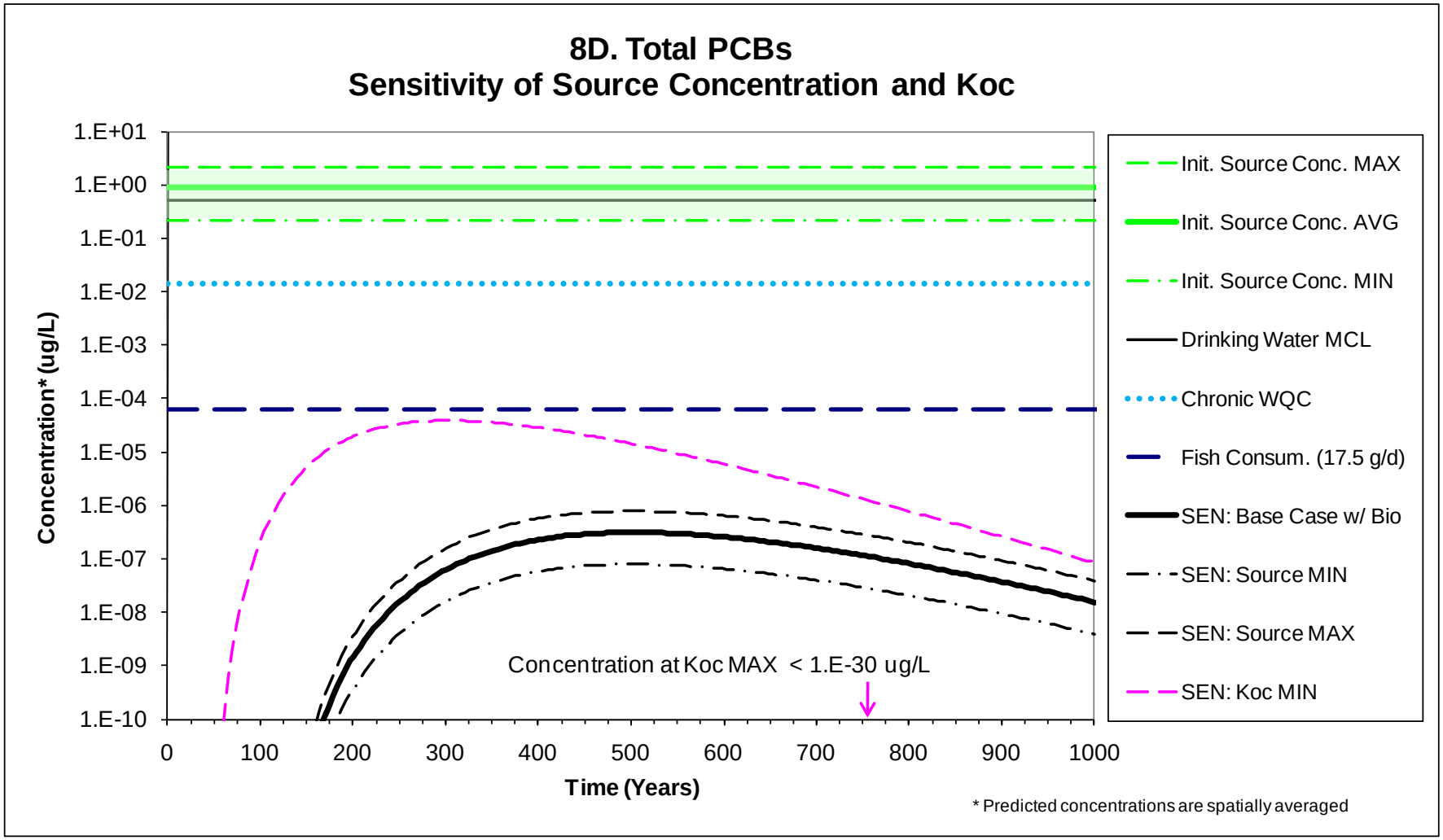

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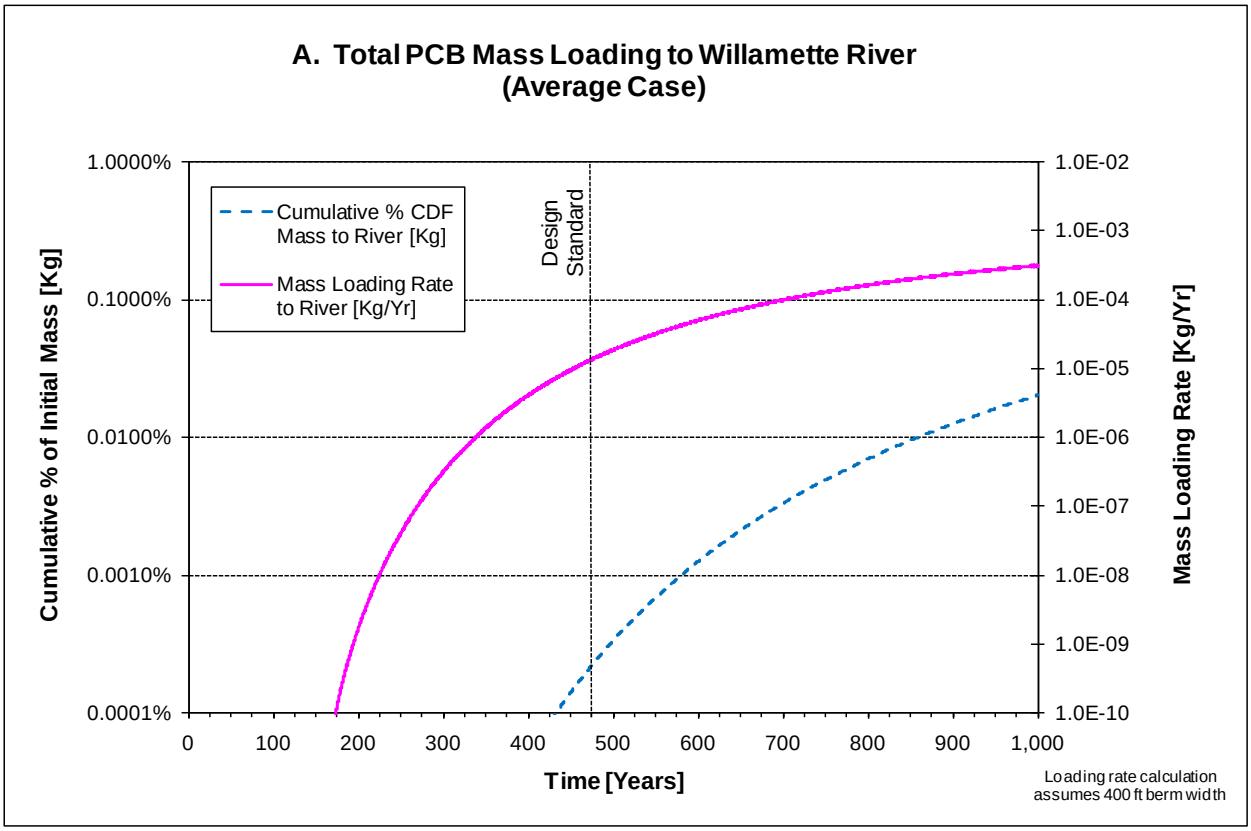
Port of Portland Terminal 4 Confined Disposal Facility



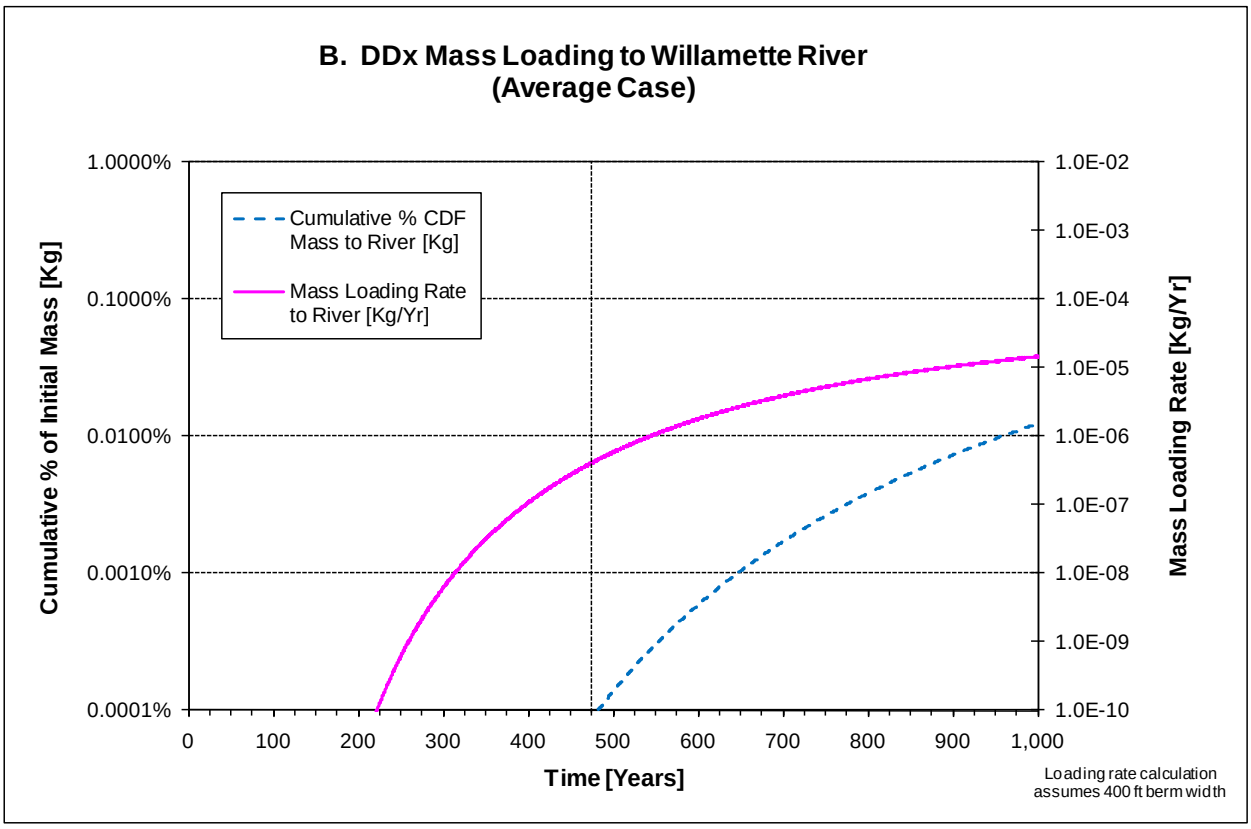


Figure 9
CDF Mass Loading
Long-Term Groundwater Modeling Results Memorandum
Port of Portland Terminal 4 Confined Disposal Facility

ATTACHMENTS

ATTACHMENT 1

Comment No.	Page No.	Section No.	Directed Comment (Yes/No)	Comment	Port Response
General Comment					A meeting between the Port and EPA occurred on 7/29/10 to clarify the EPA Comments on the Groundwater Modeling Results Memo. The following responses reflect the outcomes from that discussion, as outlined in the attached EPA-approved meeting notes, dated August 5, 2010.
1.				EPA notes the Memorandum was concise and well-written. Thank you.	Comment noted. Thank you.
2.				EPA is likely to require additional modeling prior to approving disposal of any specific sediments into the CDF, possibly including modeling for additional contaminants. EPA is particularly concerned about PCBs, given the modeling results that show potential to exceed the fish consumption criteria. EPA anticipates this means that only sediments with relatively low concentrations of PCBs (i.e., lower than currently modeled) may be accepted into the CDF, unless engineering controls (see below) are implemented to reduce PCB concentrations discharging from the berm.	In the 7/29 meeting between the Port and EPA, it was acknowledged that additional modeling may need to be conducted during final design of the Portland Harbor remedy. Given that the 10 AOPCs evaluated in the existing groundwater model were shown to be protective of water quality in the river, and that these are likely the higher risk AOPCs in the Portland Harbor, it is expected that subsequent modeling efforts would be focused on AOPCs with above-average leachate concentrations when more is known about their placement sequence in the CDF. The Port acknowledges that some AOPCs may have additional contaminants that may have to be evaluated during the Portland Harbor design process. The Port does not agree with EPA's conclusions regarding the acceptability of sediments containing PCBs, given the following: • Total PCBs in groundwater are not predicted to exceed fish consumption criterion until nine years short of the design standard (i.e. 466 yrs versus 475 years) and only in the conservative scenario of (a) no biodegradation, and (b) achieving the fish consumption criterion in pore water which does not correlate to direct exposure for fish. • The Total PCB concentration remains below both the upstream background concentration and the analytical detection limit at 475 years.

Comment No.	Page No.	Section No.	Directed Comment (Yes/No)	Comment	Port Response
					• No toxicity is indicated by analysis of coplanar dioxin-like congeners, which are a more accurate measure of human health risk from bioaccumulation. The evaluation of PCB congener toxicity will be expanded in the revised report, and will supersede the results of Total PCBs with respect to fish consumption.
3.				Please evaluate engineering measures to reduce discharge concentrations of contaminants, particularly PCBs that exceed applicable criteria, including fish consumption criteria.	In the 7/29 meeting between the Port and EPA, it was agreed that the CDF as currently designed would be carried through the 60% Design. A Contingency Planning section will be added to the Design Analysis Report providing a brief evaluation of possible engineering control measures for the CDF. This evaluation will consider a select number of engineering measures that could be implemented either during construction or in the future as a facility retrofit.
4.				Please address "salt washout" as indicated in the Port's response to EPA Comment 13.	"Salt washout" is a marine phenomenon which occurs when marine sediment is placed in a CDF which is then subjected to movement of fresh groundwater. It is not relevant to Terminal 4.
5.				Please provide sensitivity analyses for all analytes.	In the 7/29 meeting between the Port and EPA, the Port agreed to conduct a focused set of additional sensitivity analyses with biodegradation. It was agreed that model scenarios combining no biodegradation and the application of fish consumption criteria in pore water with worst-case sensitivity parameters is an unrealistic combination of extreme events and would not be performed in that manner. The Port will perform sensitivity of Koc values and initial leachate concentrations for copper, benzo(a)pyrene, DDx, and PCBs. It has been determined that the minimum Koc value for DDx is an unrealistic literature value and will be revised based on site-specific Willamette River data.

Comment No.	Page No.	Section No.	Directed Comment (Yes/No)	Comment	Port Response
6.				The 60% CDF design should indicate design and construction QA/QC measures to ensure that key metrics, including hydraulic conductivity, foc, Koc, etc., are achieved at average or better values for the final CDF.	For construction QA/QC, the Port proposes to measure grain size as a surrogate for hydraulic conductivity, and total organic carbon as a surrogate for partitioning characteristics. This will be discussed in the Design Analysis Report.
7.				Please evaluate and discuss the possibility that the preferential flow path between the two upper training dikes will cause the ultimate sorption capacity of the trace amount of organic matter in the berm fill to be exceeded. Does this section of the berm need to be amended with additional organic material?	Through the use of chemical partitioning isotherms in the groundwater model, when the leachate concentration in the berm groundwater reaches the corresponding equilibrium concentration on the berm sediment, any excess contaminant mass in the leachate will then "by-pass" that area until it reaches a downgradient part of the berm that has additional sorption capacity. This process is implicitly included in the model. Amendment of the berm with organic material will be discussed in the new Contingency Planning section (see response to Comment No. 3)
8.		Graphs		Please add peak and average concentration lines for sensitivity analyses to the graphs (for all parameters, or, at a minimum, for the sensitivity parameter with the greatest adverse impact). Please provide additional discussion of the potential for variation in results due to the variability in bulk sediment concentrations (per comparison table in Port's response to EPA Comment 21), overall variability of input parameters, etc. Where exit concentration sensitivity lines (without biodegradation) have the potential to exceed WQC or other limits, please complete a model scenario that includes biodegradation, plus the additional parameter with the greatest positive deviation.	The Port agrees to conduct a focused set of additional sensitivity analyses with biodegradation (see response to Comment No. 5).
9.				Please provide an improved description and representation (with one or more figures) of the spatial averaging process, and how the spatial averaging compares to the peak concentrations. Where do the peak concentrations typically occur? Is there a high concentration pathway?	The Port will provide the requested description and figure. Peak concentrations typically occur in the shallow part of the saturated zone, as shown on Figure 6.

Comment No.	Page No.	Section No.	Directed Comment (Yes/No)	Comment	Port Response
Specific Comments					
10.	4	Bound'y Cond'n		Please clarify "base on p=0.1".	Noted and will be clarified in the revised memo.
11.	16			Please rewrite the last paragraph of the Sensitivity section that discusses the importance of the biodegradation rate. EPA objects to the phrasing that not including degradation may cause the predictions to be overestimated. The base model runs provide the base case, and the sensitivity analyses indicate a deviation from the base case.	The Port disagrees with this characterization. Zero biodegradation is a case in which prediction bias can only occur in one direction, which is toward overestimation of groundwater concentrations. This potential bias may be especially severe when modeling extremely long time periods, i.e. 475 years.
12.	17, 18			In two places the report states "Dredging the contaminated sediments in the Harbor and placing them in the CDF is expected to result in greater than 99.99 percent reduction in the mass loadings of PCBs and DDx to the river." Please add a footnote that this is true for the assumptions made in the modeling study, and the study does not include evaluation of accepting sediment from the Gasco or Arkema sites.	Noted and will be included in the revised memo.
		Tables 1 & 2		Please re-title or footnote the column headings ("Min.", "Average", "Max."), as they are unclear. For example, sometimes the average values were used for the base run and sometimes the max values were used for the base run. For the biodegradation half-life values, the values listed as "average" are not averages (i.e., mean values), but rather some reasonable middle value you have selected to use as the input parameters for the sensitivity analysis. Please add a footnote clarifying that the "infinite" half-life for biodegradation effectively means that biodegradation will be set to zero (i.e., no biodegradation).	The requested clarifications will be made. Please note, however, that biodegradation rates used in the model are neither "average" nor "some reasonable middle value". More accurately, they are conservatively slow values from the upper end of the literature range. This will be clarified as well.
13.		Table 2		Please verify the following data: A. Average Koc (sediment) for Total PCB Arochlors = 4.87. Table A-1 in the Groundwater Model Input Parameter Memorandum (GMIPR) indicates 4.55. B. Average Koc (sediment) for PCB-126 = 4.80. Table A-1 in the GMIPR indicates 4.36. C. Max Koc (berm) for B(a)P = 6.67. Table A-2 in the GMIPR indicates 7.85.	All values have been verified and are correct as presented. The Koc values for Total PCB Aroclors and PCB-126 were derived from a linear isotherm model, given the strength of the regression coefficient, rather than using the Harbor-wide summary statistics (see Table A-2). The Max Koc for B(a)P of 6.67 was taken directly from RI Table E6-5 after two extreme outliers were removed, and revised from the previous value of 7.85 which included the anomalous outliers.
14.		Table 3		Please verify the upstream background concentration for PCB-126 = 4.7E-08. This value is below the indicated Analytical	The upstream background concentration for PCB-126 is correct, according to LWG RI Table 7.4-4a.

Comment No.	Page No.	Section No.	Directed Comment (Yes/No)	Comment	Port Response
				Reporting Limit of 5.0E-08. If so, how was it determined?	The difference noted in the reviewer's comment is due to different analytical methods being used to define background versus analytical reporting limits. Portland Harbor background concentrations were determined using high-volume XAD methods with ultra-low detection limits. However, such methods cannot be applied to pore water samples. The reporting limits for pore water samples, i.e. groundwater exiting the CDF, were based on standard grab samples with low-level detection limits.
15.		Table 4 vs. Graphs		Please verify the following results: CENTERLINE CONCENTRATION: A. AVG (BASE) = 2.8E-04 for PCBs, which is different than indicated on the graph. B. AVG (BASE) = 6.00E-06 for DDx, which is different than indicated on the graph. C. MAX (BASE) = 6.00E-06 for DDx with biodegradation, which is different than indicated on the graph. SPATIAL AVERAGE CONCENTRATION: D. MAX (BASE) = 1.60E-06 for DDx with biodegradation, which is different than indicated on the graph.	There are minor errors in the plotting of peak concentrations that will be corrected in the final report. Spatially averaged concentrations are plotted correctly. In Table 4, DDX concentrations were inadvertently taken at 450 years rather than 475 years; this will also be corrected in the final report. None of these minor errors have any significant effect on the conclusions of the report.
16.		Figure 5D		Please add the background concentration. Please verify the accuracy of the plotting of the gray shaded zone for Analytical Limit. Manually plotting sensitivity results appears to indicate that DDx concentrations could exceed WQC at 475 years (without degradation). Extrapolating the Koc sensitivity results to the biodegradation case (i.e., 504 times deviation) appears to indicate that breakthrough could also occur. Please clarify the modeling results by adding sensitivity results to all graphs and discussing the results in greater detail in the text.	Background concentration will be added to Figure 5D. Analytical Limit is correct as presented (note log scale). The Port agrees to conduct a focused set of additional sensitivity analyses with biodegradation (see response to Comment No. 5), including graphic presentations and additional discussion in the text.
17.		Figure 5F		Verify Initial Concentration is 0.27 per Table 2. Add a line indicating background.	Initial Concentration is correct as presented. Note the units change from ng/L in Table 2 to ug/L in Figure 5F. Background will be added to the graph.

Port of Portland

TERMINAL 4 PHASE II

Outcomes from the 7/29/10 Preliminary Discussion on
EPA Comments of the Groundwater Modeling Results Memo
August 5, 2010

1. CLARIFICATION OF SIGNIFICANT TECHNICAL ISSUES

- EPA agrees the modeling results are favorable and the CDF as currently designed should be carried through 60% Design, but would like a contingency planning discussion of possible engineering control measures added in the 60% Design and additional model simulations to bolster the robustness and defensibility of the results and design.

a. Modeling Basis of Design (comment nos. 2, 3)

- The Port acknowledged that additional modeling may need to be conducted during final design of the Portland Harbor remedy. The GW model will continue to be an important management tool, and it is expected that subsequent modeling efforts would be focused on higher risk AOPCs (e.g. those with above-average leachate concentrations). In addition, it was acknowledged that AOPC sediment samples collected for leachate testing and applied in the development of the model results are most likely derived from the higher risk AOPCs in Portland Harbor.
- It was agreed that the CDF as currently designed would be carried through 60% Design. A Contingency Planning section will be added to the Design Analysis Report providing a brief evaluation of possible engineering control measures for the CDF. This evaluation will consider a select number of engineering measures that could be implemented either during construction or in the future as a facility retrofit.
- It was agreed that model scenarios combining no biodegradation with application of fish consumption criteria in pore water, as presented in the Groundwater Results Memo, are conservative (i.e. protective). Combining such scenarios with worst-case sensitivity parameters is therefore an unrealistic combination of extreme events.
- The Port will provide a more accurate characterization of the fish consumption risk for PCBs (further details presented below).

b. Scope of Sensitivity Analysis (comment nos. 5, 8, 16)

- The Port agrees to conduct the following additional modeling analyses:
  - Determine the longest biodegradation half life (i.e. slowest rate) that will comply with the fish consumption criterion in pore water for Total PCBs.
  - Conduct a focused set of additional sensitivity analyses with biodegradation. The Port proposes to include sensitivity of Koc and leachate concentrations for copper,

benzo(a)pyrene, DDX, and PCBs. The minimum Koc for DDX is an unrealistic literature value and will be revised based on site-specific Willamette River data. It will be acceptable to estimate error bars for the sensitivity analyses based on scaling of results from analogous simulations.

- The Port will conduct further evaluation of PCB congeners, since this will provide a more accurate characterization of fish consumption risk. This analysis will build on the model of PCB-126 shown in Figure 5, in consideration of the leachate concentrations and toxicity equivalency factors of the other dioxin-like congeners. As such, Figure 5 will be revised to place greater emphasis on the use of PCB congeners, rather than Total PCBs, for evaluating human health risk via fish consumption.

- These additional model scenarios will not affect the 60% Design. The additional modeling work can therefore proceed on a parallel path with the 60% Design.

c. Other Comments

2. SCHEDULE

- The Port received sufficient clarifications on EPA's written comments at the meeting to allow the 60% Design to proceed. Prior to the meeting, the Port was unsure to what extent or whether EPA's comments would affect the 60% Design.

a. Impact of Additional Modeling Tasks

b. Coordination with LWG Alternatives Screening Analysis

3. NEXT STEPS

- Port will provide response to EPA comments 30 days from the July 29 meeting, i.e. by August 30
- Port will conduct additional modeling analyses as described above
- GW Modeling Report will be revised as per agreements and submitted with 60% Design
- Port will add a section on Contingency Planning to Design Analysis Report as described above
- Kelly will follow up with Sean regarding proposed schedule update for 60% Design

ATTACHMENT 2

Port of Portland

TERMINAL 4 PHASE II

CDF 60 Percent Design Approach Meeting with EPA
Wednesday April 28, 2010
1:00 – 3:00 PM (Pacific)

ATTENDEES

In Person:
Sean Sheldrake, EPA
Kristine Koch, EPA
Ken Fellows, Parametrix
Kelly Madalinski, Port of Portland
Krista Koehl, Port of Portland
Tom Schadt, Anchor QEA
John Verduin, Anchor QEA
Todd Thornburg, Anchor QEA
Ben Hung, Anchor QEA
Cy Young, ODSL
Brian Cunninghame, Warm Springs Tribe

Via Teleconference:
Rene Fuentes, EPA
Chip Humphrey, EPA
Jim Anderson, ODEQ
Tom Gainer, ODEQ
Erin Madden, Cascadia Law
Jennifer Peers, Stratus
Genevieve Angle, NOAA
Sheila Fleming, Ridolfi

MEETING SUMMARY

PROCESS OVERVIEW

The goals of the September 1, 2010 CDF design submittal include maintaining consistency with the harbor-wide feasibility study process while providing information to allow EPA to make remedial decisions within harbor-wide context. Finalization of the T4 CDF design and construction and other cleanup efforts at T4 will not take place until after the Portland Harbor ROD.

The CDF feasibility, cost, and protectiveness evaluation will be based on EPA-specified CDF performance standards and the LWG response on clarifying EPA performance standards. The September 1 CDF design submittal will also consist of additional evaluations (e.g., biodegradation rates). However, proposing alternative performance standards and assumptions will not be the focus of the T4 CDF design submittal, as that analysis will be performed in the context of the harbor-wide FS.

Port of Portland

TERMINAL 4 PHASE II

CDF 60 Percent Design Approach Meeting with EPA
Wednesday April 28, 2010
1:00 – 3:00 PM (Pacific)

CDF DESIGN LEVEL CLARIFICATIONS

On February 18, 2010, EPA issued CDF performance standards to the Lower Willamette Group (LWG) for use in the development and evaluation of alternatives in the Portland Harbor Feasibility Study. LWG provided a response on April 14, 2010 clarifying the EPA performance standards. Several of the EPA standards were characterized as design level issues. The Port identified six design level issues requiring further clarification from EPA on how to address in the T4 60 percent design submittal. Below are the specific issues and resolution of those issues based on the meeting with EPA.

- **Short term water quality impact duration during hydraulic dredging of the CDF** (Performance Standard #22 in LWG Table [*EPA February 18, 2010 CDF Performance Standards Comments and LWG April 14, 2010 Responses*]).

  Resolution: This EPA standard defines the duration for short-term water quality impacts as the period from the beginning of the fill activity until the water level in the CDF reduces to within 0.1-foot of the water level in the river. EPA confirmed that this standard is meant to define the duration for short-term water quality model predictions in the event of hydraulic dredging and filling. EPA stated and acknowledged that some other metric could be used to define the duration for short-term water quality model predictions, including "asymptotic run-out to steady state," for instance. The Port and EPA agreed that a tolerance greater than 0.1-foot (like 1-foot) or other metric (such as a narrative metric) could reasonably be used to define the short-term water quality impact duration in the event of hydraulic dredging, considering the 1 to 2-foot diurnal tidal swings in the river. The Port and EPA also discussed offloading of barges with a high-solids pump using make-up water from within the CDF, and it was acknowledged that the head difference in the pond created by this scenario would not be significant.

- **Physically closing any hydraulic connection or notch** (Performance Standard #23 in LWG Table).

Resolution: EPA confirmed that the definition of hydraulic connection in this standard is related to a surface water connection through a notch in the berm or discharge over a weir, not groundwater or surface water moving through the berm. If the design included barges moving through a notch in the berm to bottom-dump material, the notch would need to be closed between filling seasons.

- **No installation of piles in contaminated sediment zone requirement** (Performance Standard #29 in LWG Table).

  Resolution: EPA indicated that while this performance standard states that installation of piles driven through the contaminated sediment zone may not be performed, EPA is open to reviewing the use of piles and not mandating an outright prohibition. EPA suggested that the O&M plan may contain a set of procedures that would be followed to provided justification and appropriate analysis for use of piles. The Port and EPA agreed that, for the purposes of the T4 CDF design, this performance standard could be amended to read: Installation of piles driven through the contaminated sediment zone is not allowed *without further analysis and EPA approval.*

- **Stormwater discharges/infiltration into fill** (Performance Standard #26 and #29 in LWG Table).

  Resolution: Performance Standard #26 states that "stormwater discharges or infiltration into the CDF is not allowed." Performance Standard #29 relates to implementing institutional controls, including the requirement to "prevent stormwater infiltration into the CDF and CDF buffer zone." EPA indicated that these performance standards may be viewed in the same way as the performance standard related to pile installation in the contaminated sediment zone, i.e., evaluation of stormwater infiltration facilities would require further analysis and EPA approval. In general, EPA prefers to prevent, or at least minimize, stormwater discharges and infiltration into the CDF and CDF buffer zone. It was clarified that the primary concern was deliberate infiltration of stormwater into the ground surface in an engineered

stormwater management facility, and not the incidental infiltration of rainfall on a pervious surface (i.e. passive infiltration). EPA is willing to review analysis of various amounts of discharges/infiltration and sensitivity of modeled groundwater concentrations to this parameter. The Port indicated it is planning to run model scenarios with both pervious and impervious (i.e. pavement) covers. EPA stated that a component of their concern related to the fact that stormwater would be oxygenated and therefore leaching characteristics given this additional flow may be different than leaching characteristics for groundwater only. DEQ stated that infiltration of stormwater in general does not seem like a major design issue, given that the CDF is designed as a "flow-through" facility, unless the geochemical impact of oxygenated water is significant or the stormwater itself was contaminated. To summarize, EPA is interested in understanding whether this is a sensitive design parameter, and passive infiltration may be acceptable.

- **Utility conduits within 500 feet of the CDF** (Performance Standard #8 in LWG Table).

  Resolution: The performance standard includes identifying, removing, or modifying utilities trenches, storm drain lines, and other conduits within 500 feet of the CDF. The performance standard applies to all utilities. EPA stated that they did not have a specific reference for the 500-foot offset distance (referred to as the CDF buffer), although they indicated some of their performance standards were borrowed from a review of solid waste landfill regulations. It was clarified that utilities needed to be identified and evaluated, but not necessarily "removed or modified", depending on the evaluation. The key concern for EPA, generally, is that utility conduits may provide preferential pathways for groundwater exiting the CDF. To address these concerns, the Port may review existing and planned utility conduits to determine whether there is a potential for these preferential pathways to occur. The majority if not all of the utility conduits are expected to be located at elevations above the design elevation for the contaminated fill zone, in which case a preferential pathway for groundwater exiting the CDF would not be of concern.

Port of Portland

TERMINAL 4 PHASE II

CDF 60 Percent Design Approach Meeting with EPA
Wednesday April 28, 2010
1:00 – 3:00 PM (Pacific)

- **Imported fill criteria** (Performance Standard #25 in LWG Table).

  Resolution: Specific acceptance criteria have not been established by EPA for the Portland Harbor. However, based on previous discussions EPA considers the narrative standard developed for the McCormick and Baxter sediment cap to be the default acceptance criteria for the T4 Site. The Port noted that this standard is for an in-water sediment cap, and the fill above the contaminated fill zone in the CDF is not an in-water sediment cap. As such, different acceptance criteria may be both appropriate and protective of human health, including trench workers at the terminal, and the aquatic receptors in the river. EPA agreed and stated that the Port may perform evaluations of CDF performance, using the CDF groundwater model, based on different acceptance criteria in addition to the default acceptance criteria, to determine exiting groundwater COC concentration sensitivity to this parameter.

DISCUSSION OF EPA COMMENTS ON GROUNDWATER INPUT MEMO

The Port will provide responses to EPA comments within 30 days of receipt of the EPA comments. The responses will be substantive enough for EPA to understand how the Port is moving forward with the groundwater modeling effort. The Groundwater Input Memo will be updated and provided to EPA as an appendix to the CDF 60% Design Report when that report is submitted.

The Port provided rationale to EPA for omitting any further short-term water quality modeling evaluation as part of the CDF 60% Design submittal. The Port's rationale was based on the following: (1) it is likely that Phase 2 dredging at T4 will be mechanical, not hydraulic; (2) if the CDF is sited elsewhere in the harbor, hydraulic dredging at T4 will not likely be feasible; (3) short-term modeling was already performed using a conservatively large hydraulic dredging rate and duration (memo dated 7/30/07) and it was shown that groundwater exit concentrations were orders of magnitude below water quality criteria; and (4) hydrogeologic analysis of source concentrations and hydraulic gradients

indicates the "pre-loading" effect in the berm will be insignificant compared to long-term contaminant transport processes. The Port will provide this rationale in the response to comments on the Groundwater Input Memo. EPA stated that they accept the Port's determination to omit any further short term modeling work from the groundwater modeling approach based on the rationale provided. However, if hydraulic dredging ends up being proposed at T4, then the Port will need to update the short term modeling evaluation as part of those subsequent design submittals.

NEXT STEPS

The Port and EPA will continue to confer as needed to enable the design process to progress on schedule. The Port will provide responses to EPA comments on the Groundwater Input Memo as described above. The Port will forward the most up-to-date schedule to EPA. The next major deliverable will be the Groundwater Results Memo.

ATTACHMENT 3

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10
OREGON OPERATIONS OFFICE
805 SW Broadway, Suite 500
Portland, Oregon 97205

February 18, 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
EPA Performance Standards for Confined Disposal Facilities for the Portland Harbor Feasibility Study

Dear Mr. Wyatt:

EPA is providing the enclosed performance standards for use by the Lower Willamette Workgroup (LWG) in the development and evaluation of Confined Disposal Facility (CDF) alternatives in the Portland Harbor Feasibility Study (FS). EPA's performance standards draw heavily upon the detailed performance standards that have been provided for the Port of Portland's proposed Terminal 4 CDF. The site Record of Decision (ROD) will document the final performance standards to be applied to any CDFs, and additional performance standards may be established as part of the design of specific facilities.

The LWG shall evaluate any CDFs proposed in the FS using the enclosed performance standards. These performance standards will be considered just one facet of a sensitivity analysis of the performance of various CDF designs, and the LWG shall determine the feasibility and costs of CDF designs that fully achieve these performance standards. LWG may evaluate other CDF designs and performance standards in the FS, and compare the feasibility, costs, and protectiveness of these alternative CDF designs to CDF designs that comply with EPA's specified performance standards. EPA encourages this sensitivity analysis approach because we believe it will provide the public with a clearer picture of which design factors most affect CDF performance, protectiveness, and cost.

EPA believes that CDFs must provide protective disposal facilities for sediment that contribute to the overall cleanup of the Portland Harbor site, including meeting the site Remedial Action Objectives and ROD requirements. EPA has developed the enclosed performance standards based on protectiveness and compliance with currently identified Applicable or Relevant and Appropriate Requirements (ARARs). EPA acknowledges that final sediment and surface water cleanup standards will not be established for the Portland Harbor Superfund Site until the ROD is issued. The enclosed performance standards may not fully address all ARARs (e.g., historic/cultural issues, habitat mitigation, etc.). The LWG shall evaluate ARARs and the need for additional performance standards as part of developing the Feasibility Study.

EPA considers that the enclosed performance standards would be generally applicable to confined aquatic disposal facilities as well as CDFs; however, additional performance standards may need to be developed to address issues specific to confined aquatic disposal, such as:

- Control of placement of contaminated sediments
- Allowable water quality impacts
- Scour protection during flooding (possibly including floods in excess of the 100-year event)
- Cap material, thickness, placement technique, and long-term stability
- Physical intrusion into the floodway and navigation channel
- Interim capping and protection during dormant periods.

We look forward to working with the LWG on the use of these standards to develop and evaluate CDF alternatives for the Portland Harbor Feasibility Study. If you have any questions please contact Chip Humphrey at (503) 326-2678 or Eric Blischke at (503) 326-4006.

Sincerely,

Chip Humphrey
Eric Blischke
Remedial Project Managers

cc: Jim McKenna, Port of Portland
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.

CDF Performance Standards for Portland Harbor Superfund Site Feasibility Study

The LWG shall develop and evaluate Confined Disposal Facility (CDF) alternatives that meet the following performance standards. These performance standards establish minimum criteria, and are not intended to relieve a CDF project owner, designer, or developer from complying with any and all additional applicable requirements, or any short-term or long-term liability associated with a particular action or project. These performance standards also provide guidance on cost estimating assumptions to be used for the FS.

- Design: The CDF shall be designed to:
    - Contain the volume, level, and characteristics of contaminated sediment to be placed within it, using site-specific designs as needed to accommodate the specific contaminated materials proposed for disposal. The CDF shall be designed to achieve these performance standards when filled with the specified design volume of contaminated sediment meeting CDF sediment acceptance criteria that will be established, considering representative sediment contaminant concentrations and contaminant mobility data obtained from, or estimated for, sediments from Portland Harbor sites where dredging is a reasonably anticipated remedial action that would generate sediments requiring confinement.
    - Minimize physical intrusion into waters of the US.
    - Minimize water flow into and out of the CDF, including preventing or restricting preferential flow paths of clean or contaminated groundwater into or out of the CDF. The evaluation should include identifying, removing or modifying utilities trenches, storm drain lines, wells, and other conduits within 500 feet of the CDF (or other distance as determined to be appropriate). Utilities, storm drain lines and other conduits are not allowed under or within the contaminated sediment fill prism.
    - Achieve confinement of all hazardous substances disposed of in the facility through the groundwater pathway so that the CDF does not contribute any long-term discharge and/or release of contaminants above applicable and relevant and appropriate requirements under federal or state law for surface water in the lower Willamette River.
    - Limit contaminant concentrations in groundwater (including berm pore water) exiting the CDF to levels below EPA's national recommended chronic water quality criteria for both aquatic organisms and fish consumption by humans (17.5 g/day), more stringent Oregon water quality standards, and MCLs without dilution in the water column. This should include dormant periods between CDF filling, and after closure. Analyses for meeting these criteria shall not consider biodegradation of contaminants within the CDF.
    - CDFs shall be designed in a manner that is consistent with the Remedial Action Objectives and Management Goals that have been established for the Feasibility Study. Habitat mitigation and land acquisition assumptions for individual CDFs shall be developed for cost estimating purposes in the FS.

- CDF Berms shall be designed to
    - Provide a static safety factor of 1.5 or greater and a seismic safety factor of 1.1 or greater. The design seismic event shall correspond to a 10 percent probability of exceedance in 50 years.
    - Be resistant to erosive forces by the largest of 100-year flood flow, 100-year waves, vessel-induced waves from typical passing vessels, and anticipated propeller wash from vessels that operate in the area.
    - Have an appropriate gradation to allow transport of groundwater while retaining (filtering) sediment during filling and after closure.
- Construction of any CDF shall not measurably increase the 100-year flooding stage or decrease flood storage of the Willamette River. The FS shall consider cumulative effects of multiple sites and related remedial actions including sediment capping.
- Maintain saturated or unsaturated conditions (as appropriate) within the confined contaminated sediments prism, considering reasonably anticipated seasonal and long-term cyclical groundwater levels, and considering site infiltration or zero recharge (as appropriate) from the overlying ground surface, to eliminate or reduce potential mobility of chemicals of concern.
- Minimize releases of 303(d) listed contaminants to the extent practicable.
- Unless modified by EPA, all CDFs shall be designed to meet these performance standards, ARARs and the final Portland Harbor ROD requirements in perpetuity.

- Construction and Filling:
    - Construct the CDF berm and related components in a manner that minimizes to the extent practicable water quality exceedances within the construction zone and achieves compliance with water quality criteria/standards at and beyond the specified point of compliance.
    - Construct the CDF in a manner that minimizes impacts to fisheries and wildlife by removing fish to the extent practicable from the CDF area before and during berm construction.
    - Construct the CDF berm with acceptable material. For cost estimating purposes, acceptable material should be based on requirements established in the December 2003 Technical Plans and Specifications (Ecology and the Environment 2003) for the McCormick & Baxter sediment cap located within the Willamette River. Materials will generally be imported clean granular material, but typically all materials shall be free of roots, inappropriate organic material, contaminants, and all other deleterious and objectionable material. However, CDF berm construction material shall have an organic fraction meeting minimum specified values consistent with contaminant transport modeling.

- Accept only sediments meeting final sediment acceptance criteria. EPA shall approve all sediment to be disposed of in any CDF.

- Plan and manage the CDF filling to avoid any short-term overflow(s), or minimize the overflows to the extent possible. If a CDF overflow during filling cannot be avoided, complete an analysis of overflow discharge rates and duration, contaminant concentrations, and ability to meet water quality criteria at end of pipe. Evaluate BMPs and treatment options needed to meet water quality criteria at the end of the pipe. If EPA agrees that criteria cannot be met at the end of the pipe then a dilution zone modeling analysis of the discharge impacts shall be completed to demonstrate compliance with water quality criteria. Overflows must meet acute water quality criteria. Chronic water criteria will be used to guide implementation of BMPs to minimize contaminant loadings to the river. The design shall consider engineering controls and treatment options needed to meet chronic discharge criteria at end of pipe.

- During CDF filling, concentrations in groundwater (berm pore water) exiting the CDF must meet acute water quality criteria. Chronic water criteria will be used to guide implementation of BMPs to minimize contaminant loadings to the river. For the CDF, short-term water quality impacts are defined as the period from the beginning of the fill activity until the water level in the CDF reduces to within 0.1 foot of the water level in the river.

- Physically close any hydraulic connection between river and the CDF (except through groundwater) except during periods of actual approved overflow.

- Prior to final closure of any CDFs, the facility shall be managed in a manner that minimizes impacts to fisheries and wildlife. Potential and short-term exposures of fish and wildlife to contaminated sediments and/or water within a CDF shall be fully assessed and disclosed.

- Cap contaminated sediments with clean soils/sediment, or soils/sediments that meet specific acceptance criteria that are established by EPA.

- Stormwater discharges or infiltration of stormwater into the CDF is not allowed.

- Long-Term:

  - Monitor CDF(s) in perpetuity, or until reduced monitoring is approved by EPA, to document that the CDF(s) achieves confinement of all hazardous substances placed in it so that the facility does not contribute any discharge and/or release of contaminants above performance standards/ROD criteria for surface water or sediment in the lower Willamette River.

  - Provide appropriate financial assurance for project development, closure, long-term monitoring, mitigation as needed, and contingency actions.

  - Implement appropriate institutional controls:

    - Prevent disturbance of the sediment

- Prevent stormwater infiltration into the CDF or the CDF buffer zone.
- Prevent installation of groundwater extraction wells for any purpose with the CDF or the CDF buffer zone.
- Restrict development on the CDF. Structures may be constructed over the CDF; however, foundations must remain at least 3 feet above the upper surface of the contaminated sediment zone. Installation of piles driven through the contaminated sediment zone is not allowed. However, EPA is willing to consider proposals for jet grouted piles or other technologies that will not disturb the contaminated sediments.

The COCs to be included in any CDF evaluation shall be consistent with the COCs approved by EPA for the in-water RI/FS or as specifically modified by EPA. The LWG may submit a request for evaluation of a reduced list of contaminants to be evaluated for any particular CDF.

Water quality monitoring associated with construction and filling of CDFs will be specified in an EPA issued Water Quality Monitoring and Compliance Conditions Plan (WQMCCP). For purposes of the FS, the LWG shall develop cost estimates based on the water quality monitoring plans for similar projects, including relevant information in the WQMCCP for the T4 abatement project. It is anticipated that multiple WQMCCPs will be necessary to implement the selected remedies for the Portland Harbor. Water quality monitoring, including background water quality monitoring, would be completed per approved Water Quality Monitoring Plans, Operations Plans, and Long-Term Monitoring Plans. Total Suspended Solids may be allowed as a supplementary parameter along with turbidity to aid in evaluating construction impacts to water quality.

LWG
LOWER WILLAMETTE GROUP

Acting Chairperson: Jim McKenna, Port of Portland
Treasurer: Fred Wolf, Legacy Site Services for Arkema

April 14, 2010

Chip Humphrey
Eric Blischke
U.S. Environmental Protection Agency, Region 10
805 SW Broadway, Suite 500
Portland, OR 97205

Re: EPA Performance Standards for Confined Disposal Facilities for the Portland Harbor Feasibility Study (Lower Willamette River, Portland Harbor Superfund Site, USEPA Docket No: CERCLA-10-2001-0240)

Chip and Eric:

The Lower Willamette Group (LWG) is in receipt of your letter of February 18, 2010 regarding performance standards for Confined Disposal Facilities (CDFs) for the Feasibility Study (FS). We appreciate the time EPA has spent with us on March 10, 18 and 29 and follow-up conversations to clarify the directions provided in the February 18, 2010 letter. Based on the clarifications provided by EPA, the LWG will address the performance standards as directed by EPA as part of the alternatives screening and present the results to EPA at the screening check-in. We understand that this is an acceptable approach to EPA as a means for moving the FS forward while also ensuring EPA has the information it needs to make remedial decisions.

Please see the attached table that lists the EPA comment, the LWG response, and EPA clarifications for specifics on how each directive will be addressed. If our understanding of EPA's clarifications is incorrect, then the LWG wishes to request an extension of the dispute deadline to resolve the misunderstanding. If EPA will not grant such an extension, then the LWG wishes to invoke dispute resolution over the EPA directive.

We look forward to moving forward with the FS.

Sincerely,

Jim McKenna

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

EPA February 18, 2010 CDF Performance Standards Comments and LWG April 14, 2010 Responses

Performance Standard – EPA Comment	LWG Designation as Feasibility Study or Design Issue?	LWG Response	LWG Notes on EPA Verbal Clarifications to LWG Questions During March 10, 18, and 29, 2010 Meetings
1. General – Directive nature of comments.	NA	To date, the FS methods discussions have been collaborative and have often avoided directive comments that require formal responses before dispute deadlines expire. This collaborative approach works better for an expedited FS and avoids potential process delays created by the need for formal responses, dispute extensions, and dispute decisions. We request EPA withdraw these comments as directive and clarify them as guidance to help expedite resolution of these issues. Or at a minimum, we request EPA withdraw as directive those comments designated here as "design" level issues, given that FS evaluations don't typically address this level of detail. We request that EPA instead designate these design level comments as guidance that will primarily be addressed in future designs (post-ROD).	EPA indicated that potential clarification of some comments as non-directive depended on the type of objections or potential disagreements that LWG might have on the standards. There might be some situations where EPA might indicate a particular issue can be considered guidance instead of directive.
2. General – Date of comments and relationship to FS schedule.	NA	Given that this information came two months after EPA's December 18, 2009 FS comments (which was significantly after LWG's requests for such information in the fall of 2009) and that LWG indicated that all major FS issues need to be resolved by the end of February 2010 to keep the project on schedule, these comments are extending the expedited FS schedule.	EPA agreed with the LWG assessment that the timing of the submittal of the draft FS was delayed commensurate with the amount of time after the end of February 2010 it takes to resolve issues with the standards.
3. Letter - The LWG shall evaluate any CDFs proposed in the FS using the enclosed performance standards. These performance standards will be considered just one facet of a sensitivity analysis of the performance of various CDF designs, and the LWG shall determine the feasibility and costs of CDF designs that fully achieve these performance standards. LWG may evaluate other CDF designs and performance standards in the FS, and compare the feasibility, costs, and protectiveness of these alternative CDF designs to CDF designs that comply with EPA's specified performance standards. EPA encourages this sensitivity analysis approach because we believe it will provide the public with a clearer picture of which design factors most affect CDF performance, protectiveness, and cost.	FS Issue	The LWG agrees that alternative performance standards should be presented in the FS process. We believe it will provide more realistic options that EPA will need to select from during Proposed Plan and ROD development. The LWG will present the EPA water quality performance standards and alternative performance standards at the screening check-in based on the understandings outlined below. Design-level performance standards would be addressed in the FS as described below.	EPA added that it was acceptable to view any LWG proposed alternative approaches to performance standards at the screening check-in, as opposed to asking for more input now from LWG on the content of those alternative approaches.
4. Letter - EPA considers that the enclosed performance standards would be generally applicable to confined aquatic disposal facilities as well as CDFs; however, additional performance standards may need to be developed to address issues specific to confined aquatic disposal, such as: • Control of placement of contaminated sediments • Allowable water quality impacts • Scour protection during flooding (possibly including floods in excess of the 100-year • event)	FS Issue	Given that LWG has been requesting this type of information since, at least, the fall 2009, any additional comments from EPA on CAD standards or any other details of the FS methods will have further schedule implications. The LWG has noted before that the FS evaluations of cap, CAD, and CDF technologies should be conducted on a consistent basis because this is the most technically sound approach. To the extent that any future CAD comments differ from the existing cap and CDF comments, this will	EPA indicated that it is unlikely that another letter on CAD sites will come from EPA. EPA indicated that this comment was included in the letter as "just in case" language. EPA indicated they understand that a later letter on CAD standards would further delay the FS schedule. EPA indicated that at this time the CDF standards should be applied to CADs as well, where applicable.

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Performance Standard – EPA Comment	LWG Designation as Feasibility Study or Design Issue?	LWG Response	LWG Notes on EPA Verbal Clarifications to LWG Questions During March 10, 18, and 29, 2010 Meetings
• Cap material, thickness, placement technique, and long-term stability • Physical intrusion into the floodway and navigation channel • Interim capping and protection during dormant periods.		create a further departure from this preferred consistent approach.	
5. General – Design level of detail of some of EPA's comments.	NA	Many of EPA's comments address aspects of CDF design that are normally not addressed in an FS level analysis and should not be addressed one way or the other in this FS. The LWG proposes proceeding with the FS with the understanding that these design level issues will be addressed in brief qualitative text and without specific quantitative estimates or costing. The LWG proposed in the March 29 meeting, and continues to propose, that each design level standard (as designated by LWG) will be qualitatively and briefly discussed in a manner that compares between alternatives. Accordingly, specific quantitative estimates related to costs, feasibility, or effectiveness will not be developed in the FS for these design level standard issues.	On March 10th, EPA indicated that the LWG should use these design level comments if these issues "come up" in the FS. EPA further commented on March 18th that some aspects of these design issues are still part of an FS evaluation in a basic sense. The example of stormwater and utility lines was discussed. It was tentatively agreed the FS could discuss very approximately the number and types of such utilities that might exist for a CDF site and to what extent handling those utilities might impact the approximate overall cost or feasibility of design. It was discussed that this concept could be extended to other design level comments.
Design – *The CDF shall be designed to:*			
6. Contain the volume, level, and characteristics of contaminated sediment to be placed within it, using site-specific designs as needed to accommodate the specific contaminated materials proposed for disposal. The CDF shall be designed to achieve these performance standards when filled with the specified design volume of contaminated sediment meeting CDF sediment acceptance criteria that will be established, considering representative sediment contaminant concentrations and contaminant mobility data obtained from, or estimated for, sediments from Portland Harbor sites where dredging is a reasonably anticipated remedial action that would generate sediments requiring confinement.	FS Issue	The FS will evaluate at a general level the extent to which a CDF can be designed to protectively contain the sediments proposed for dredging under various alternatives.	None.
7. Minimize physical intrusion into waters of the US.	FS Issue	Noted, assuming EPA's March 18th clarification noted in bold is confirmed in writing by EPA. FS would normally consider to what extent a CDF would intrude into waters of the U.S. and cause navigation or flood concerns. However, the level of allowable physical intrusion of a CDF into waters of the U.S. should be determined in the FS by an ARARs evaluation, not by a vague standard to "minimize" intrusion.	EPA indicated that the ARAR (CWA Section 404) includes language to avoid, "minimize", and then mitigate. **EPA agreed that compliance with the ARAR, as normally evaluated on similar projects, would determine compliance with this standard.**
8. Minimize water flow into and out of the CDF, including preventing or restricting preferential flow paths of clean or contaminated groundwater into or out of the CDF. The evaluation should include identifying, removing or modifying utilities trenches, storm drain lines, wells, and other conduits within 500 feet of the CDF (or other distance as determined to be appropriate). Utilities, storm drain lines and other conduits are not allowed under or within the contaminated sediment fill prism.	Design Issue	The comment will be addressed consistent with the LWG proposed approach to design level issues as noted in response to Comment 5. An FS would not normally get into details of indentifying and removing specific utilities or how specific utilities or potential preferential pathways might factor into future designs.	The example of stormwater and utility lines was discussed during the March 18th meeting. It was tentatively agreed the FS could discuss very approximately the number and types of such utilities that might exist for a CDF site and to what extent handling those utilities might impact the approximate overall cost or feasibility of design.

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Performance Standard – EPA Comment	LWG Designation as Feasibility Study or Design Issue?	LWG Response	LWG Notes on EPA Verbal Clarifications to LWG Questions During March 10, 18, and 29, 2010 Meetings
9. Achieve confinement of all hazardous substances disposed of in the facility through the groundwater pathway so that the CDF does not contribute any long- term discharge and/or release of contaminants above applicable and relevant and appropriate requirements under federal or state law for surface water in the lower Willamette River.	FS Issue	The FS will consider potential impacts to water quality through groundwater pathways by comparing long term discharge estimates to appropriate surface water quality criteria.	None.

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Performance Standard – EPA Comment	LWG Designation as Feasibility Study or Design Issue?	LWG Response	LWG Notes on EPA Verbal Clarifications to LWG Questions During March 10, 18, and 29, 2010 Meetings
10. Limit contaminant concentrations in groundwater (including berm pore water) exiting the CDF to levels below EPA's national recommended chronic water quality criteria for both aquatic organisms and fish consumption by humans (17.5 g/day), more stringent Oregon water quality standards, and MCLs without dilution in the water column. This should include dormant periods between CDF filling, and after closure. Analyses for meeting these criteria shall not consider biodegradation of contaminants within the CDF.	FS Issue	Disagree. The standard is vague as compared to, for example, the cap evaluation approach described in EPA's December 18, 2009 FS guidance comments. The appropriate technical approach is for the CDF standards to be consistent with cap (and CAD) standards. The FS CDF (and other technology) chemical concentration predictions should be compared to water criteria over a spatial extent (vertical and horizontal) that is consistent with the exposure area that is normally addressed in the application of these criteria. The comment also indicates that no biodegradation should be assumed to take place for the purposes of modeling. This is contrary to LWG's understanding of past comments by EPA on both the Portland Harbor chemical fate/cap modeling methods as well as T4 design modeling methods. The EPA required performance standards and assumptions are sufficiently conservative (particularly in combination) that they would greatly increase the assumed costs associated with CDFs to such an extent that it could unfairly bias the FS analysis. Similarly, if these standards and assumptions are applied to caps it would make typical isolation caps (e.g., 1 to 3 feet of clean sand) infeasible for much of the localized AOPC areas (e.g., assuming no chemical biodegradation for any chemicals, including polycyclic aromatic hydrocarbon compounds). With EPA's clarifications, it is our understanding that EPA is still requiring an analysis using the groundwater discharge performance standards and assumptions stated in the EPA comments and in their verbal clarifications. However, we also understand that EPA agrees to allow the LWG to propose alternative groundwater discharge performance standards and assumptions to better understand the implications of the EPA required performance standards, and to use the appropriate alternative performance standards and assumptions in the detailed evaluation of the FS based on this analysis. **On this basis, LWG agrees to move forward with these evaluations through the screening phase of the FS, but we are on record as disagreeing with the technical reasoning for this approach. Further, LWG will present a comparative evaluation of performance standards and assumptions in the Alternatives Screening check in and the LWG will seek EPA approval at that time of its recommended path forward consistent with the findings of those evaluations.**	EPA asked for more description of how the comment is vague, which resulted in additional EPA verbal clarifications of EPA positions as follows: • Horizontal spatial averaging for fish consumption criteria should be allowed for CDF evaluations. The spatial extent is defined as the area of the CDF berm face. • All other criteria should be applied on a point by point basis (whether or not such criteria would be applied in that manner in other contexts). • No dilution in the water column should be allowed for any of these criteria. • Comparison of all criteria to estimated discharges of groundwater to surface water should be made within the berm sand (not rip rap) immediately prior to entering the surface water. EPA stated that, for the T4 project, EPA previously decided that no biodegradation will be allowed. For the Portland Harbor FS, EPA indicated that EPA's biodegradation rate agreement only applied to the site-wide MNR/recontamination model. EPA indicated that caps, CADs, and CDFs should be evaluated assuming zero biodegradation rate in the FS. Per comment 3, EPA indicated that the LWG can provide evaluations assuming non-zero biodegradation rates as long as the EPA requested zero biodegradation evaluations that also conform to other standards in these comments are presented. The LWG sought clarification on March 29 that EPA's requirement to not allow any dilution in surface water applies to mechanisms taking place in the actual surface water body. The LWG indicated this prohibition was assumed to not include mechanisms of surface water exchange that occur within sediment near the sediment/surface water interface. EPA agreed that their prohibition of accounting for surface water dilution was limited to mechanisms that occur within the water column itself, not within the surface sediment.

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Performance Standard – EPA Comment	LWG Designation as Feasibility Study or Design Issue?	LWG Response	LWG Notes on EPA Verbal Clarifications to LWG Questions During March 10, 18, and 29, 2010 Meetings
10. (continued)			On March 29, EPA also indicated that it was not their intent to unfairly bias the FS analysis away from CDFs or to preclude capping in areas that would normally be expected to be feasibly capped. However, EPA indicated that they could not alter their proposed groundwater discharge performance standards or assumptions without a more detailed understanding of the basis for the LWG's contentions.
11. CDFs shall be designed in a manner that is consistent with the Remedial Action Objectives and Management Goals that have been established for the Feasibility Study. Habitat mitigation and land acquisition assumptions for individual CDFs shall be developed for cost estimating purposes in the FS.	FS Issue	The FS will assess consistency with RAOs and management goals. Habitat mitigation and land costs will be included at a conceptual level and/or as a cost range.	None.
12. CDF Berms shall be designed to: • Provide a static safety factor of 1.5 or greater and a seismic safety factor of 1.1 or greater. The design seismic event shall correspond to a 10 percent probability of exceedance in 50 years. • Be resistant to erosive forces by the largest of 100-year flood flow, 100-year waves, vessel-induced waves from typical passing vessels, and anticipated propeller wash from vessels that operate in the area. • Have an appropriate gradation to allow transport of groundwater while retaining (filtering) sediment during filling and after closure.	Design Issue	The comment will be addressed consistent with the LWG proposed approach to design level issues as noted in response to Comment 5. FS would not normally determine detailed seismic and erosion requirements. The FS would consider generally that the CDFs would have to be robust enough to prevent routine failure or erosion. See next comment regarding flood modeling.	None.
13. Construction of any CDF shall not measurably increase the 100-year flooding stage or decrease flood storage of the Willamette River. The FS shall consider cumulative effects of multiple sites and related remedial actions including sediment capping.	FS Issue	Flood assessment modeling will be conducted for the FS at a comprehensive alternative level, but not for individual parts of the alternative (e.g., just a CDF). Given this approach, we agree that the FS will generally evaluate so called "cumulative" effects represented by the entirety of each comprehensive alternative.	EPA clarified that they regard this as an FS level issue. LWG agrees, per the response.
14. Maintain saturated or unsaturated conditions (as appropriate) within the confined contaminated sediments prism, considering reasonably anticipated seasonal and long-term cyclical groundwater levels, and considering site infiltration or zero recharge (as appropriate) from the overlying ground surface, to eliminate or reduce potential mobility of chemicals of concern.	Design Issue	The comment will be addressed consistent with the LWG proposed approach to design level issues as noted in response to Comment 5. The FS will approximately estimate the elevation a CDF could be filled to using maintenance of saturated conditions as a guiding principle. However, it will not contain a detailed evaluation of long term groundwater cycles and levels of site infiltration.	None.
15. Minimize releases of 303(d) listed contaminants to the extent practicable.	FS Issue	Noted. The FS will consider to what extent a CDF might release contaminants, including 303(d) contaminants, through an evaluation of compliance with ARARs. However, this will be a qualitative evaluation in the FS for most 303(d) contaminants, given that every potential chemical will not be modeled.	EPA indicated that the standard is consistent with the language in the ARARs. EPA agreed that the LWG could take the approach of evaluating compliance with the ARARs in the FS and the LWG can understand this to comply with the standard as written here. EPA indicated that such evaluations should be sure to include consideration of all the 303d listed chemicals in the Lower Willamette. The LWG assumes this means those chemicals listed for RM 0-24.8 of the Lower Willamette River.

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Performance Standard – EPA Comment	LWG Designation as Feasibility Study or Design Issue?	LWG Response	LWG Notes on EPA Verbal Clarifications to LWG Questions During March 10, 18, and 29, 2010 Meetings
16. Unless modified by EPA, all CDFs shall be designed to meet these performance standards, ARARs and the final Portland Harbor ROD requirements in perpetuity.	Design Issue	The comment will be addressed consistent with the LWG proposed approach to design level issues as noted in response to Comment 5. The FS will evaluate compliance with the standards and ARARs that LWG agrees with per these responses and at the level of detail appropriate to an FS per responses on design level comments. The FS cannot evaluate compliance with Portland Harbor ROD requirements that do not exist at this time.	None.
Construction and Filling:			
17. Construct the CDF berm and related components in a manner that minimizes to the extent practicable water quality exceedances within the construction zone and achieves compliance with water quality criteria/standards at and beyond the specified point of compliance.	FS Issue	Assuming EPA's March 18th clarification noted in bold is confirmed in writing by EPA, the FS will evaluate compliance with water quality ARARs during construction and filling of CDFs, but will not evaluate the same operations against a vague standard of "minimization".	EPA indicated that the ARAR (CWA Section 404) includes language to avoid, "minimize", and then mitigate. **EPA agreed that compliance with the ARAR, as normally evaluated on similar projects, would determine compliance with this standard.**
18. Construct the CDF in a manner that minimizes impacts to fisheries and wildlife by removing fish to the extent practicable from the CDF area before and during berm construction.	Design Issue	If EPA agrees to the overall proposed LWG approach to design level issues as noted above, this will be addressed in the FS. The FS will not discuss construction details like removing fish from the CDF area before construction. The FS will generally discuss that currently undetermined construction measures may be required to minimize impacts to fish and wildlife.	None.
19. Construct the CDF berm with acceptable material. For cost estimating purposes, acceptable material should be based on requirements established in the December 2003 Technical Plans and Specifications (Ecology and the Environment 2003) for the McCormick & Baxter sediment cap located within the Willamette River. Materials will generally be imported clean granular material, but typically all materials shall be free of roots, inappropriate organic material, contaminants, and all other deleterious and objectionable material. However, CDF berm construction material shall have an organic fraction meeting minimum specified values consistent with contaminant transport modeling.	Design Issue	Per the Comment 5 proposed overall approach on design level issues, the LWG proposes to address this design level issue qualitatively and briefly in the FS in a manner that compares between alternatives. The comment will be addressed consistent with the LWG proposed approach to design level issues as noted in response to Comment 5. The FS will assume that the berm would be made of relatively clean material, but would not have a specification such as noted in the comment. For FS cost purposes, a range of potential clean source materials that could meet Organic Carbon (OC) requirements will be assumed.	None.
20. Accept only sediments meeting final sediment acceptance criteria. EPA shall approve all sediment to be disposed of in any CDF.	Design Issue	The comment will be addressed consistent with the LWG proposed approach to design level issues as noted in response to Comment 5 with the following understanding: • Because no final acceptance criteria for Portland Harbor CDFs have been yet specified by EPA, the FS cannot consider them explicitly. The FS will assess at a general level the potential for any materials to	None.

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Performance Standard – EPA Comment	LWG Designation as Feasibility Study or Design Issue?	LWG Response	LWG Notes on EPA Verbal Clarifications to LWG Questions During March 10, 18, and 29, 2010 Meetings
		cause short term or long term violations of water quality ARARs to make this determination, consistent with LWG responses on other related performance standards.	
21, Plan and manage the CDF filling to avoid any short-term overflow(s), or minimize the overflows to the extent possible. If a CDF overflow during filling cannot be avoided, complete an analysis of overflow discharge rates and duration, contaminant concentrations, and ability to meet water quality criteria at end of pipe. Evaluate BMPs and treatment options needed to meet water quality criteria at the end of the pipe. If EPA agrees that criteria cannot be met at the end of the pipe then a dilution zone modeling analysis of the discharge impacts shall be completed to demonstrate compliance with water quality criteria. Overflows must meet acute water quality criteria. Chronic water criteria will be used to guide implementation of BMPs to minimize contaminant loadings to the river. The design shall consider engineering controls and treatment options needed to meet chronic discharge criteria at end of pipe.	Design Issue	The comment will be addressed consistent with the LWG proposed approach to design level issues as noted in response to Comment 5. The FS will generally consider to what extent overflow discharges would be necessary and if so, generally evaluate the likely water quality levels near the point of discharge and compare them to acute criteria. However, detailed analyses of discharge rates, dilution zone modeling, or determination of detailed BMPs relative to any expected chronic exceedances will not be determined.	EPA indicated that CDF evaluations in the FS should start by assuming the CDF would not have a surface water connection to the river. If this turns out to be infeasible or extremely costly, the FS could then evaluate the potential impacts of allowing overflow only during filling. This evaluation would also assume that the surface water connection would be closed off between filling projects. For CADs, EPA indicated that interim cover should be assumed to be needed between filling projects. EPA indicated the FS should assume that cover would need to be placed at the end of each construction season.
22. During CDF filling, concentrations in groundwater (berm pore water) exiting the CDF must meet acute water quality criteria. Chronic water criteria will be used to guide implementation of BMPs to minimize contaminant loadings to the river. For the CDF, short-term water quality impacts are defined as the period from the beginning of the fill activity until the water level in the CDF reduces to within 0.1 foot of the water level in the river.	Design Issue	The comment will be addressed consistent with the LWG proposed approach to design level issues as noted in response to Comment 5. The FS will not evaluate concentrations in groundwater short term, determine specific BMPs to minimize these short term concentrations, or define the "short term" period specifically (other than they are defined as during the construction phase).	None.
23. Physically close any hydraulic connection between river and the CDF (except through groundwater) except during periods of actual approved overflow.	FS Issue	The FS will consider to what extent overflow discharges would be generally necessary and if so, generally evaluate the likely water quality levels near the point of discharge and compare them to acute criteria. However, detailed analysis of discharge rates, dilution zone modeling, or determination of detailed BMPs relative to any expected chronic exceedances will not be determined. Per EPA's clarification, potential impacts of surface water moving through the berm will be generally discussed in the FS, but no specific quantitative estimates of this process will be made.	EPA indicated that CDF evaluations in the FS should start by assuming the CDF would not have a surface water connection to the river. If this turns out to be infeasible or extremely costly, the FS could then evaluate the potential impacts of allowing overflow only during filling. This evaluation would also assume that the surface water connection would be closed off between filling projects. Also, the LWG inquired if EPA is requiring the closure of the surface water connection to water behind the berm that could move through the berm before CDF is fully filled. EPA indicated that this pathway should be evaluated to determine the likelihood of any substantial impacts on surface water. If impacts are likely via this pathway, then the FS should assume that measures would be added to the CDF construction to minimize this impact.
24. Prior to final closure of any CDFs, the facility shall be managed in a manner that minimizes impacts to fisheries and wildlife. Potential and short-term exposures of fish and wildlife to contaminated sediments and/or water within a CDF shall be fully	Design Issue	The comment will be addressed consistent with the LWG proposed approach to design level issues as noted in response to Comment 5. The FS will consider at a general level to what extent impacts to fisheries and	None.

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Performance Standard – EPA Comment	LWG Designation as Feasibility Study or Design Issue?	LWG Response	LWG Notes on EPA Verbal Clarifications to LWG Questions During March 10, 18, and 29, 2010 Meetings
assessed and disclosed.		wildlife could occur due to CDF operation and will discuss that currently undetermined operational measures may be required to minimize impacts to fish and wildlife. The FS will not discuss operation details regarding minimizing fish and wildlife impacts and will not include detailed estimates of exposures.	
25. Cap contaminated sediments with clean soils/sediment, or soils/sediments that meet specific acceptance criteria that are established by EPA.	Design Issue	The comment will be addressed consistent with the LWG proposed approach to design level issues as noted in response to Comment 5. The FS will assume that the cap would be made of relatively clean material, but comparisons cannot be made to a specification that does not exist at this time.	None.
26. Stormwater discharges or infiltration of stormwater into the CDF is not allowed.	Design Issue	The comment will be addressed consistent with the LWG proposed approach to design level issues as noted in response to Comment 5. The FS will discuss conceptually that stormwater discharge or infiltration through a CDF is generally to be avoided, but will not describe a design for rerouting or otherwise handling stormwater discharges in the CDF area.	None.
Long-Term:			
27. Monitor CDF(s) in perpetuity, or until reduced monitoring is approved by EPA, to document that the CDF(s) achieves confinement of all hazardous substances placed in it so that the facility does not contribute any discharge and/or release of contaminants above performance standards/ROD criteria for surface water or sediment in the lower Willamette River.	FS Issue	The FS will discuss at a conceptual level the need for long term monitoring of all aspects of comprehensive alternatives to confirm whether ROD cleanup levels and ARARs are being met. However, it is impossible for the FS to consider any specifics of monitoring related to assessing attainment of ROD standards, criteria, and ARARs that have not been established yet. In general, specific monitoring plan requirements or performance standards will not be determined in the FS. Per EPA's clarification, we agree to include a general cost estimate for monitoring and state the general assumptions (e.g., numbers of wells, frequency of sampling, etc.) that were used to estimate the costs. For FS costing purposes, long-term CDF monitoring costs will be estimated for a 30-year period (not in perpetuity), consistent with other conceptual monitoring cost estimates (e.g., MNR) in the FS and guidance in general.	EPA agreed this comment states a general concept that long term monitoring will be considered as a component of CDF alternatives and costing. EPA indicated that reference to ROD standards/criteria only refers to the intent of the monitoring, not specific standards that would be assumed for the FS. EPA indicated the FS should include a general cost estimate for monitoring and state the general assumptions (e.g., numbers of wells, frequency of sampling, etc.) that were used to estimate the costs. EPA indicated that LWG should use a 30-year period for the cost estimate but that the FS should state that monitoring will actually be in perpetuity or until EPA decides it is no longer needed.
28. Provide appropriate financial assurance for project development, closure, long-term monitoring, mitigation as needed, and contingency actions.	Design Issue	The comment will be addressed consistent with the LWG proposed approach to design level issues as noted in response to Comment 5. The FS will assume and state that performing parties will need to establish such assurances as part of remedial design. Financial assurance requirements or details will not be described in an FS.	None.

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 part

Performance Standard – EPA Comment	LWG Designation as Feasibility Study or Design Issue?	LWG Response	LWG Notes on EPA Verbal Clarifications to LWG Questions During March 10, 18, and 29, 2010 Meetings
29. Implement appropriate institutional controls: • Prevent disturbance of the sediment • Prevent stormwater infiltration into the CDF or the CDF buffer zone. • Prevent installation of groundwater extraction wells for any purpose with the CDF or the CDF buffer zone. • Restrict development on the CDF. Structures may be constructed over the CDF; however, foundations must remain at least 3 feet above the upper surface of the contaminated sediment zone. Installation of piles driven through the contaminated sediment zone is not allowed. However, EPA is willing to consider proposals for jet grouted piles or other technologies that will not disturb the contaminated sediments.	Design Issue	The comment will be addressed consistent with the LWG proposed approach to design level issues as noted in response to Comment 5. The FS will discuss conceptually the level and range of institutional controls that would need to accompany a CDF alternative. However, the specific controls would not be determined in the FS, because they are dependent on the details of the specific design eventually determined.	None.

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 part

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10
OREGON OPERATIONS OFFICE
805 SW Broadway, Suite 500
Portland, Oregon 97205

April 23, 2010

Mr. Jim McKenna
Port of Portland & Interim Chairman, Lower Willamette Group
121 Northwest Everett
Portland, Oregon 97209

Re: Portland Harbor Superfund Site; Administrative Order on Consent for Remedial Investigation and Feasibility Study; Docket No. CERCLA-10-2001-0240

Dear Mr. McKenna:

This is in response to the Lower Willamette Group (LWG) letter and table that were provided on April 14, 2010 as a follow-up response to EPA's February 18, 2010 letter and subsequent discussions at meetings regarding performance standards for Confined Disposal Facilities (CDFs) for the Feasibility Study (FS). EPA recently agreed to extend the deadline to invoke dispute resolution on EPA's CDF performance standards until April 30, 2010.

EPA acknowledges the LWG's response that it will address the performance standards as directed by EPA as part of the alternatives screening and present the results to EPA at the screening check-in. EPA generally agrees that addressing the performance standards as directed by EPA as part of the alternatives screening check-in is an acceptable approach as a means for moving the FS forward. We are looking forward to our upcoming planning meeting to discuss the alternatives screening check-in process and expectations for the check-in meeting.

EPA does have some comments on LWG's table to more accurately reflect EPA's position on the LWG comment response and notes on EPA's verbal clarifications provided in the table. Our comments are attached. EPA does not believe that our comments on the table significantly affect our previous direction, and requests that the LWG confirm that the performance standards will be addressed as directed.

If you have any questions 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 Comments on LWG Table - EPA February 18, 2010 CDF Performance Standards Comments and LWG April 14, 2010 Responses

General

1. EPA directs the LWG to address each of the performance standards in sufficient detail as to reasonably understand the substantial impacts of the performance standards on each CDF and CAD evaluated in the FS, and in sufficient detail to estimate costs of the alternatives within a range of +50% to -30%.
2. Schedule - EPA disagrees to the extent that the LWG is assuming that the draft FS completion date is automatically delayed day-for-day until issues related to the performance standards are resolved. EPA acknowledges that resolution of CDF performance standards has impacted the schedule; however, as previously discussed with the LWG, EPA needs to consider the net effect and circumstances of the individual issues and events that delay FS tasks before agreeing to delays in the overall schedule.
3. EPA agrees with the clarification and notes that we will be discussing the format and timing of the alternatives screening level check-in.
4. The CDF performance standards should generally be applied to CADs in a consistent manner as to CDFs. EPA is also willing to consider proposals from LWG that address the specific items listed in EPA's letter.
5. EPA agrees that qualitative evaluation of "design" performance standards as designated by LWG may be sufficient for comparison of alternatives; however, the FS must include cost estimates for implementation of each alternative, and these cost estimates must include consideration of the costs of both remedial design technical analyses and remedial action construction related impacts, as best they can be foreseen at the FS level.
6. No further comment.
7. EPA cautions that CWA 404 is not the only ARAR relevant to floodway intrusions into the navigation channel. FEMA regulations and Section 10 of the Rivers and Harbors Act must also be considered in the analysis.
8. No further comment.
9. No further comment.
10. No further comment.
11. No further comment.
12. EPA agrees, but notes that the qualitative evaluation must be more than simply re-stating the performance requirement. For example, for seismic considerations, EPA agrees that detailed site-specific geotechnical investigations and seismic modeling can be deferred until remedial design; however, the FS should include a review of regional soil and geologic maps as well as readily available site-specific geotechnical data by a geotechnical engineer with substantial local experience in assessment of soil/sediment stability in/near the Willamette River so as to identify relative significance of seismic concerns amongst the variously CDF and CAD sites. The review should identify conditions of potential concern that can reasonably be foreseen from available data, and provide recommendations (and estimated costs) for further analyses. Seismic conditions of concerns and costs may differ between sites. Depending upon the outcome of the review, further analysis of seismic issues in the FS for one or all sites may be appropriate.
13. No further comment.
14. No further comment.

15. No further comment.
16. No further comment.

Construction and Filling

17. EPA cautions that CWA Section 404 is not the only ARAR applicable to meeting water quality standards during construction of the remedy. Section 401 and 301 of the CWA requires meeting water quality standards.
18. No further comment.
19. No further comment.
20. The FS should identify the potential volume of sediment that can be disposed of in each CDF and CAD and any sediment disposal acceptance requirement that might apply. The FS should present a general plan as best it can be identified at the FS level.
21. No further comment.
22. EPA agrees, and notes that the FS should identify in a general manner the proposed plan for filling each CDF. If all material is to be placed via clamshell, then not completing a short-term modeling analysis appears appropriate. However, for a CDF that will be filled primarily by hydraulic dredging methods where a berm or similar feature is relied on to "filter" the return water, discussion of (and possibly preliminary modeling of) short term water quality impacts may be appropriate.
23. No further comment.
24. EPA expects that cost estimates will consider that some controls will be required and the FS should discuss the types of controls that would likely be needed.
25. No further comment.
26. No further comment.
27. No further comment.
28. A reasonable estimate of the cost for providing financial assurance (such as a percentage of estimated construction cost) should be included in the FS cost estimates.
29. No further comment.

LWG
LOWER WILLAMETTE GROUP

Chairperson: Bob Wyatt, NW Natural
Treasurer: Fred Wolf, Legacy Site Services for Arkema

May 5, 2010

Chip Humphrey
Eric Blischke
U.S. Environmental Protection Agency, Region 10
805 SW Broadway, Suite 500
Portland, OR 97205

Re: EPA Performance Standards for Confined Disposal Facilities for the Portland Harbor Feasibility Study (Lower Willamette River, Portland Harbor Superfund Site, USEPA Docket No: CERCLA-10-2001-0240)

Chip and Eric:

The Lower Willamette Group (LWG) is in receipt of your April 23, 2010 letter responding to the LWG's April 14, 2010 response to EPA's February 18, 2010 performance standards for Confined Disposal Facilities (CDFs) for the Feasibility Study (FS). We appreciate the time EPA has spent resolving these issues so that the LWG may move forward with the FS.

In your April 23 letter, you provided comments on LWG's responses, and asked the LWG to confirm that the performance standards will be addressed as directed. Attached are responses to EPA's additional comments. Based on the attachment and the letters of April 14 and April 23, the LWG believes the issues have been resolved, and LWG will address the performance standards as directed by EPA as described in the referenced documents. If EPA has concerns regarding our additional responses, then LWG requests a two week extension (to May 21) of the deadline to dispute the directives to provide adequate time to resolve those concerns. If EPA does not provide that extension, the LWG must dispute the directives.

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

Responses to EPA's CDF Performance Standards Comments Dated April 23, 2010.

1. EPA directs the LWG to address each of the performance standards in sufficient detail as to reasonably understand the substantial impacts of the performance standards on each CDF and CAD evaluated in the FS, and in sufficient detail to estimate costs of the alternatives within a range of +50% to -30%.

Response: We agree to address each of the performance standards in sufficient detail to reasonably understand the substantial impacts of each performance standard. We agree to estimate costs for entire FS alternatives within the +50% to -30% range per FS guidance. This will not involve estimating the cost impact of each individual performance standard for each disposal site to this degree of accuracy. Instead, the LWG agrees to identify any cost implications associated with each performance standard that are expected to substantially impact the accuracy of the overall estimate for the alternative within the specified range.

2. Schedule - EPA disagrees to the extent that the LWG is assuming that the draft FS completion date is automatically delayed day-for-day until issues related to the performance standards are resolved. EPA acknowledges that resolution of CDF performance standards has impacted the schedule; however, as previously discussed with the LWG, EPA needs to consider the net effect and circumstances of the individual issues and events that delay FS tasks before agreeing to delays in the overall schedule.

Response: The LWG's goal regarding schedule communication is to always be clear to EPA on the estimated schedule impacts associated with any activity EPA is undertaking (such as discussion of comments). The LWG will continue to discuss the net effect on the schedule of these and other ongoing project activities with EPA. The LWG's estimate of this particular schedule impact is not expected to change through such discussions unless EPA identifies some new project approach that will save time elsewhere in the project.

3. EPA agrees with the clarification and notes that we will be discussing the format and timing of the alternatives screening level check-in.

Response: No further response is necessary.

4. The CDF performance standards should generally be applied to CADs in a consistent manner as to CDFs. EPA is also willing to consider proposals from LWG that address the specific items listed in EPA's letter.

Response: The LWG has no further response at this time.

5. EPA agrees that qualitative evaluation of "design" performance standards as designated by LWG may be sufficient for comparison of alternatives; however, the FS must include cost estimates for implementation of each alternative, and these cost estimates must

include consideration of the costs of both remedial design technical analyses and remedial action construction related impacts, as best they can be foreseen at the FS level.

Response: See response to Comment 1. We will estimate costs related to remedial design technical analyses where they are expected to substantially impact the overall alternative cost estimate within the ranges specified in response to Comment 1.

6. No further comment.

7. EPA cautions that CWA 404 is not the only ARAR relevant to floodway intrusions into the navigation channel. FEMA regulations and Section 10 of the Rivers and Harbors Act must also be considered in the analysis.

Response: The LWG agrees to consider the requirements of all ARARs relevant to this issue in the FS.

8. No further comment.

9. No further comment.

10. No further comment.

11. No further comment.

12. EPA agrees, but notes that the qualitative evaluation must be more than simply restating the performance requirement. For example, for seismic considerations, EPA agrees that detailed site-specific geotechnical investigations and seismic modeling can be deferred until remedial design; however, the FS should include a review of regional soil and geologic maps as well as readily available site-specific geotechnical data by a geotechnical engineer with substantial local experience in assessment of soil/sediment stability in/near the Willamette River so as to identify relative significance of seismic concerns amongst the variously CDF and CAD sites. The review should identify conditions of potential concern that can reasonably be foreseen from available data, and provide recommendations (and estimated costs) for further analyses. Seismic conditions of concerns and costs may differ between sites. Depending upon the outcome of the review, further analysis of seismic issues in the FS for one or all sites may be appropriate.

Response: The LWG agrees with the comment except for the following portions:

- **"…provide recommendations (and estimated costs) for further analyses. "**

The LWG does not agree that the FS needs to determine the content of future design level analyses (or costs of those studies which will generally be minor as

compared to overall construction costs) in order to qualitatively assess major seismic issues that may be associated with a disposal site.

- **"Seismic conditions of concerns and costs may differ between sites. Depending upon the outcome of the review, further analysis of seismic issues in the FS for one or all sites may be appropriate."**

Additional analyses are warranted if the information is needed to make an FS decision. If major issues are determined for this design level standard or any other design level standard, it is not the LWG's intent to embark upon design level analyses of those issues as part of the FS. Also, regarding costs, see response to Comment 1.

13. No further comment.

14. No further comment.

15. No further comment.

16. No further comment.

Construction and Filling
17. EPA cautions that CWA Section 404 is not the only ARAR applicable to meeting water quality standards during construction of the remedy. Section 401 and 301 of the CWA requires meeting water quality standards.

Response: The LWG agrees to consider the requirements of all ARARs relevant to this issue in the FS.

18. No further comment.

19. No further comment.

20. The FS should identify the potential volume of sediment that can be disposed of in each CDF and CAD and any sediment disposal acceptance requirement that might apply. The FS should present a general plan as best it can be identified at the FS level.

Response: The LWG agrees to estimate volumes or ranges of volumes of sediment that can be disposed each CDF or CAD. The LWG is not clear regarding the meaning of the following portion of the comment: "…any sediment disposal acceptance requirement that might apply. The FS should present a general plan as best it can be identified at the FS level".

However, rather than seeking clarification from EPA on this comment, the LWG reiterates our previous response for moving forward, which we believe resolves this

issue: The FS will assess at a general level the potential for any materials to cause short term or long term violations of water quality ARARs to make this determination.

21. No further comment.

22. EPA agrees, and notes that the FS should identify in a general manner the proposed plan for filling each CDF. If all material is to be placed via clamshell, then not completing a short-term modeling analysis appears appropriate. However, for a CDF that will be filled primarily by hydraulic dredging methods where a berm or similar feature is relied on to "filter" the return water, discussion of (and possibly preliminary modeling of) short term water quality impacts may be appropriate.

Response: The LWG has no further response at this time.

23. No further comment.

24. EPA expects that cost estimates will consider that some controls will be required and the FS should discuss the types of controls that would likely be needed.

Response: See response to Comment 1. Controls of this nature are expected to represent relatively minor costs as compared to overall construction and operation of a CDF. However, the costs of these controls will be estimated if they are expected to substantially impact the overall alternative cost estimate within the ranges specified in response to Comment 1. The LWG agrees that if some obvious measures exist to minimize impacts to fish or wildlife during CDF filling operations, they can be discussed in the FS. However, as noted in the original response [emphasis added]: The FS will not discuss operational <u>details</u> regarding minimizing fish and wildlife impacts and will not include <u>detailed estimates</u> of exposures.

25. No further comment.

26. No further comment.

27. No further comment.

28. A reasonable estimate of the cost for providing financial assurance (such as a percentage of estimated construction cost) should be included in the FS cost estimates.

Response: LWG has no further response at this time.

29. No further comment.

APPENDIX B
DRAWINGS

APPENDIX B
DRAWINGS
(PREFINAL 60 PERCENT DESIGN SUBMITTAL)
TERMINAL 4 CONFINED DISPOSAL FACILITY
PORT OF PORTLAND, PORTLAND, OREGON

Prepared for
Port of Portland
Portland, Oregon

Prepared by
Anchor QEA, LLC
6650 SW Redwood Lane, Suite 333
Portland, Oregon 97224

NOTE: The Drawings in this Appendix include only those Drawings that have been revised from Anchor 2006, *Design Analysis Report (Prefinal 60 Percent Design Deliverables): Terminal 4 Early Action, Port of Portland*. Other relevant Drawings from Anchor 2006 still apply.

August 2011

SHEET NO.	DESCRIPTION
GENERAL INFORMATION	
1 (GI-1)	PROJECT INDEX SHEET
2 (GI-2)	SITE PLAN AND VICINITY MAP
3 (GI-3)	EXISTING CONDITIONS
4 (GI-4)	EXISTING UTILITIES (NOT INCLUDED)
5 (GI-5)	SITE PLAN AFTER SLIP 3 DREDGING COMPLETE (NOT INCLUDED)
6 (GI-6)	SITE PLAN AFTER CDF FILLED
DEMOLITION	
7 (C-1)	DEMOLITION PLAN: SLIP 1 (1)
8 (C-2)	DEMOLITION PLAN: SLIP 3 (1)
9 (C-3)	STRUCTURAL DEMOLITION DETAILS (1)
10 (C-4)	STRUCTURAL DEMOLITION DETAILS (1)
11 (C-5)	STRUCTURAL DEMOLITION DETAILS (1)
12 (C-6)	STRUCTURAL DEMOLITION DETAILS (1)
13 (C-7)	STRUCTURAL DEMOLITION DETAILS (1)
14 (C-8)	STRUCTURAL DEMOLITION DETAILS (1)
DRAINAGE AND CIVIL UTILITY ADJUSTMENT PLANS	
15 (C-9)	SLIP 1 STORMWATER REROUTE (1)
16 (C-10)	PLAN AND PROFILE SHEET: SLIP 1 - STORMWATER REROUTE (1)
17 (C-11)	PLAN AND PROFILE SHEET: SLIP 1 - STORMWATER REROUTE (1)
18 (C-12)	PLAN AND PROFILE SHEET: SLIP 1 - STORMWATER REROUTE (1)
19 (C-13)	PLAN AND PROFILE SHEET: SLIP 1 - STORMWATER REROUTE (1)
20 (C-14)	PLAN AND PROFILE SHEET: SLIP 1 - STORMWATER REROUTE (1)
21 (C-15)	PLAN AND PROFILE SHEET: SLIP 1 - STORMWATER REROUTE (1)
22 (C-16)	PLAN AND PROFILE SHEET: SLIP 1 - STORMWATER REROUTE (1)
23 (C-17)	PLAN AND PROFILE SHEET: SLIP 1 - STORMWATER REROUTE (1)
24 (C-18)	SPLASHPAD AND OUTFALL DESIGN (1)
25 (C-19)	BULKHEAD WALL PENETRATION (1)
26 (C-20)	TRENCH DETAILS (1)
27 (C-21)	MANHOLE AND CATCHBASIN DETAILS (1)
28 (C-22)	MANHOLE AND CATCHBASIN DETAILS (1)
CONFINED DISPOSAL FACILITY PLAN	
29 (C-23)	CONFINED DISPOSAL FACILITY GRADING PLAN
30 (C-24)	CONTAINMENT BERM OVEREXCAVATION PLAN
31 (C-25)	CONFINED DISPOSAL FACILITY PLAN
32 (C-26)	CONFINED DISPOSAL FACILITY SECTIONS
33 (C-27)	SETTLEMENT MONITORING PLAN (NOT INCLUDED)
34 (C-28)	CONFINED DISPOSAL FACILITY MONITORING WELL LOCATIONS AND DETAILS (NOT INCLUDED)

SHEET NO.	DESCRIPTION
DREDGE PLAN	
35 (C-29)	DREDGE PLAN - SLIP 3 & BERTH 414 (1)
36 (C-30)	DREDGE PLAN SECTIONS - SLIP 3 (1)
37 (C-31)	DREDGE PLAN SECTIONS - SLIP 3 (1)
38 (C-32)	DREDGE PLAN SECTIONS - SLIP 3 (1)
39 (C-33)	DREDGE PLAN SECTIONS - BERTH 414 (1)
40 (C-34)	POST-DREDGE SEDIMENT SAMPLING LOCATIONS (1)
CAP PLAN	
41 (C-35)	CAP PLAN (1)
42 (C-36)	CAP PLAN - WHEELER BAY (1)
43 (C-37)	CAP SECTIONS (1)
44 (C-38)	CAP SECTIONS (1)
45 (C-39)	CAP SECTIONS (1)
46 (C-40)	BERTH 410 CONDITIONS (1)
STRUCTURAL - BERTH REPLACEMENT	
47 (S-1)	GENERAL STRUCTURAL NOTES 1 (1)
48 (S-2)	GENERAL STRUCTURAL NOTES 2 (1)
49 (S-3)	GENERAL ARRANGEMENT PLAN (1)
50 (S-4)	BERTH SURFACE FEATURE PLAN (1)
51 (S-5)	PILING AND PILE CAP PLAN (1)
52 (S-6)	DECK PLAN (1)
53 (S-7)	PIER CROSS SECTION (1)
54 (S-8)	PILE CAP ELEVATION & DETAILS 1 (1)
55 (S-9)	PILE CAP ELEVATION & DETAILS 2 (1)
56 (S-10)	PILE CAP ELEVATION & DETAILS 3 (1)
57 (S-11)	PILE CAP ELEVATION & DETAILS 4 (1)
58 (S-12)	DECK REINFORCING PLAN (1)
59 (S-13)	PILE CONNECTION DETAILS (1)
60 (S-14)	DECK PANEL DETAILS 1 (1)
61 (S-15)	DECK PANEL DETAILS 2 (1)
62 (S-16)	BULKHEAD PLAN & DETAILS 1 (1)
63 (S-17)	BULKHEAD PLAN & DETAILS 2 (1)
64 (S-18)	PRECAST PILE CAP PLAN & DETAILS (1)
65 (S-19)	DOCK FENDER SYSTEM DETAILS (1)
66 (S-20)	DOLPHIN & WALKWAY PLAN & DETAILS (1)
67 (S-21)	DOLPHIN & WALKWAY DETAILS 1 (1)
68 (S-22)	DOLPHIN & WALKWAY DETAILS 2 (1)
69 (S-23)	MISCELLANEOUS STEEL DETAILS 1 (1)
70 (S-24)	MISCELLANEOUS STEEL DETAILS 2 (1)

SHEET NO.	DESCRIPTION
ELECTRICAL	
75 (E-1)	LEGENDS AND SYMBOLS - ELECTRICAL (1)
76 (E-2)	BERTH 405 GENERAL PLAN - ELECTRICAL (1)
77 (E-3)	PARTIAL PLAN - ELECTRICAL (1)
78 (E-4)	PARTIAL PLAN AND DETAILS - ELECTRICAL (1)
79 (E-5)	DETAIL - ELECTRICAL (1)

NOTE:

(1) REFERENCE THE DECEMBER 2006 PREFINAL 60 PERCENT DESIGN FOR THESE PLANS AS THEY HAVE NOT CHANGED: ANCHOR ENVIRONMENTAL, L.L.C. (ANCHOR). 2006. DESIGN ANALYSIS REPORT (PREFINAL 60 PERCENT DESIGN DELIVERABLES): TERMINAL 4 EARLY ACTION, PORT OF PORTLAND, PORTLAND, OREGON. PREPARED FOR THE PORT OF PORTLAND. DECEMBER 2006.

(60%) DESIGN SET - NOT FOR CONSTRUCTION

NO.	DATE	BY	REVISIONS	CK'D	APPV'D

NO.	DATE	BY	REVISIONS	CK'D	APPV'D

PORT OF PORTLAND
PORTLAND, OREGON

ANCHOR QEA
1423 3RD AVENUE, SUITE 300 | SEATTLE, WA 98101 | (206) 287-9130

2005D078 — DESIGN NUMBER
800010 — PROJECT NUMBER

REGISTERED PROFESSIONAL ENGINEER 77473PE OREGON NOV. 8, 2005 JOHN RICHARD VERDUIN
EXPIRATION DATE:

DESIGNED BY T. GRIGA
DRAWN BY T. GRIGA
CHECKED BY J. VERDUIN
DATE OCTOBER 2010
GRAPHICAL SCALE BAR 0 1/4" 1/2" 1" 2"

TERMINAL 4

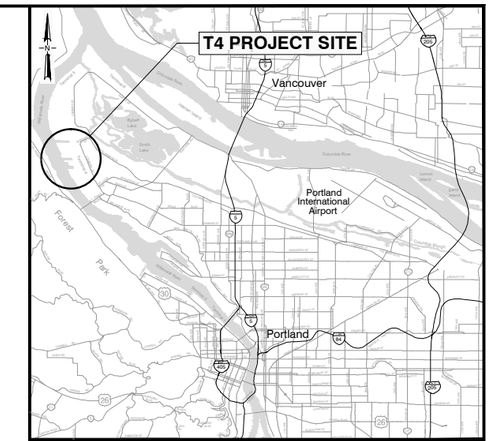
TERMINAL 4 - CDF
PROJECT INDEX SHEET

SUBMITTED BY
PROJECT ENGINEER

TYPE CD | DRAWING NO. T4 1/87 (GI-1)

8/8/2011 5:48:42 PM TGRIGA K:\jobs\050323.port_of_portland\050323114.cr\60%.cdf\no.xrefs\t4-60%.cdf-design\gi-1.dwg

SITE PLAN 1 / GI-3
SCALE: 1" = 150'



VICINITY MAP
SCALE: N.T.S.

NOTES:

1. HORIZONTAL DATUM: PORT OF PORTLAND LOCAL PROJECTION (INTERNATIONAL FEET)
   VERTICAL DATUM: NGVD 29-47
   CONTOUR INTERVAL = 1 FT
2. FOR NGVD CONTROL POINT, SEE PORT OF PORTLAND DRAWING RG 2006-3024 (NOVEMBER 2006)

(60%) DESIGN SET - NOT FOR CONSTRUCTION

NO.	DATE	BY	REVISIONS	CK'D	APPV'D

NO.	DATE	BY	REVISIONS	CK'D	APPV'D

PORT OF PORTLAND
PORTLAND, OREGON

ANCHOR QEA

2005D078 — DESIGN NUMBER
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CHECKED BY J. VERDUIN
DATE OCTOBER 2010
GRAPHICAL SCALE BAR 0 1/4" 1/2" 1" 2"

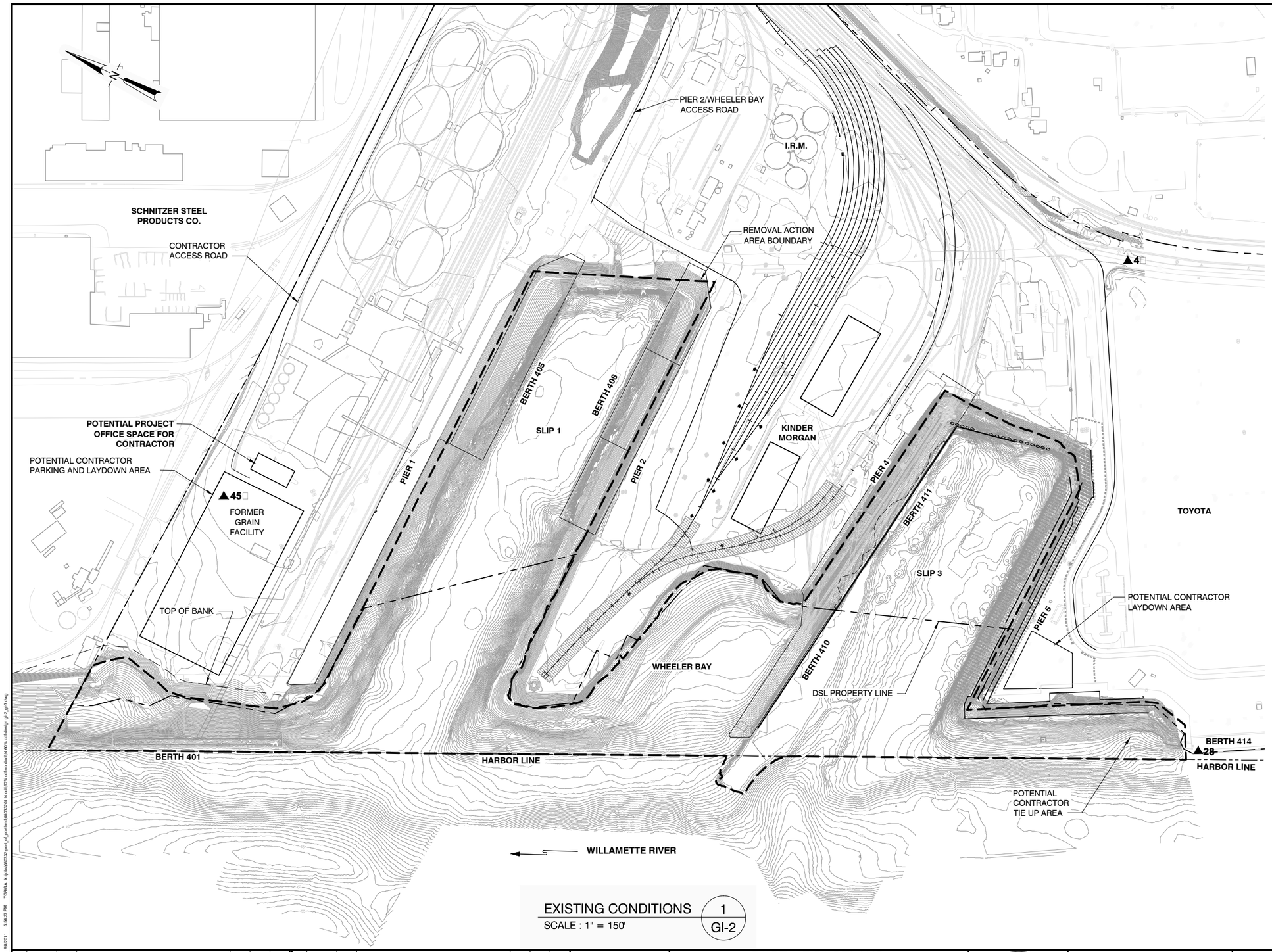
TERMINAL 4

TERMINAL 4 - CDF
SITE PLAN AND VICINITY MAP

SUBMITTED BY
PROJECT ENGINEER

TYPE CD
DRAWING NO. T4 2 / 87 (GI-2)

8/8/2011 5:54:52 PM TGRIGA k:\jobs\050132\port_of_portland\dwg\t4 cdf\60% cdf no date\t4 60% cdf design gi-2_gi-3.dwg



LEGEND:

TRACK FOUL AREA

4▲ SURVEY CONTROL POINT

STATION	NORTHING	EASTING	NGVD29 (47) ELEV.	DESCRIPTION
4	67011.054	71927.686	35.18	3" BRASS CAP STAMPED "4-B"
28	66167.751	70697.587	26.148	3" BRASS CAP STAMPED "T-4-28, 1999"
45	69137.290	70087.858	32.790	4" BRASS CAP SW COR. GRATTON DLC

NOTES:

1. HORIZONTAL DATUM: PORT OF PORTLAND LOCAL PROJECTION (INTERNATIONAL FEET)
   VERTICAL DATUM: NGVD 29-47
   CONTOUR INTERVAL = 1 FT
2. FOR NGVD CONTROL POINT, SEE PORT OF PORTLAND DRAWING RG 2006-3024 (NOVEMBER 2006)

EXISTING CONDITIONS — 1 / GI-2

SCALE : 1" = 150'

(60%) DESIGN SET - NOT FOR CONSTRUCTION

NO.	DATE	BY	REVISIONS	CK'D	APPV'D

NO.	DATE	BY	REVISIONS	CK'D	APPV'D

PORT OF PORTLAND
PORTLAND, OREGON

ANCHOR QEA

2005D078 — DESIGN NUMBER

800010 — PROJECT NUMBER

REGISTERED PROFESSIONAL ENGINEER 77473PE OREGON NOV. 8, 2005 JOHN RICHARD VERDUIN

EXPIRATION DATE:

DESIGNED BY T. GRIGA
DRAWN BY T. GRIGA
CHECKED BY J. VERDUIN
DATE OCTOBER 2010
GRAPHICAL SCALE BAR 0 1/4" 1/2" 1" 2"

TERMINAL 4

TERMINAL 4 - CDF
EXISTING CONDITIONS

SUBMITTED BY
PROJECT ENGINEER

TYPE CD | DRAWING NO. T4 | 3 / 87 (GI-3)

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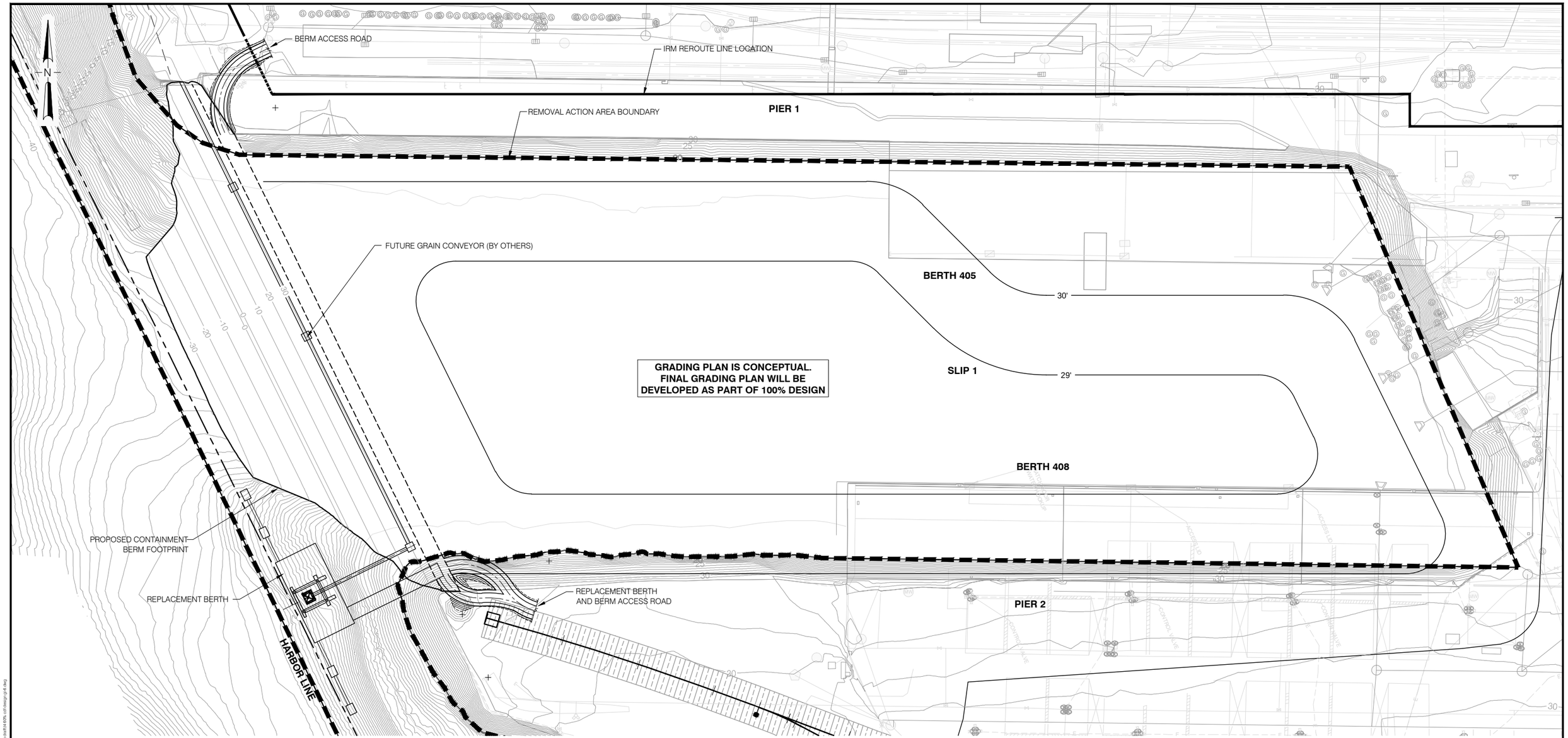

HORIZONTAL DATUM: PORT OF PORTLAND
LOCAL PROJECTION (INTERNATIONAL FEET)
VERTICAL DATUM: NGVD 29-47
CONTOUR INTERVAL: 1 FOOT
BERM CONTOUR INTERVAL: 5 FEET

SITE PLAN AFTER CDF FILLED
SCALE: 1" = 60'

1
GI-6

(60%) DESIGN SET - NOT FOR CONSTRUCTION

NO.	DATE	BY	REVISIONS	CK'D	APPV'D

NO.	DATE	BY	REVISIONS	CK'D	APPV'D

PORT OF PORTLAND
PORTLAND, OREGON

ANCHOR QEA

2005D078
DESIGN NUMBER

800010
PROJECT NUMBER

REGISTERED PROFESSIONAL ENGINEER 77473PE
OREGON NOV. 8, 2005 JOHN RICHARD VERDUIN
EXPIRATION DATE:

DESIGNED BY M. CRYSTAL
DRAWN BY T. GRIGA
CHECKED BY J. VERDUIN
DATE OCTOBER 2010
GRAPHICAL SCALE BAR 0 1/4" 1/2" 1" 2"

TERMINAL 4

TERMINAL 4 - CDF
SITE PLAN AFTER CDF FILLED

SUBMITTED BY
PROJECT ENGINEER

TYPE CD
DRAWING NO. T4 6/87 (GI-6)

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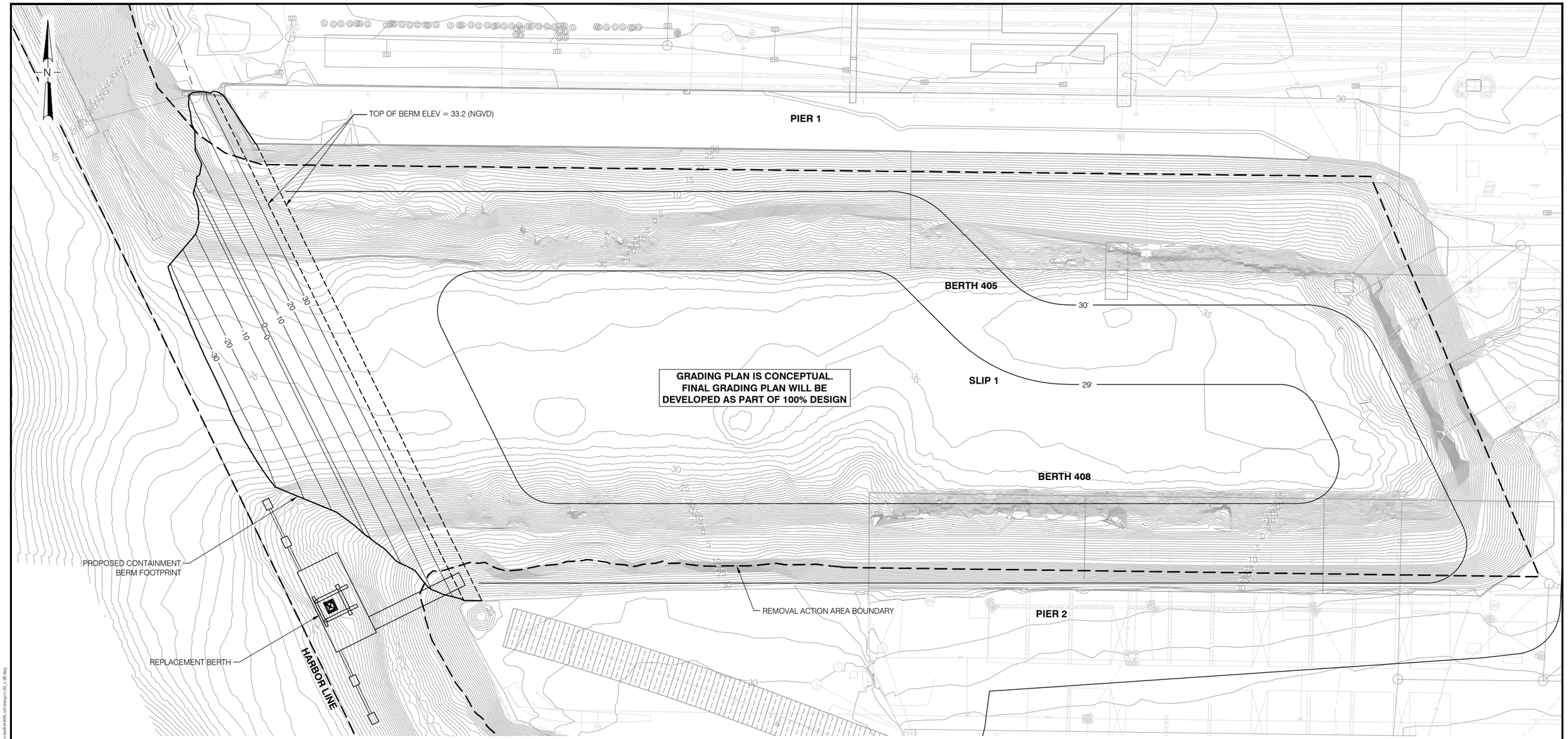

HORIZONTAL DATUM: PORT OF PORTLAND
LOCAL PROJECTION (INTERNATIONAL FEET)
VERTICAL DATUM: NGVD 29-47
CONTOUR INTERVAL: 1 FOOT

CONTAINMENT BERM OVEREXCAVATION PLAN (1 / C-24)
SCALE : 1" = 60'

(60%) DESIGN SET - NOT FOR CONSTRUCTION

NO.	DATE	BY	REVISIONS	CK'D	APPV'D

NO.	DATE	BY	REVISIONS	CK'D	APPV'D

PORT OF PORTLAND
PORTLAND, OREGON

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800010 — PROJECT NUMBER

REGISTERED PROFESSIONAL ENGINEER 77473PE OREGON NOV. 8, 2005 JOHN RICHARD VERDUIN
EXPIRATION DATE:

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CHECKED BY J. VERDUIN
DATE OCTOBER 2010
GRAPHICAL SCALE BAR 0 1/4" 1/2" 1" 2"

TERMINAL 4

TERMINAL 4 - CDF
CONFINED DISPOSAL FACILITY GRADING PLAN

SUBMITTED BY
PROJECT ENGINEER

TYPE CD
DRAWING NO. T4 29 / 87 (C-23)

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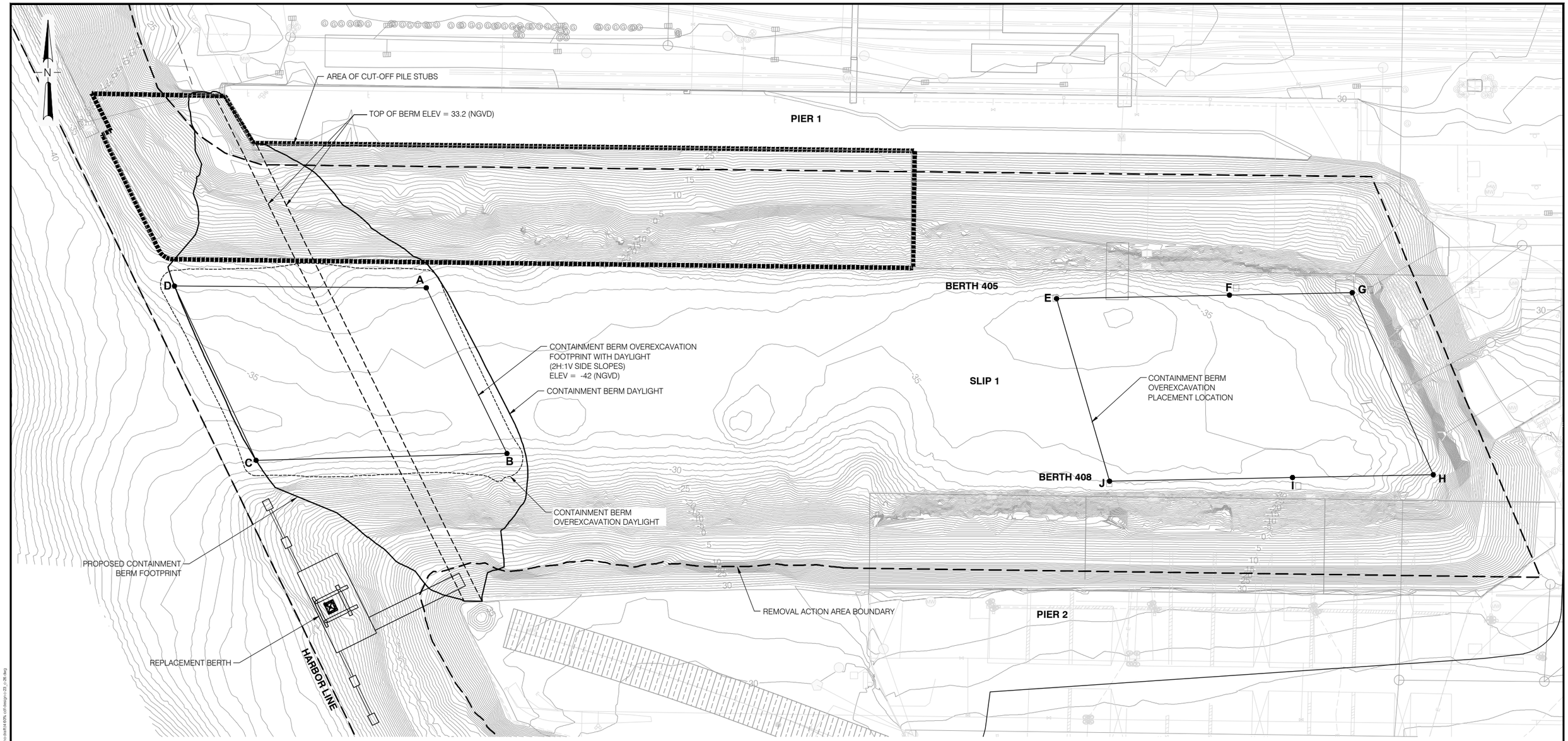

LEGEND

- CONTROL POINT LOCATION

CONTROL POINTS		
POINT	EASTING	NORTHING
A	69922.33	68462.18
B	70023.62	68254.05
C	69708.63	68245.60
D	69606.24	68464.43
E	70713.72	68448.65
F	70930.86	68453.01
G	71085.07	68456.11
H	71186.74	68227.50
I	71010.07	68223.95
J	70780.25	68219.33

HORIZONTAL DATUM: PORT OF PORTLAND
LOCAL PROJECTION (INTERNATIONAL FEET)
VERTICAL DATUM: NGVD 29-47
CONTOUR INTERVAL: 1 FOOT

CONTAINMENT BERM OVEREXCAVATION PLAN (1 / C-24)
SCALE : 1" = 60'

(60%) DESIGN SET - NOT FOR CONSTRUCTION

NO.	DATE	BY	REVISIONS	CK'D	APPV'D

NO.	DATE	BY	REVISIONS	CK'D	APPV'D

PORT OF PORTLAND
PORTLAND, OREGON

ANCHOR QEA

2005D078 — DESIGN NUMBER
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REGISTERED PROFESSIONAL ENGINEER 77473PE OREGON NOV 8, 2005 JOHN RICHARD VERDUIN
EXPIRATION DATE:

DESIGNED BY M. CRYSTAL
DRAWN BY T. GRIGA
CHECKED BY J. VERDUIN
DATE OCTOBER 2010
GRAPHICAL SCALE BAR 0 1/4" 1/2" 1" 2"

TERMINAL 4

TERMINAL 4 - CDF
CONTAINMENT BERM OVEREXCAVATION PLAN

SUBMITTED BY
PROJECT ENGINEER

TYPE CD
DRAWING NO. T4
30 / 87 (C-24)

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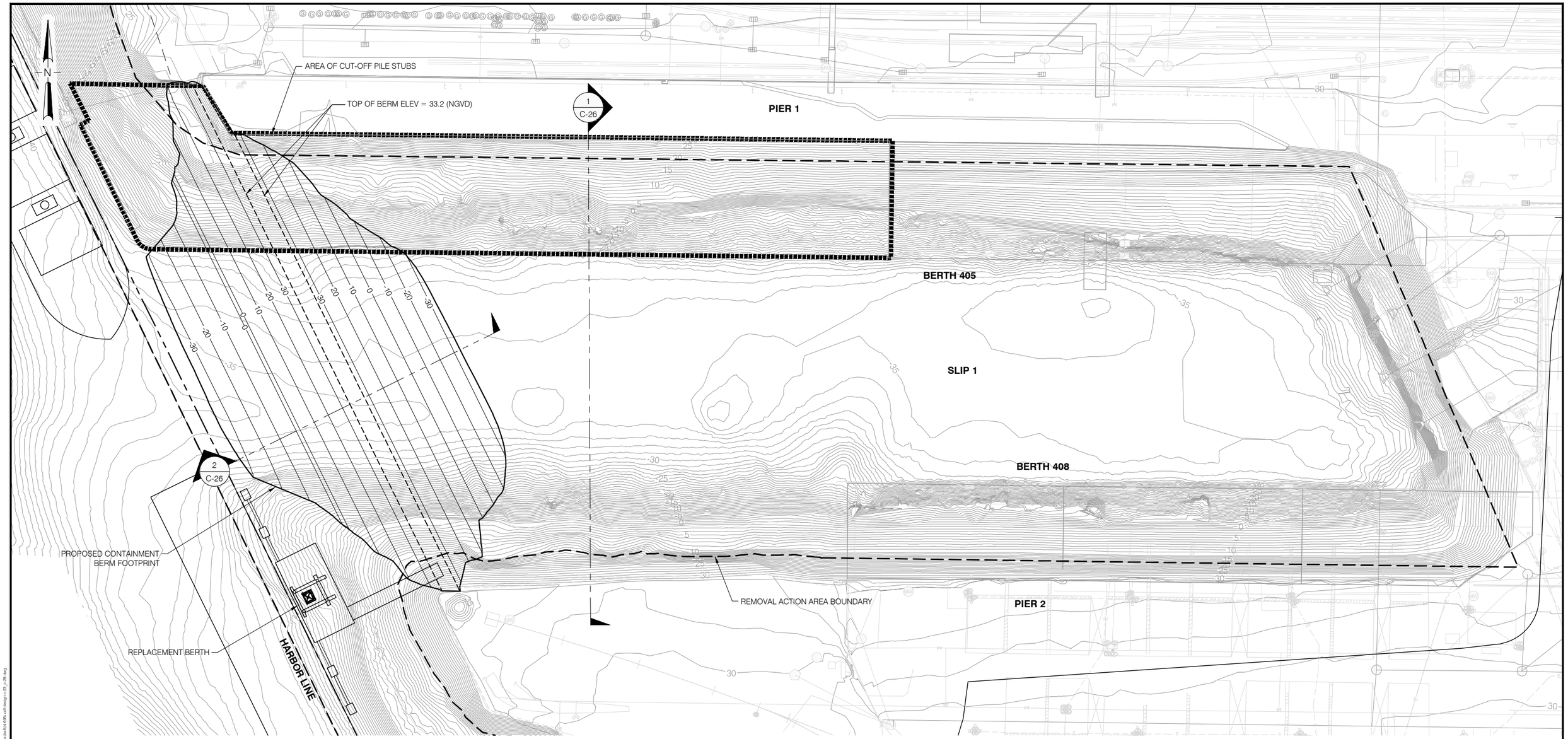

LEGEND

- CONTROL POINT LOCATION

POINT	EASTING	NORTHING
A	68705.10	69655.81
B	68643.05	69708.74
C	68068.71	69992.17
D	68069.12	69969.67

2 — DETAIL NUMBER
C-26 — SHEET WHERE DETAIL SHOWN

HORIZONTAL DATUM: PORT OF PORTLAND
LOCAL PROJECTION (INTERNATIONAL FEET)
VERTICAL DATUM: NGVD 29-47
CONTOUR INTERVAL: 1 FOOT
BERM CONTOUR INTERVAL: 5 FEET

CONFINED DISPOSAL FACILITY PLAN
SCALE : 1" = 60'

1
C-25

(60%) DESIGN SET - NOT FOR CONSTRUCTION

NO.	DATE	BY	REVISIONS	CK'D	APPV'D

NO.	DATE	BY	REVISIONS	CK'D	APPV'D

PORT OF PORTLAND
PORTLAND, OREGON

ANCHOR QEA

2005D078
DESIGN NUMBER

800010
PROJECT NUMBER

REGISTERED PROFESSIONAL ENGINEER 77473PE OREGON NOV. 8, 2005 JOHN RICHARD VERDUIN

EXPIRATION DATE:

DESIGNED BY M. CRYSTAL
DRAWN BY T. GRIGA
CHECKED BY J. VERDUIN
DATE OCTOBER 2010
GRAPHICAL SCALE BAR 0 1/4" 1/2" 1" 2"

TERMINAL 4

TERMINAL 4 - CDF
CONFINED DISPOSAL FACILITY PLAN

SUBMITTED BY
PROJECT ENGINEER

TYPE CD
DRAWING NO. T4
31 / 87 (C-25)

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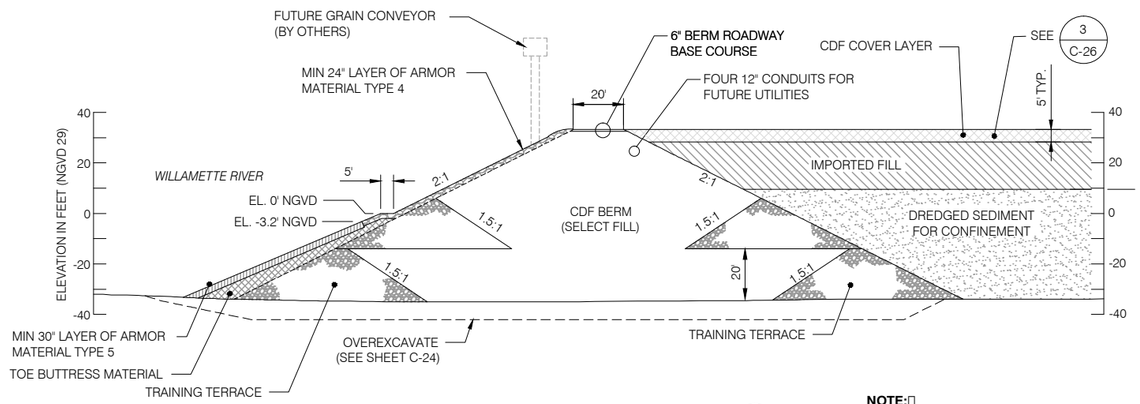
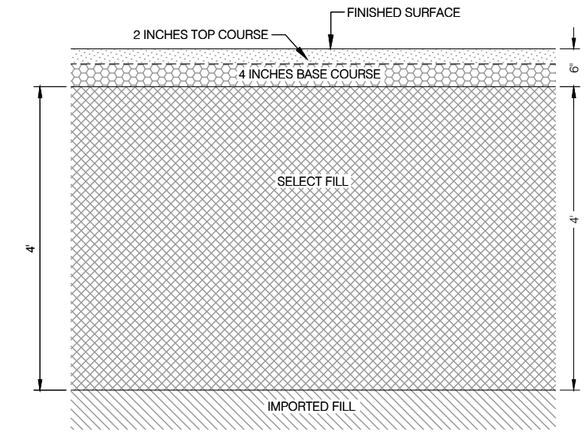


BERM CROSS SECTION 1 / C-25

SCALE: H: 1"=30'
V: 1"=30'

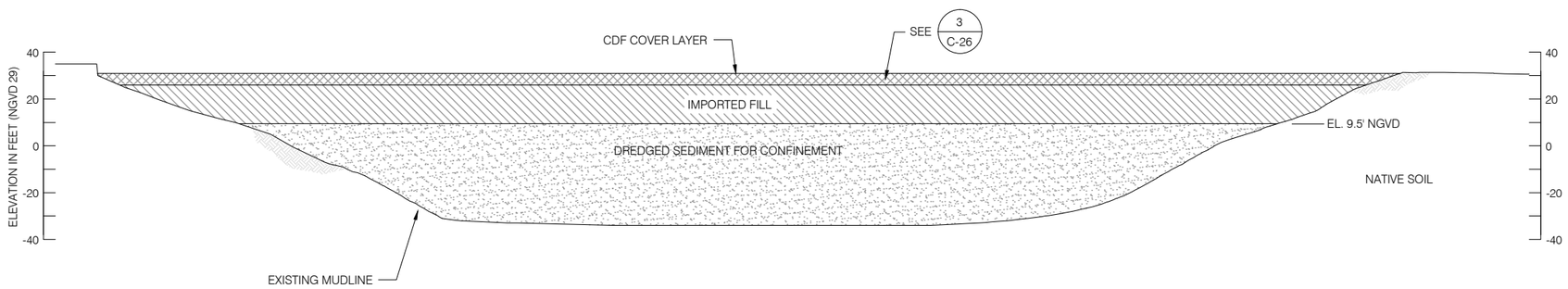
NOTE:

CONTRACTOR CAN USE TRAINING TERRACES TO BUILD THE BERM. THE TERRACES SHALL EACH BE 20' IN HEIGHT. SEE SPECIFICATIONS FOR MORE DETAILS.



CDF COVER LAYER DETAIL 3 / C-26

SCALE: NOT TO SCALE



CDF CROSS SECTION 2 / C-25

SCALE: H: 1"=30'
V: 1"=30'

HORIZONTAL DATUM: PORT OF PORTLAND
LOCAL PROJECTION (INTERNATIONAL FEET)
VERTICAL DATUM: NGVD 29-47

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(60%) DESIGN SET - NOT FOR CONSTRUCTION

NO.	DATE	BY	REVISIONS	CK'D	APPV'D	NO.	DATE	BY	REVISIONS	CK'D	APPV'D

PORT OF PORTLAND
PORTLAND, OREGON

ANCHOR QEA

2005D078 — DESIGN NUMBER
800010 — PROJECT NUMBER

REGISTERED PROFESSIONAL ENGINEER 77473PE OREGON NOV. 8, 2006 JOHN RICHARD VERDUIN

EXPIRATION DATE:

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DRAWN BY T. GRIGA
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DATE OCTOBER 2010
GRAPHICAL SCALE BAR 0 1/4" 1/2" 1" 2"

TERMINAL 4

TERMINAL 4 - CDF
CONFINED DISPOSAL FACILITY SECTIONS

SUBMITTED BY
PROJECT ENGINEER

TYPE CD | DRAWING NO. T4 32/87 (C-26)

APPENDIX C
CONSTRUCTION SPECIFICATIONS

APPENDIX C
CONSTRUCTION SPECIFICATIONS
(PREFINAL 60 PERCENT TERMINAL 4 CDF DESIGN SUBMITTAL)
PORT OF PORTLAND, PORTLAND, OREGON

Prepared for
Port of Portland
Portland, Oregon

Prepared by
Anchor QEA, LLC
6650 SW Redwood Lane, Suite 333
Portland, Oregon 97224

NOTE: The Construction Specifications in this Appendix include only those sections that have been revised from Anchor 2006, *Design Analysis Report (Prefinal 60 Percent Design Deliverables): Terminal 4 Early Action, Port of Portland*. Other relevant sections from Anchor 2006 still apply.

August 2011

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		No. of Pages
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404113	Process Piping Heat Tracing	
404213	Process Piping Insulation	

EXHIBITS

A	Regulatory Documents (not included)
B	Soil/Sediment Data (not included)

Note:

1. Reference the December 2006 Prefinal 60 Percent Design for these sections as they have not changed: Anchor Environmental, L.L.C. (Anchor). 2006. Design Analysis Report (Prefinal 60 Percent Design Deliverables): Terminal 4 Early Action, Port of Portland, Portland, Oregon. Prepared for the Port of Portland. December 2006.

DIVISION 1
GENERAL REQUIREMENTS

See Anchor 2006 for the sections listed below:

- 011110 Safety and Heath
- 013200 Construction Progress Documentation
- 013300 Submittal Procedures
- 014500 Quality Control
- 015000 Temporary Facilities and Controls
- 015639 Tree and Plant Protection
- 015713 Temporary Erosion, Sediment, and Pollution Control
- 017000 Execution Requirements
- 017419 Construction Waste Recycling
- 017700 Closeout Procedures
- 019100 General Commissioning Requirements

SECTION 011100 - SUMMARY OF WORK

PART 1 - GENERAL

1.1 DESCRIPTION

A. In 2000, the U.S. Environmental Protection Agency (USEPA) added the Portland Harbor Superfund Site to the National Priorities List. The Port of Portland (Port) is one of ten potentially responsible parties that entered into an Administrative Order on Consent with USEPA for a Remedial Investigation/Feasibility Study (RI/FS) of the Superfund Site in fall 2001. The Administrative Order on Consent allows Early Actions to be conducted to address known contamination at specific locations within the Superfund Site. Contaminants found in Terminal 4 sediment samples during a remedial investigation directed by the Oregon Department of Environmental Quality (DEQ) led to a determination that a Removal Action at Terminal 4 is warranted. Accordingly, the Port is conducting a Non-Time-Critical Removal Action (NTCRA) under an Administrative Order of Consent for Removal Action (the AOC) executed by the Port and USEPA in October 2003.

The USEPA issued an Action Memorandum on May 11, 2006 that documented the selection of the Removal Action. This project implements the Removal Action. Elements of the Removal Action cover in this project include the following elements:

1. Relocation of a Port tenant's offloading facility
2. Structure demolition at two berths
3. Pile demolition
4. Confined Disposal Facility (CDF) containment berm construction
5. New dock construction, including dolphins, outside the new containment berm footprint
6. Stormwater and outfall structure installation and relocation
7. Filling the CDF
8. Completing the CDF cover

B. The Terminal 4 facility itself is within or adjacent to the Portland Harbor Superfund Site. The Removal Action Area (RAA) is defined in the AOC as "that portion of the site adjacent to and within the Port of Portland's Terminal 4 at 11040 North Lombard, Portland, Multnomah County, Oregon, extending west from the ordinary high water line on the northeast bank of the Lower Willamette River to the edge of the navigation channel, and extending south from the downstream end of Berth 414 to the downstream end of Berth 401, including Slip 1, Slip 3, and Wheeler Bay."

C. The Port has procured the following regulatory agency documents which are included in the project manual as Exhibit A:

1. National Marine Fisheries Service (NMFS) Biological Opinion
2. USEPA Water Quality Monitoring and Compliance Conditions Plan

D. The Port is in the process of obtaining regulatory agency documents. The NMFS Biological Assessment is included in Exhibit A.

E. The Contractor shall familiarize itself with the regulatory agency documents and ensure full compliance with all of its conditions.

F. Conflicts, if any, between the contract documents and these issued regulatory agency documents, observed by the Contractor, shall be brought to the attention of the Port immediately.

1.2 SOILS AND SEDIMENT INFORMATION

A. A record of soil exploration in the vicinity of this work is included as Exhibit B.

B. Additional records of soil and sediment exploration in the vicinity of this work are available in the Port Engineering files for examination by the Contractor upon request. The Port makes no representation as to the completeness or accuracy of this information.

1.3 KNOWN SITE CONDITIONS AFFECTED BY REGULATORY AGENCIES

A. The following materials or conditions are known to exist on the construction site. The Contractor shall comply with federal, state, or local agencies' ordinances or regulations pertaining to these conditions:

1. Contaminated soil or groundwater
2. Heavy metals
3. Pencil-pitch
4. Grease, oils, fuels, and other hydrocarbons
5. Polychlorinated biphenyls (PCBs)
6. Volatile organic compounds (VOCs)
7. Environmental (E) – Zone

1.4 UNEXPECTED HAZARDOUS OR ENVIRONMENTALLY SENSITIVE SITE CONDITIONS

A. If the Contractor encounters suspected hazardous or environmentally sensitive conditions in the work area beyond those mentioned in these specifications or the drawings, the Contractor shall immediately stop all work in the area of the suspected condition and notify the Port.

B. The Port will make arrangements for testing and appropriate abatement, if required.

C. The Contractor shall alert his employees to these facts and shall assure that no operations occur that disturb the suspected hazardous or environmentally sensitive condition.

1.5 CITY OF PORTLAND SPECIFICATIONS

A. A portion of the work will be constructed in a City of Portland (City) right-of-way or easement under City public works permits. The City public works permits require improvements be constructed in accordance with the City of Portland Standard Construction Specifications, latest revision, as amended, and as amended in the permits.

B. The Port specifications incorporate by reference those portions of the City of Portland Standard Construction Specifications pertinent to this project, including pertinent standard specifications of other entities referenced by the City of Portland specifications.

C. Work subject to City public works permits and specifications shall be warranted for 2 years from the date of final acceptance.

D. In the case of a discrepancy between City and Port specifications, notify the Port immediately.

1.6 INTERNATIONAL BUILDING CODE

A. Work shall conform to the latest adopted edition of the International Building Code (IBC), as amended by the State of Oregon and as enforced by the City of Portland Bureau of Development Services.

1.7 PLUMBING CODE

A. Water systems (except fire sprinkler systems), sanitary sewers, and storm drainage work shall comply with the requirements of the current edition of the Uniform Plumbing Code with Oregon amendments and the City of Portland Municipal Code as enforced by the City of Portland Bureau of Development Services.

1.8 MECHANICAL CODE

A. Work shall comply with the requirements of the current edition of the International Mechanical Code with Oregon amendments and Fire and Life Safety Regulations, as enforced by the City of Portland Bureau of Development Services.

1.9 ELECTRICAL CODE

A. Work shall comply with the requirements of the National Electrical Code, Oregon Electrical Specialty Code (OAR 918-305), Oregon Administrative Rules, Oregon Electrical Safety Law (ORS 479), and City of Portland Municipal Code Titles 26 and 32 as enforced by the City of Portland Bureau of Development Services.
   1. Work specifically to be inspected by the City of Portland includes the new dock, storm water system modifications, and piping re-routing.
   2. City of Portland inspectors will be escorted by Port personnel on inspections within the restricted areas. The Contractor shall not be the sole escort or conduct such inspections with City of Portland personnel without Port escort.

B. The Contractor shall be, and remain, in compliance with licensing requirements of the State of Oregon and the City of Portland including required individual state electrical licensing for personnel performing electrical work on this project.

1.10 THIRD-PARTY CERTIFICATION REQUIREMENTS

A. Electrical equipment furnished or installed shall bear the seal of a State of Oregon Electrical and Elevator Board approved testing laboratory.
   1. Underwriters' Laboratories (UL) and Canadian Standards Association (CSA) are approved laboratories for all categories of electrical products.
   2. Additional approved laboratories may exist. Examples of other approved laboratories include FM Global (FM) for categories of equipment for hazardous locations, fire pump controls, and electronic protective systems. Other laboratories will be allowed if the Contractor can demonstrate that the laboratory is approved by the State of Oregon Electrical and Elevator Board.

B. Equipment Without Proper Labeling:
   1. A letter of acceptance by a State of Oregon Special Deputy Electrical Inspector will be accepted in lieu of a testing laboratory certification for specific and/or unusual equipment not normally listed. Unless otherwise specified, costs, work, and time required for obtaining state acceptance shall be the Contractor's responsibility.
   2. Labels or permits will not be required for equipment and materials specifically considered exempt by the authority having jurisdiction.

1.11 SPECIAL INSPECTIONS

A. In accordance with the International Building Code (IBC) Chapter 17, special inspections are required for the following types of work:
   1. Concrete
   2. Bolts Installed in Concrete
   3. Ductile Moment-Resisting Concrete Frame
   4. Reinforcing Steel and Prestressing Steel
   5. Welding
   6. High-Strength Bolting
   7. Piling, Drilled Piers, and Caissons
   8. Special Grading, Excavation, and Filling
   9. Special Cases (work which, in the opinion of the building official, involves unusual hazards or conditions)

B. The Contractor shall be responsible for the timely coordination of all special inspections required. The Port will determine which testing agency or agencies to use and will make arrangements for the testing agency's or agencies' reimbursement.

1.12 PROGRESS MEETINGS

A. Regularly scheduled job meetings will be held between the Contractor and the Port. The Contractor's representative at job meetings shall be the person directly responsible for the work. The time and place of the meetings will be established by the Port.

B. Other unscheduled meetings may be required to resolve specific issues at the work area.

END OF SECTION 011100

SECTION 013100 - PROJECT MANAGEMENT AND COORDINATION

PART 1 - GENERAL

1.1 PORT/TENANT OPERATIONS

A. Work in coordination and cooperation with the Port, tenants, and other contractors so that normal operations may be carried on without interruption.

B. The Port or tenant operations may require that certain of the Contractor's operations be scheduled around Port or tenant activities, and certain areas of the work may be required to be bypassed and accomplished when Port or tenant operations permit.

C. Coordinate the work with Port tenants through the Port.

1.2 OTHER CONTRACTORS

A. The Port reserves the right to award other contracts for work in the vicinity of work covered by this contract.

B. Contemplate in planning and work scheduling the following projects which may be in progress in the vicinity during the time of this contract:
   1. Terminal 4 earthen stockpile removal
   2. Kinder Morgan maintenance work

C. The various contractors and the Port will mutually establish a schedule of construction for the use of common work areas.

1.3 CONTRACTOR'S COORDINATION

A. The Contractor is responsible for overall coordination of the work.

B. The drawings and specifications are arranged for convenience only and do not necessarily determine which trades perform the various portions of the work.

C. Transmit to the trades doing the work of other divisions the information required for work to be provided under their respective sections (such as foundations, electric wiring, access door locations, etc.) in ample time for their installation.

D. Consult with the trades doing the work of other divisions so that, whenever possible, motors, motor controls, pumps, valves, etc., shall be of the same manufacturer.

E. Compare the drawings and specifications of the separate trades before proceeding, noting discrepancies and conflicts. Obtain written instructions for changes necessary. Before installation, make provisions to avoid interferences.

F. Prior to the installation and connection of mechanical and electrical work for work of other sections, or of other contractors, verify the requirements indicated in those divisions with the requirements and characteristics of the other crafts or other contractors' equipment.
   1. Coordinate layout of mechanical and electrical work before fabrication and installation begins.
   2. Bring deviations and conflicts to the attention of the Port immediately.

G. Mechanical and electrical drawings show the general arrangement of the work. Follow as closely as actual building construction and the work of other trades permit.
   1. Electrical drawings are diagrammatic and do not show all offsets, fittings, and accessories which may be required.
   2. Investigate the structure and finish conditions affecting the work and arrange the work accordingly.

END OF SECTION 013100

SECTION 013553 – MARINE TERMINAL SECURITY, SAFETY, AND OPERATING REGULATIONS

PART 1 - GENERAL

1.1 MARINE TERMINAL SECURITY POLICY

A. These requirements are in accordance with the federal Marine Transportation Security Act. The Contractor shall obtain, thoroughly review, and comply with all Port rules and regulations pertaining to marine security before commencing work under this contract.

B. The regulations contained in this section and the regulations adopted by the Port are subject to change at any time without notice. Copies of current Port rules and regulations may be obtained during the Port's normal business hours at the Terminal 6 marine security office.

C. Some time during 2008 the federal Transportation Worker Identification Credential (TWIC) regulations will go into effect at Terminal 4. The Contractor will have to comply with TWIC regulations and its application at Terminal 4.

1.2 SECURITY CONTACTS

A. Contact Port marine security to obtain security information and make arrangements for entry:
   1. 24-hour telephone number: 503-240-2230
   2. Terminal 6 administration office: 503-240-2009
   3. E-mail: marinesecuritydept@portofportland.com

B. Port marine security superintendent: 503-240-2235

C. Port marine security manager: 503-240-2232

1.3 SECURITY GATES AND FENCES

A. Access to the work site shall be through the project security gate at the entrance to Terminal 4.

B. The Contractor shall maintain security against unauthorized access to the marine terminal area through the project security gate.

C. Temporary fence replacement panels and gates shall provide the same level of security and protection against unauthorized access as the adjacent security fence. Temporary fences may utilize undamaged salvaged fence materials. Fence materials need not be galvanized, and posts may be driven. The height of fence or gate woven-wire fabric shall match the height of adjacent security fence fabric. Replaceable panels, used in lieu of gates or temporary fencing, shall be constructed so that they provide protection against unauthorized access equal to that of the gates and temporary fencing specified herein. Use of such panels is subject to the Port's approval.

D. All equipment and vehicles shall be positioned a minimum of 10 feet away from either side of the perimeter security fence.

1.4 SUBMITTALS

A. Prior to being granted authorization to enter Port marine terminals, the Contractor shall complete the following:
   1. Submit complete contact information, including company name, address, telephone number, and name and telephone number of project superintendent.
   2. Submit a complete list of vehicles that will be accessing the terminal to carry out the work. The list shall include the vehicle make, model, year, color, license plate number including state of issuance, and description of identifying markings on the vehicle.
   3. Submit a list of Contractor personnel and subcontractor personnel who will be accessing the terminal to perform work. The list shall include complete names as they appear on their driver's licenses.
   4. Submit documentation that personnel have received training on security measures from the Port marine security department.

1.5 PERSONNEL SECURITY REGULATIONS

A. Contractor personnel, subcontractor personnel, material delivery personnel, and others entering the marine terminal shall present a valid state driver's license or government-issued ID as identification. All identification cards must:
   1. Be tamper resistant and show no signs of tampering or such disrepair that verification of the veracity of the ID is impossible.
   2. Include a photograph bearing a close resemblance to the person presenting the credential.
   3. Be current within a visible expiration date on the ID.
   4. Be an original issue document/card. Reproductions, copies, enlargements, etc. are not acceptable forms of ID.
   5. Show the relevant details of the holder such as the name, description, and controlling authority (issuer) of the ID.

B. The Port's marine security officer may request to see the identification of any person on the terminal at any time. Refusal to comply will result in immediate removal from the terminal.

1.6 VEHICLE REGULATIONS

A. Contractor Vehicles
   1. Contractor vehicles in the ship berth areas shall be clearly marked either by permanent markings or temporary markings (such as magnetic signs) on both sides of the vehicle.
   2. When outside the work area, all personnel, vehicle, and equipment movement shall be under the control of the Contractor's authorized escort, using the Contractor's approved escort vehicle(s).
      a. The Contractor escort vehicle(s) shall be equipped with an amber flashing light mounted on the roof of the cab. The escort vehicle(s) shall have signs mounted on the front and rear of the vehicle consisting of a black background and yellow

lettering containing the Contractor's name and the words "ESCORT ONLY." Signs shall be readable from a distance of 300 feet.

b. The escort vehicle driver shall serve as liaison and shall be responsible for transporting workers to and from the work area.

c. Personnel and vehicles authorized to be in the marine terminal environment shall remain with the escort vehicle(s) while traveling to and from the work area.

d. Multiple vehicles may be escorted in convoy formation. Convoy vehicles shall travel in close formation, and the escort vehicle driver shall control speed to maintain safety. Convoys shall consist of no more than three vehicles plus the escort vehicle.

B. Personal Vehicles

1. Personal vehicles shall be parked in designated areas away from the berth. The Contractor's personnel shall be shuttled to and from the work area by the Contractor.

C. Material Delivery Vehicles

1. Material delivery personnel will be permitted to access the Port's marine terminals between the hours of 6 a.m. and 8 p.m.

2. The Contractor shall notify the Port prior to deliveries. This notification shall precede arrival at the terminal and shall include:

a. The name of the company.

b. The nature of the items being delivered.

c. The date of delivery.

d. Notification is not a substitute for the driver and vehicle information required in advance as noted above.

3. Temporary Passes: Upon entry at the terminal, a material delivery vehicle will receive a temporary pass, which shall be displayed on the dashboard of the vehicle while on the marine terminal. The pass is not valid for re-entry. The pass does not need to be returned and may be discarded upon departure.

D. Passengers in Vehicles: Only employees of the delivery company will be allowed access to the terminal. A passenger whose information was not previously provided as an employee of the delivery company will not be allowed access.

1.7 TRAINING INFORMATION

A. The Contractor shall contact the Port marine security superintendent to schedule training classes for all Contractor's and subcontractors' personnel.

B. The Contractor shall provide as much notice as possible, a minimum of 48 hours, to schedule training class requests for large groups.

C. The approximate duration of the training class is 30 minutes.

1.8 PROHIBITIONS

A. The following prohibitions are in place:

1. Giving rides to non-Contractor personnel (including ship's crew) on and off the terminal is not allowed.
2. After completing work, all persons shall directly depart the terminal. Vehicles left on the terminal or parked improperly will be towed at the vehicle owner's expense.

1.9 REMEDIES OF THE PORT UPON VIOLATION OF REGULATIONS REFERENCED OR CONTAINED IN THIS SECTION

A. In addition to any other rights or remedies that the Port may have in the event that the Contractor, subcontractor, anyone directly or indirectly employed by any of them, and anyone for whose acts any of them may be liable fails to comply with the regulations referenced or contained in this section, the Port shall have the right to:
   1. Revoke security clearance of the offending individual and/or the Contractor permanently or for a prescribed period of time.
   2. Suspend the work or any portion thereof and continue the suspension until completion of any investigation or evaluation by the Port and full compliance with any corrective measures which the Port may reasonably require.
   3. Require the Contractor to provide to the Port a written plan, satisfactory to the Port, to demonstrate the Contractor's ability to prevent future violations.

B. The Contractor shall be fully liable to the Port for any costs or damages incurred by the Port as a result of any breach of security or violation of security regulations by the Contractor. The Contractor shall also be liable to reimburse the Port for any fines, penalties, assessments, judgments or other costs imposed upon the Port as a result of the Contractor's breach of security or violation of security regulations, as described herein. As used herein, reference to the Contractor shall include all of his employees, agents, subcontractors, suppliers, or other invitees.

C. The Contractor shall defend, indemnify, and hold harmless the Port against any and all claims of any nature made against the Port by any party resulting, in whole or in part, from the Contractor's breach of security or security violations. Defense shall be provided by legal counsel acceptable to the Port. As used herein, reference to the Contractor shall include all of his employees, agents, subcontractors, suppliers, or other invitees.

END OF SECTION 013553

SECTION 015710 – ENVIRONMENTAL PROTECTION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Section 013300 – Submittal Procedures

B. Section 024113 – Site Demolition

C. Section 352027 – CDF Construction

1.2 DESCRIPTION OF WORK

A. This section covers preventing environmental pollution and minimizing environmental degradation during and as a result of construction operations. Other Technical Sections may also contain specific requirements for environmental protection. Those specific requirements are in addition to or modify the requirements in this section, the more stringent requirements shall control. The control of environmental pollution requires consideration of noise levels, air, water, and land.

B. All environmental pollution shall be prevented, abated, and controlled, and environmental degradation arising from construction activities shall be minimized by complying with all applicable federal, state, and local laws and regulations concerning environmental pollution control and abatement, as well as the specific requirement in this contract.

C. The Contractor shall comply with all substantive requirements of permits.

1.3 SUBMITTALS

A. Environmental Protection Plan (EPP)
   1. Submit in accordance with Section 013300 – Submittal Procedures.
   2. The Environmental Protection Plan submitted pursuant to this Section presents the procedures by which the Contractor shall establish and maintain quality control for environmental protection of all items of the Removal Action. This plan shall address all construction tasks. The Contractor shall record on daily reports any problems in complying with laws, regulations, and ordinances, and any corrective action taken.
   3. The conservation measures required by the National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS) shall be implemented to minimize short-term impacts from construction activities.
   4. Potential conservation measures include, but are not limited to, the following list. Additional conservation measures may be required from the Biological Opinion issued by NMFS.
      a. In-water work for this project will comply with the timing restrictions specified in the in-water work window that has been specified by the Oregon Department of Fish and Wildlife (ODFW; ODFW 2000a), when salmonids are expected to be present in very low numbers. In the Lower Willamette River, the work window is

in the summer and early fall, from July 1 through October 31, and in the winter, from December 1 through January 31. As an additional conservation measure, in-water work will be limited to the late summer and fall in-water work window, from July 1 to October 31. After the berm is built and Slip 1 is enclosed from the river, work in the confined disposal facility (CDF) will not be bound by these windows. A spill containment and control plan will be present and will contain notification procedures, specific cleanup and placement instructions for different products, quick response containment and cleanup measures that will be available for the Removal Action, proposed methods for placement of spilled materials, and employee training for spill containment.

b. Prior to entering the water, all equipment will be checked for leaks and completely cleaned of any external petroleum products, hydraulic fluid, coolants, and other deleterious materials.

c. If incidental demolition material drops into the water during demolition activities in Slip 1, the Contractor will retrieve this material and remove it from the substrate using an "orange peel" bucket device.

d. A containment boom will be used to contain and collect any floating debris generated during demolition. Oil-absorbent materials will be employed if visible sheens are observed floating during pile removal. The boom will remain in place until all oily material and floating debris have been collected.

e. All treated wood debris removed during the project will be removed to a U.S. Environmental Protection Agency (USEPA)-approved upland facility. Once removed, any treated wood piling will not be left in the water or stacked on the streambank.

f. Construction debris will be collected and removed from the project area to an appropriate upland facility.

g. Construction barges will be placed at sufficient depth so as to not ground out during low water conditions.

h. During the berm key dredging, the Contractor will not be permitted to perform bottom stockpiling or multiple bites of the clamshell bucket.

i. All dredged materials from the berm key will be completely contained on barges and/or in dump trucks to prevent spillovers from occurring during transport to the CDF.

j. Following berm construction, to minimize take of listed fish species and to ensure compliance with Oregon Revised Statutes (ORS) 509.585 regarding fish passage, an effort will be employed to remove as many listed species as practicable from within Slip 1.

k. No cast-in-place concrete will be used in water.

l. During pile driving with an impact hammer (e.g., proofing), a bubble curtain or other sound attenuation device capable of at least a 15 dB reduction in sound pressure level will be used, lowering the anticipated peak sound pressure level at the point of impact to 202 dB.

m. For trenching activities associated with the stormwater re-route, material excavated from the trench will be piled in such a way as to preclude material falling into the river. Erosion control measures will be employed for this material and may include silt fences, geofabric, straw bale structures, jute mats, and coconut (coir) logs.

n. Appropriate methods will be used (e.g., oil pads, oil boom) to contain or remedy any sheen that appears on the water surface following pile extraction.

o. Water quality monitoring will be conducted to ensure that applicable standards are not exceeded outside compliance boundaries specified by the USEPA, Section 401

Water Quality Monitoring and Compliance Conditions Plan (see Exhibit A). The Contractor may be required to modify production rates or construction methods if water quality exceedances occur.

p. To minimize impacts to water quality, capping material used will have a minimum amount of fines.

q. The Contractor will submit an Environmental Protection Plan as one of the Removal Action submittals. This plan will specify how the Contractor will adhere to best management practices (BMPs) for in-water construction work and will describe methods that will be taken to prevent any petroleum products, chemicals, or other toxic or deleterious materials from entering the water.

r. If fish kills occur or fish are observed in distress due to activities that are a part of the Removal Action, work will stop immediately and the appropriate state and federal agencies will be notified.

PART 2 - PRODUCTS—NOT USED

PART 3 - EXECUTION

3.1 NOTIFICATION OF NONCOMPLIANCE

A. The Contractor will be notified by the Port of noncompliance with the provisions of this section. Immediate corrective action shall be taken. Such notice, delivered at the site, shall be sufficient for the Contractor to take action. The Port may issue an order stopping all or part of the work for failure to comply until corrective action has been taken. No time lost resulting from such stop orders shall be the subject of a claim for extension of time or for costs or damages. The Contractor is required to comply with all environmental requirements whether or not notified by the Engineer or noncompliance.

3.2 SUBCONTRACTORS

A. Compliance with this section by subcontractors will be responsibility of the Contractor.

3.3 IMPLEMENTATION

A. Environmental Protection Plan: At least 4 weeks prior to start of any scheduled activities, an Environmental Protection Plan, including proposals for implementing this section for environmental protection shall be submitted by the Contractor for approval. The Port shall require 3 weeks to review the plan. If unsatisfactory, it will be returned for resubmission. No physical work at the site shall be started until this Plan has been approved or specific authorization is obtained to start a phase of the work. The Port may require preparation and submittal of supplemental plans if additional environmental protection planning is found necessary for later phases of work. As a minimum, the Plan shall include the sections indicated below.

1. Contamination Prevention: A contamination prevention section shall list all potentially hazardous products, such as petroleum and toxic materials on the job site and corresponding provisions to be taken to prevent accidental introduction of such materials

into any water body, the air, or the ground. The section shall also include plans for preventing polluted runoff from plant, equipment parking, and maintenance areas from entering local water bodies. The Contractor shall detail the methods that will be used to monitor the haul barges for leakage during loading and transport of dredged berm key material. If leakage is evidenced, however minor, the operations shall be terminated and not restarted until repairs, satisfactory to the Port, are made. Any spillage or leaks shall promptly be cleaned up and placed in the prescribed disposal area.

2. Containment Cleanup: A containment and cleanup section shall include the procedures, instructions, and reports to be used in the event of an unforeseen incident requiring a containment action. This section shall include as a minimum:
   a. The name of the individual on each shift who will be responsible for implementing and supervising the containment and cleanup.
   b. A list of materials and equipment to be immediately available. For all work in or adjacent to water, a 200-foot-long, minimum containment boom, and a cleanup kit, consisting of absorptive pads and other materials necessary to remove and dispose of the spill material safely, shall be available at the job site. Materials and equipment for other cleanup work shall be tailored to the potential hazards involved.
   c. The names and locations of suppliers of containment materials and names and locations of additional fuel oil recovery, cleanup, restoration, and disposal equipment available in case of an unforeseen spill emergency.
   d. The methods and procedures to be used for expeditious cleanup.
   e. The name of the individual on each shift who will report any spills and who will follow up with complete documentation.
   f. The requirements for containment and cleanup measures from spills or leakages or other types of releases shall be included in the plan.
   g. Agencies, individuals, and phone number of agencies to be contacted on a 24-hour basis.
3. Erosion and Turbidity Control: An erosion and turbidity control section shall include any construction that will disturb upland or intertidal surfaces or introduce turbidity into water bodies. This section shall include the Contractor's plan for controlling erosion and water turbidity as a result of upland soil or intertidal excavation; stockpiling; stabilization; filling and grading; mechanical dredging; dredge material disposal; pile driving or pulling; demolition; and capping operations. Temporary erosion and sediment control measures such as booms, silt curtains, ditches, dikes, drains, and sedimentation basins shall be identified. Potential changes to operations that may be implemented if water quality standards are violated shall also be included. These measures and any others that may be necessary to achieve specified water quality shall be included in the plan.

B. Coordination: At the pre-construction meeting, the Port and Contractor shall discuss the Contractor's operations to develop mutual understandings relative to the administration of the environmental protection program.

C. Supervision: During the work, all activities, including those of subcontractors, shall be supervised to assure compliance with the intent and details of the plan. Environmental Compliance meetings shall be conducted by the Contractor for himself and his subcontractors to assure that all personnel working at the site are familiar with the environmental protection provisions. All equipment and materials for environmental protection shall be inspected every 2 weeks to assure that they are in proper order and have not deteriorated. A written inspection

report must be provided to the Supervising Contractor giving the condition of the equipment and materials.

3.4 PROTECTION OF LAND RESOURCES

A. The land resources within the project boundaries and outside the limits of work under this contract shall be preserved in their present condition or be restored to a condition after construction that will appear to be natural, agreeable to the Engineer, and not detract from the appearance of the project. Activities shall be confined to areas defined by the Plans and Specifications. Areas of bare soil exposed at any time shall be held to a minimum.

3.5 PROTECTION OF WATER RESOURCES

A. General: Compliance with state water quality standards and substantive requirements of any permits and clearances obtained for the work is the Contractor's responsibility. The water quality requirements for discharge from the closure berm fill are contained below.

B. Erosion Control: Surface drainage from cuts and fill, whether or not completed, and from borrow and waste disposal areas, shall be held in sedimentation ponds or the areas shall be graded to control erosion within acceptable limits. Temporary erosion and sediment control measures such as partial backfilling, mulching, ditches, dikes, drains, sedimentation basins, or silt fences or curtains shall be provided as needed, and maintained. The area of bare soil exposed at any time by construction shall be held to a minimum.

C. Disposal: Except as provided in the contract, disposal of any wastes, effluents, trash, grease, chemicals, or other contaminants in water bodies shall not be allowed. If any waste material is dumped in unauthorized areas, the material shall be removed and the area restored to a condition approximating the adjacent undisturbed area.

3.6 WATER QUALITY MONITORING

A. Water quality monitoring will be performed by the Port, consistent with the Water Quality Monitoring Plan (Appendix E to the DAR). The Contractor shall familiarize themselves with water quality requirements and with the Port's monitoring plans and activities. In the event of a water quality exceedance, the Contractor may be required to modify their procedures, methods, or equipment approximately so as to remedy the exceedances, at no additional expense to the Port. The purpose of the specified water quality monitoring is to provide ongoing assessment of the water quality impacts of the Removal Action activities, as specified in the Water Quality Monitoring Plan.

3.7 PROTECTION OF FISH AND WILDLIFE

A. All work shall be performed and all steps taken to prevent interference or disturbance to fish and wildlife. Water flows or habitat outside the project boundaries that are critical to fish or wildlife shall not be altered or disturbed. Stop dredging, capping, pile driving, or other operations, if fish kill or distressed fish are observed, and immediately notify the Port, USEPA, and appropriate permitting agencies.

3.8 PROTECTION OF AIR – EQUIPMENT FUELING AND MAINTENANCE

A. Ultra Low Sulfur Diesel Fuel

1. All diesel-powered off-road vehicles and equipment used on the project site for 3 consecutive days or more shall be fueled with ultra low sulfur diesel (ULSD). This includes, at a minimum, vehicles with engine horsepower ratings of 50 HP and above, and internal combustion engines used to power generators, compressors, and similar equipment.
2. The ULSD fuel shall contain no more than 15 parts per million sulfur.
3. The Contractor shall submit the following:
   a. Prior to beginning construction, submit a list of the diesel-powered equipment that will use ULSD fuel. The list shall include:
      1) Equipment number, make, model, and contractor/subcontractor name.
      2) Type and source of ULSD fuel to be used.
   b. Submit monthly updates to the list of construction equipment.
   c. Submit monthly reports of hours of operation for all diesel powered equipment.
4. Submit copies of diesel fuel delivery slips and fuel receipts each month, noting the type of diesel fuel used with each piece of diesel-powered equipment.
5. The Port encourages the use of other diesel emission reduction alternative fuels (e.g., biodiesel).
6. The Port encourages retrofit emission control devices on equipment or use of USEPA Tier II or Tier III equipment.

3.9 DUST CONTROL

A. Dust control shall be performed as the work proceeds, whenever a dust nuisance or hazard occurs.

3.10 MAINTENANCE OR POLLUTION CONTROL FACILITIES

A. The Contractor shall maintain all constructed facilities and portable pollution control devices for the duration of the contract or for that length of time construction activities create the particular pollutant.

End of section 015710

DIVISION 2

EXISTING CONDITIONS

(See Anchor 2006)

DIVISION 3

CONCRETE

(See Anchor 2006)

DIVISION 5

METALS

(See Anchor 2006)

DIVISION 6

WOOD, PLASTICS & COMPOSITES

(See Anchor 2006)

DIVISION 9

FINISHES

(See Anchor 2006)

DIVISION 26

ELECTRICAL

(See Anchor 2006)

DIVISION 31

EARTHWORK

(See Anchor 2006)

DIVISION 32

EXTERIOR IMPROVEMENTS

(See Anchor 2006)

DIVISION 33

UTILITIES

(See Anchor 2006)

DIVISION 35
WATERWAY & MARINE

See Anchor 2006 for the sections listed below:

- 352025 Capping
- 355914 Marine Fenders
- 356216 Steel Pipe Piles
- 353200 Woody Debris Structures

SECTION 352023 - DREDGING

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section describes the dredging to be completed as part of the project. Dredging will be completed at the containment berm prior to berm construction.

1.2 RELATED WORK SPECIFIED ESLEWHERE

A. 312000 Site Clearing and Earthwork

B. 312300 Trenching, Backfilling, and Compacting

C. 352025 Capping

D. 352025 Confined Disposal Facility (CDF) Construction

1.3 GENERAL

A. General – This project is part of a Portland Harbor Superfund Site Study Area. Sediments within the Terminal 4 Early Action site boundary determined by Administrative Order on Consent (AOC) are contaminated with constituents such as polyaromatic hydrocarbons (PAHs), polychlorinated bi-phenols (PCBs), metals, and pesticides. As part of the Port's Terminal 4 sediment cleanup project and under terms of the AOC with the U.S. Environmental Protection Agency (USEPA), the Port must implement the sediment cleanup as specified in the May 11, 2006 Action Memorandum issued by the USEPA. The USEPA-selected cleanup includes dredging, capping, monitored natural recovery, and construction of an on-site CDF for placement of the dredged sediments discussed in this section. For additional summary of the project refer to Section 011100 "Summary of Work".

B. Construction Period:
   1. The fish window for the Willamette River is July 1 to October 31 each year. This is the period when in-water work is allowed to be performed. Outside of this window all activities within any of the waterways or considered in-water will not be allowed.
   2. December 1 to January 31 is a winter work window; however, the Contractor should not assume that in-water work will be allowed during the winter period.
   3. In-water work restrictions do not apply to upland work or work that is not considered in-water work by the applicable regulations and or agencies.
   4. The Port does not have restriction on work hours of the site. However, the Contractor's work will need to adhere to City ordinances regarding light and noise.

C. Sequencing – Dredging and disposal tasks must be completed within the timeframe defined above in Part 1.3.B of this section. Additionally, certain dredging and disposal tasks must be

completed in a chronological order in relation to other tasks involved in the project. The berm foundation overexcavation shall be completed prior to berm construction.

D. Scheduling Conflicts – Time-sensitive conflicts that may affect construction schedule are listed below. The Contractor shall work with the Port tenants to accommodate their schedules. Currently, three active Port of Portland waterfront operations are occurring at Terminal 4.

1. International Raw Materials (IRM) – IRM will import and export liquid bulk materials at Berth 401 when dredging begins. Both barges and ships call on the berth. Vessel calls are very infrequent, typically less than once per month.
2. Kinder Morgan Bulk Terminals (Kinder Morgan) (Berths 410/411) – Kinder Morgan exports Soda Ash from the Berth 410/411 facility. The facility has a fixed loader so ships are brought in and line-towed during loading. Ships are typically loaded over a 2 to 3 day period. Ships call on the facility approximately 8 times per month. The current lease provides the Port the option, with certain conditions, to schedule a shut down with a maximum duration of 10 consecutive days per year of Kinder Morgan's operations at Slip 3 to facilitate necessary maintenance. The Port does have the option of approaching Kinder Morgan about shutdowns that extend past the 10 consecutive days. The Contractor shall identify how long of a shutdown of Slip 3 is anticipated with their bid.
3. Toyota – Berth 414 is currently used to offload automobiles. Toyota's shipping activities are not anticipated to impact the currently planned Removal Action.

E. Berm Foundation Overexcavation Dredging – A containment berm will be constructed at the mouth of Slip 1. Dredging from the footprint of this berm will be completed prior to berm construction. The dredge depths are shown on the drawings. This activity must be completed before the start of construction of the containment berm at the mouth of Slip 1.

F. Debris Material and Handling – The Contractor shall anticipate encountering significant amounts and types of debris material during dredging. Any debris material encountered from the dredge prism shall be properly disposed of at an approved upland landfill.

G. Dredged Material Offloading Conveyance System Construction – The Contractor shall construct a temporary sediment offloading and conveyance system to transfer mechanically dredged sediments into the Slip 1 CDF after the berm has closed off the slip from the river.

H. Construction Quality Control Plan (CQCP) Compliance – The Contractor shall develop a CQCP as part of the Early Action Work Plan detailing the methods for direct measurements to be made during construction to ensure Remedial Action Objectives (RAOs) and performance standards of the design will be met. The CQCP shall be complied with throughout all activities specified within this section.

I. Remedial Action Environmental Protection Plan (RAEPP) Compliance – The Contractor shall develop a RAEPP as part of the Early Action Work Plan detailing the procedures by which the Contractor will establish and maintain quality control for environmental protection of all items of the remedial action. The RAEPP shall be complied with throughout all activities specified within this section. Water quality monitoring will be conducted by the Port and occur during the dredging processes. The Contractor shall confer with the Port as to different methods of dredging if water quality exceedance issues are encountered. The Contractor shall develop and implement a Water Quality Management Plan (WQMP).

J. Health and Safety Plan (HASP) Compliance - The Contractor shall develop a HASP as part of the Early Action Work Plan. The HASP shall be complied with throughout all activities specified within this section

1.4 SOUNDINGS

A. Soundings of the work area are shown on the drawings.

B. The Contractor will be provided with updated pre-dredge soundings taken within one month of scheduled start of dredging work.

C. Post-dredge soundings will be taken by the Port after dredging is completed.

D. Bathymetric surveys performed by the Port will be completed with a Reson SeaBat 8101 multibeam bathymetric sonar using a frequency of 240 KHz, or similar equipment. Multibeam data will be conducted by running lines on a 50-foot spacing parallel with the berthing lines of the project. The sonar swath will be clipped to 45 degrees either side of vertical. Post-processing of multibeam data will be performed utilizing Caris HIPS multibeam analysis and presentation software, or similar equipment. A 3-foot shoal-biased dataset will be exported from accepted data and used for mapping of contours and calculations of volumes for Contractor's payment.

E. The vertical datum used in this project shall be National Geodetic Vertical Datum (NGVD).

F. The Contractor shall prepare a Survey Control Plan prior to beginning work. The plan shall describe the Contractor's methods, procedures, and equipment to be employed during all construction activities to control grades and locations. The Contractor is required to employ electronic positioning system (EPS), sonar sounding devices, automated electronic tide gauge, and tide gauges to accurately determine their dredging location at all times.

G. The Contractor shall conduct surveys using survey-grade depth sounder with a frequency of 200 KHz or other frequency as approved by the Port. The surveys will be performed using an EPS and a single-beam, dual frequency or multi-beam, single-frequency echosounder system.

H. The top return of the signal trace shall be the point of interpretation of the soundings.

I. Surveys shall be converted to bottom elevation with respect to NGVD, and plotted to the nearest 0.1 foot.

J. The Contractor shall provide daily sounding cross sections of the previous day's work, at no greater than 25-foot trackline intervals using a survey-grade depth sounder. The volume of material dredged and the area affected shall be determined daily. Accuracy for measured depth shall be +/- 0.25 foot; accuracy of horizontal positions shall be +/- 3 feet at the 95 percent confidence interval.

K. The Contractor shall have a set of the previous day's surveys available to the Port for review at the Contractor's on-site project office the following day. Drawings shall be prepared at a scale of 1 inch = 50 feet on plan sheets and shall depict the survey control lines. Cross section plots

shall be prepared every 100 feet perpendicular to the capping area. The cross sections shall be depicted on plan sheets.

L. Survey Control – Accurate and precise methods of horizontal and vertical control shall be established by the Contractor before work begins. These control methods shall be used accordingly as specified in the CQCP and the Survey Control Plan. The Contractor shall lay out its work from horizontal and vertical control points indicated on the CQCP and the Contract Drawings and shall be responsible for all measurement taken from these points. The Contractor shall employ a suitable method to locate and control horizontal and vertical in-water work. The Contractor is required to use Real Time Kinematic (RTK) for survey control work.

M. Quality Control Supervisor – The Quality Control Supervisor shall be present on site at all times any survey activity specified in this section is taking place in accordance with the CQCP. Daily CQC reports shall be submitted to the Port each day on the previous day's activities specified in this section.

1.5 PERMITS

A. Permits, certifications, or orders for dredging and disposal work under this Contract will be issued by the following entities prior to commencement of the work (see Exhibit A):
   1. USEPA, Section 401 Water Quality Monitoring and Compliance Conditions Plan.
   2. National Marine Fisheries Services (NMFS), Biological Opinion

B. The Contractor shall be responsible for adhering and conforming to all applicable provisions, conditions, and requirements of these agency documents.

C. All permits, certifications, or orders for dredging work under this Contract will be issued by the entities stated in this part prior to commencement of the work.

D. The Contractor is responsible for validation in writing of the receipt of these permits, certifications, or orders to the Port before commencement of the work.

1.6 EXISTING CONDITIONS

A. Dredged material shall consist of all material excavated between the existing river bottom and the dredge neat lines, as shown on the drawings.

B. The Port of Portland has conducted explorations and sampling to determine the character of sediments to be removed. The explorations are representative of the subsurface conditions at their respective locations. The exploration and sampling logs are included in Exhibit A. These conditions are generally described below in Part 1.6.E for the dredging location; however, the Contractor shall determine the soil classifications to their own satisfaction prior to signing the negotiated contract.

C. Hard material is not expected to be encountered. Hard material in its natural state is defined as material requiring blasting, and includes boulders or fragments too large to be removed in one piece by a dredge that is customary for this work. If hard material or material necessary for offsite disposal is encountered it shall be reported to the Port within 24 hours.

D. The Contractor shall verify the bid quantity of sediment to be dredged to their satisfaction prior to submitting a bid. The Contractor shall bring up any discrepancy between the Contractor estimate and the Port provided bid estimate.

E. Dredge Material – Expected soil conditions for the berm foundation overexcavation material to be dredged is predominately soft, silt with trace of sand over loose fine to medium sand.

F. Debris Material – The Contractor shall anticipate encountering significant amounts and types of debris material during dredging. Debris is defined as any materials with at least one dimension larger than 2 feet excavated as part of the dredging operations. Debris shall not be disposed within the Slip 1 CDF. Debris shall be disposed of at an appropriate off-site facility. This facility shall be designated on the Contractor's Early Action Work Plan.

G. The Contractor shall submit a Dredging and Disposal Workplan as part of the Early Action Workplan before dredging operations begin. The Workplan shall conform to sequencing, equipment, method, and special provisions specified as throughout this section. The Workplan shall include at least the following items:

1. Work Sequence and Equipment
    a. Order in which the work is to be performed indicating the work sequence by stationing, regions, zones and seasons.
    b. Number, types, and capacity of equipment to be used.
    c. Hours of operation
    d. Method of operation and the time required to complete each activity
2. Means and Methods For Dredging, Transport, and Handling
    a. Methods, procedures, and equipment to be used for dredging.
    b. Methods, procedures, and equipment to be used for transport and placement of containment berm foundation excavation material at the head of Slip 1.
    c. Methods, procedures, and equipment for preventing sediment loss and uncontrolled release of effluent from the barge or scow.
    d. Methods, procedures, and equipment for loading, transport, and disposal of debris and other pollutants to an appropriate waste facility.
    e. Methods, procedures, and equipment for cleanup and removal of project staging areas.
    f. Methods and procedures to prevent interference with tenant activity.
    g. Methods and procedures to prevent damage to Port facilities.
3. Means and Methods for Operating the CDF
    a. Means and methods of transferring mechanically dredged material into the CDF
    b. Means and methods of placing hydraulically dredged sediments into the CDF
    c. Means and methods of directing incoming dredged material
    d. Means and methods of calculating the volume and tonnage of incoming dredge material
    e. Means and methods of water management in the CDF
    f. Means and methods of material placement
    g. Means and methods of facility maintenance
    h. Means and methods of preventative maintenance

PART 2 - PRODUCTS

None

PART 3 - EXECUTION

3.1 EQUIPMENT AND STRUCTURES

A. Mechanical Dredging – The Contractor shall use a "clamshell" bucket or similar (as approved by the Port) for the CDF containment berm foundation over-excavation. The CDF containment berm overexcavation dredged material shall be temporarily stowed on barges and scows and then placed at the head of Slip 1.
   1. Clamshell buckets shall have straight closing edges for full closure without leakage and be fully shrouded to prevent dredged material from washing out or falling out of the bucket and to reduce re-suspension of material in the water column. The Contractor shall obtain approval of the Port prior to using bucket with digging teeth. Buckets with teeth are not allowed unless the Port approves their use for dredging denser materials or for removing debris.
   2. The Contractor shall calibrate and mark cables at 6-inch intervals to visually check the cut elevation of the bucket. The Contractor shall also employ RTK electronic equipment to determine bucket elevations at all times.
   3. The Contractor shall monitor hull displacement and position of each scow loaded by the dredge. Monitoring shall be from initial loading through discharge at the CDF. The Contractor shall develop its own system of monitoring displacement and capacity for submittal. The approved monitoring shall be able to measure and record average hull displacement and loaded capacity of each scow as specified.

B. Disposal Equipment – The CDF containment berm foundation overexcavation material shall be disposed of by either bottom-dumping the dredged material from a split hull barge or mechanically offloading the dredged material from a flat-deck type barge.

C. Hydraulic Diffuser
   1. The Contractor shall design and submit to the Port for approval the diffuser system to be used for filling the CDF.
   2. The diffuser shall be able to meet the following minimum performance criteria:
      a. Ability to be moved around the full extent of the CDF
      b. Ability to significantly reduce the velocity of the dredge discharge to reduce slurry mixing in the water column within the CDF
      c. Ability to adjust the discharge elevation to within a few feet of the current mudline within the CDF

D. Sediment Offloading and Conveyance Facility
   1. The Contractor shall design and submit to the Port for approval the sediment offloading and conveyance facility.
   2. The facility shall have the following minimum design elements:
      a. Spillage containment systems and methods to monitor for any spillage from offloading barge(s).

b. Any make up water used to slurry the dredged material for pumping shall be drawn from within the CDF.
c. Sufficient capacity to handle the anticipated mechanical dredging rates within Slip 3 or 4,000 cy/day, whichever is greater.
d. Ability to dispose of dredged material to at least the middle of the CDF.

3. At the completion of the offloading, sediment sampling at the offloading facility shall be performed and the results compared to the baseline conditions. Any elevated sediment concentrations will be assumed to have been caused by loss of contaminated sediment during the offloading; this new contaminated sediment area will be dredged and placed within the CDF by the Contractor at no additional cost to the Port.

3.2 DREDGING

A. Dredging shall include excavation of material to the dredge limits, depth, lines, and grade, as shown on the drawings.

B. Dredging tolerances are +0.0 foot and -1.0 feet from the required final elevation.

C. The area shall be dredged to the minimum elevations. To ensure excavation to the required dredge elevation, the Contractor is allowed a maximum 2-foot dredging allowable overdepth with only one foot of the allowable overdepth paid.

D. Side slope steepness shall be as noted on the drawings. Side slopes shall be dug from top to bottom to the grades shown on the drawings. Dredging tolerance per above also applies anywhere on the slopes.

E. The Contractor shall monitor his dredge work on a daily basis throughout the course of work for elevation, slopes, location, and tolerances and shall be responsible for damages due to excessive overdepth dredging or dredging outside the required dredge prism limits.

F. Debris larger than 2 feet in any dimension shall be disposed of at an approved upland disposal site by the Contractor.

G. The Contractor shall implement the following Best Management Practices (BMPs) during mechanical dredging operations:
1. The Contractor shall begin dredging at the highest elevation of material to be removed and work toward the lowest elevation. “Glory holing” will not be allowed.
2. The Contractor shall pause the dredge bucket as it breaks the surface of the water and allow the bucket to drain free water prior to swinging and placing dredge material on the haul barge.
3. No bottom stockpiling or multiple bites of the clamshell bucket is allowed.
4. The Contractor shall seal off barge scuppers on haul barges and repair any holes in fences to prevent unfiltered sediment to drain off a haul barge.
5. No grounding of construction barges is allowed.

H. The Contractor shall base his estimates on the pre-dredge survey. A second survey of the area to be dredged will be taken by the Port within one month of beginning work. If there are any significant changes in profile or quantity between the surveys, adjustments in the quantities and associated pay amounts will be made.

I. The Contractor shall notify the Port when dredge work is complete. A post-dredge survey of the dredged areas will be taken by the Port and used to verify completion of work to specified elevations and grades, before the Contractor demobilizes. If the Port's post-dredge hydrosurvey finds the Contractor's work not meeting contract plans and specifications, the Port will notify and provide the Contractor with hydrosurvey results. Any area found above the specified dredge elevations and grades shall be dredged to meet the required elevations and grades. All additional post-dredge hydrosurveys necessary to confirm the Contractor's work shall be provided by the Port and withheld from payment to the Contractor.

1. The Contractor shall anticipate standby time during the post-dredge survey operation, and during the evaluation of the hydrosurvey results.

J. If, in the dredging operation, excess quantities of material over the contract quantities are encountered, the Contractor shall notify the Port immediately.

K. Misplaced Material – If, during construction, the Contractor knowingly purposefully and/or accidentally loses, dumps, throws overboard, sinks, or misplaces any material, dredge, barge, scow, machinery, appliance, or any item that would be considered debris or a pollutant, the Contractor shall promptly recover and remove the item. The Contractor shall give immediate verbal notice to the Port, and submit a written explanation with the description and location of the misplaced material and the method of the resolved issue or the plan for resolving the issue. The item or location of the item shall be clearly marked.

3.3 TRANSPORTING AND PLACEMENT OF CDF BERM OVEREXCAVATION MATERIAL

A. The Contractor shall place the dredged material from the CDF containment berm foundation at the head of Slip 1 within the location shown on the drawings. The Contractor shall use EPS to confirm the positioning of the dredged material placement within the target area. The Contractor shall use care when placing the material to avoid or minimize water quality exceedances. The Contractor can place the material using a bottom-dump barge or unloading the material with a bucket. No washing of the material off of the deck is allowed. The Contractor shall use pre- and post-placement bathymetric surveys to confirm the material was placed within the targeted area.

3.4 TRANSPORTING DREDGED MATERIAL FOR PLACEMENT IN THE CDF

A. Bottom-dump, split-hull, or flat-deck barges shall be in good condition with no leaks in the hull or in the bottom-dumping mechanism. The barge shall sail with sufficient freeboard inside the barge so that no water spills over the side walls while underway. Load lines shall be clearly shown on the barge and loading shall not take the barge below the load lines. The tug shall be of sufficient horsepower for moving the barge and maneuvering through the area and marine traffic encountered between the dredging site and the disposal site. The Contractor shall certify that all barges are seaworthy and have been sealed to prevent leakage.

B. The Contractor shall provide the following information on each dredge material barge that will be used:

1. Name of barge.
2. Length, beam, and molded depth of each barge.
3. The disposal barge shall have clear and distinct draft marks.

4. Dredge material capacity of barge.
5. Hydrostatic data certified by a naval architect for determining barge displacement in short tons, per each 1 foot of displacement between loaded and light drafts.
6. Expected draft of barge loaded to capacity with dredge material.

3.5 OFFLOADING AND HAULING OF DREDGE DEBRIS MATERIALS

A. No debris will be allowed to be placed within the Slip 1 CDF.

B. All debris will be required to be offloaded and hauled to an approved Subtitle D landfill for disposal. The Contractor shall submit the name and location of the proposed landfill for approval prior to beginning dredging.

C. The Contractor shall provide a dredge debris offloading facility location for approval by the Port. The Contractor shall ensure the following minimum measures are implemented during debris transloading:
   1. As much sediment as possible shall be removed from the debris prior to loading.
   2. Maintain the swing path of the crane over a constructed spill apron during material transfer.
   3. Provide clean tarping of truck loading area, as necessary, to prevent tire contact with materials.
   4. Following loading of each truck, the truck and area immediately around the truck will be visually inspected for spilled material. Spilled material shall be cleaned up immediately.
   5. Cleaning of tires (if necessary) before leaving offloading site including dry brushing and/or tire/wheel washing is required.
   6. The truck shall be covered before leaving the site.
   7. Once the truck is cleared to leave the facility following inspection and cleaning, if applicable, the load will be documented on a manifest that will be carried by the driver.
   8. Copies of all project records, including manifests and weigh tickets, will be maintained for the project file.
   9. The Contractor will provide copies to the Port of the manifest and documentation that the load was received by the landfill.

D. The Contractor shall prepare a Sampling and Analysis Plan (SAP) to describe the sampling and analysis program to be implemented to confirm that no off-site tracking of contaminants occurred as a result of transloading dredge debris. The SAP shall present the number of samples, the sample locations, list of analytes, and statistical method to be used to compare pre-loading results to the post-loading results. Samples shall be collected weekly during the transloading operation.

E. The Contractor shall provide, in their Environmental Protection Plan, details of measures to be implemented in case of spillage either during transloading or during trucking to the landfill.

3.6 CONTROL OF POLLUTANTS OTHER THAN SEDIMENT

A. All pollutants other than sediments and/or any potentially harmful substance that does not have prescriptions for disposal within this section are contained herein. These pollutants that occur

on site during construction shall be handled and disposed of in a manner that does not contaminate surface water or surface water runoff, ground water, or upland areas.

B. Fueling of Equipment – The Contractor shall provide a plan for fueling of equipment within the HASP. At a minimum the following procedures should be followed and described in the Contractor's HASP:
   1. Discuss use of boom around floating equipment.
   2. Discuss use of oil-absorbent pads on upland equipment.
   3. A Contractor representative shall be present at all times during all fueling operations.

C. Any fuel spills or leaks shall promptly be reported to the fire department and Port.

D. Spill protection material shall be in place before performing any emergency repair to equipment.

E. Any sheens due to leakage, spills, or from dredging operations (e.g., from sediment) shall be contained by a boom and cleaned up with oil absorbent material.

3.7 WATER QUALITY AND TURBIDITY

A. Conduct dredging operations such to ensure adherence to the turbidity and water quality requirements stipulated in the permits. Minimize resuspension of sediment in the vicinity of the site.

B. Work in the dredging area shall be done to minimize turbidity, erosion of banks or bottom, or other water quality impacts. The Contractor shall take all normal precautions to prevent turbidity at the dredging site and CDF. These include making each pass of the bucket complete including dredging and placing sediment into the barge, and bringing the bucket fully over the barge before discharging. There will be no filling of the barge which will result in water overflow from the barge. The Contractor shall not overfill the barge that would cause overflow from the barge. The bucket shall be slowly placed on the bottom rather than dropped unless dropping is required to excavate the sediments. Vertical bucket retrieval shall be at slow to moderate speed to minimize the loss of materials from within the bucket. Retrieval speed of the bucket shall be reduced if water quality monitoring indicates increased levels of turbidity.

C. The Contractor shall keep an operators log and a daily progress chart aboard the dredge at all times for inspection. The daily progress chart shall include data regarding work areas completed, names of barges used, and cubic yards loaded. These documents shall be submitted to the Port for retention with the contract file at the completion of the dredging work. The Contractor will be provided a copy of this log.

D. Water Quality Monitoring and Control Plan: The Contractor shall submit a plan with methods and procedures for controlling water quality during dredging.

E. Water Quality Monitoring and Control Contingency Plan: The Contractor shall submit a contingency plan with methods and procedures for modifications of methods which fail to meet water quality requirements.

F. The Contractor shall submit the plans described above to the Port 7 days before mobilization.

3.8 REPORTING REQUIREMENTS

A. A daily report of operations shall be prepared and maintained and copies submitted to the Port.

END OF SECTION 352023

SECTION 352027 - CONFINED DISPOSAL FACILITY (CDF) CONSTRUCTION

PART 1 - General

1.1 DESCRIPTION

A. This section describes the construction of the CDF to be located within Slip 1. This includes construction of the containment berm, placement of the contaminated sediments for confinement, placement of the non-contaminated sediment, and placement of the CDF cover layer materials.

1.2 RELATED WORK SPECIFIED ESLEWHERE

A. 312000 Site Clearing and Earthwork

B. 312300 Trenching, Backfilling, and Compacting

C. 352023 Dredging

D. 352025 Capping

1.3 REFERENCED STANDARDS

A. Oregon Department of Transportation (ODOT) "Standards Specifications for Highway Construction," 2002.

1.4 DESCRIPTION

A. General – This project is part of a Portland Harbor Superfund Site Study Area. Sediments within the Terminal 4 Early Action site boundary determined by Administrative Order on Consent (AOC) are contaminated with constituents such as polyaromatic hydrocarbons (PAHs), polychlorinated bi-phenols (PCBs), metals, and pesticides. As part of the Port's Terminal 4 sediment cleanup project and under terms of the AOC with the U.S. Environmental Protection Agency (USEPA), the Port must implement the sediment cleanup as specified in the May 11, 2006 Action Memorandum issued by the USEPA. The USEPA-selected cleanup includes dredging, capping, monitored natural recovery, and construction of an on-site CDF for placement of the dredged sediments discussed in this section. For additional summary of the project refer to Section 011100 "Summary of Work".

B. Site Subsurface Conditions – The Contractor should familiarize themselves with the subsurface geotechnical conditions at the site. It is anticipated that the containment berm will settle approximately 4 feet during the construction period.

C. Construction Period:

1. The fish window for the Willamette River is July 1 to October 31 each year. This is the period when in-water work is allowed to be performed. Outside of this window all activities within any of the waterways or considered in-water will not be allowed.
2. December 1 to January 31 is a winter work window; however, the Contractor should not assume that in-water work will be allowed during the winter period.
3. In-water work restrictions do not apply to upland work or work that is not considered in-water work by the applicable regulations and or agencies.
4. The Port does not have restriction on work hours of the site. However, the Contractor's work will need to adhere to City ordinances regarding light and noise.

D. Sequencing – The CDF construction will occur in the sequencing listed below. Be aware that sequencings listed below may involve tasks that are also constrained to other sequences (refer to the appropriate section for sequencing of stated tasks not covered in this section).
1. CDF containment berm construction. The construction of the containment berm shall occur during the first construction season.
2. Placement of contaminated sediments within the CDF. Placement of contaminated sediments from Terminal 4, Slip 3 plus Berth 414 is anticipated to occur during the second construction season.
3. Construction of the CDF surface layer. The construction of the CDF surface layer will not occur until after contaminated sediments are placed in the CDF to the elevations shown on the drawings.

E. Scheduling Conflicts – Time-sensitive conflicts that may affect construction schedule are listed below. The Contractor must work with the tenants of the Port to accommodate their schedules. Currently, three active Port of Portland waterfront operations are occurring at Terminal 4.
1. International Raw Materials (IRM) – IRM will import and export liquid bulk materials at Berth 401 when demolition and berm construction in Slip 1 begins. Both barges and ships call on the berth. Vessel calls are very infrequent, typically less than once per month.
2. Kinder Morgan Bulk Terminals (Kinder Morgan) (Berths 410/411) – Kinder Morgan exports Soda Ash from the Berth 410/411 facility. The facility has a fixed loader so ships are brought in and line-towed during loading. Ships are typically loaded over a 2 to 3 day period. Ships call on the facility approximately 8 times per month. The current lease provides the Port the option, with certain conditions, to schedule a shut down with a maximum duration of 10 consecutive days per year of Kinder Morgan's operations at Slip 3 to facilitate necessary maintenance. The Port does have the option of approaching Kinder Morgan about shutdowns that extend past the 10 consecutive days. The Contractor shall identify how long of a shutdown of Slip 3 is anticipated with their bid.
3. Toyota – Berth 414 is currently used to offload automobiles. Toyota's shipping activities are not anticipated to impact the currently planned Removal Action.

F. CDF Construction – Three separate construction components will encompass the CDF construction. The three construction elements and related mandatory chronological activities are as follows:
1. CDF containment berm construction – A containment berm will be constructed at the mouth of Slip 1. Dredging below the footprint of the berm will be completed prior to berm construction. The dredge depths are shown on the drawings. Section 352023—Dredging provides requirements for the dredging beneath the containment berm. The dredging will be backfilled with structural fill and the berm constructed to the grades

shown on the drawings. This element must be completed before the end of the first construction season.

2. Contaminated sediment placement – After the containment berm is completed contaminated sediments from Slip 3 and at Berth 414 will be dredged and placed behind the berm. This will be completed in the second construction season. The dredging will be completed using mechanical dredging. After the Slip 3 and Berth 414 material is dredged and placed, contaminated sediment from other sites within the Portland Harbor Superfund Site will be placed in the CDF.
3. CDF Cover – After the contaminated sediment is placed to elevation 9.5 feet NGVD, the CDF cover will be placed. The CDF cover will consist of two units. The lower unit of fill will be non-contaminated dredge material and/or fill from an upland quarry. The upper portion of the fill will be a structural layer to support surface activities. The surface of this upper layer will be compacted crushed rock.

G. Dredged Material Offloading Conveyance System Construction – The Contractor shall construct a temporary sediment offloading and conveyance system to transfer mechanically dredged sediments from the Terminal 4 Early Action Project into the Slip 1 CDF after the berm has sealed off the slip.

H. Construction Quality Control Plan (CQCP) Compliance – The Contractor shall develop a CQCP as part of the Early Action Work Plan detailing the methods for direct measurements to be made during construction to ensure Remedial Action Objectives (RAOs) and performance standards of the design will be met. The CQCP shall be complied with throughout all activities specified within this section.

I. Remedial Action Environmental Protection Plan (RAEPP) Compliance – The Contractor shall develop a RAEPP as part of the Early Action Work Plan detailing the procedures by which the Contractor will establish and maintain quality control for environmental protection of all items of the remedial action. The RAEPP shall be complied with throughout all activities specified within this section. Water quality monitoring will be conducted by the Port and occur during the dredging processes. The Contractor shall confer with the Port as to different methods of dredging if water quality exceedance issues are encountered. The Contractor shall develop and implement a Water Quality Management Plan (WQMP).

J. Health and Safety Plan (HASP) Compliance – The Contractor shall develop a HASP as part of the Early Action Work Plan. The HASP shall be complied with throughout all activities specified within this section

1.5 CDF FILLING WORK PLAN

A. The Contractor shall submit a Workplan as part of the Early Action Workplan before CDF construction begins. The Workplan shall conform to sequencing, equipment, method, and special provisions specified as throughout this section. The Workplan shall include at least the following items:
   1. Work Sequence and Equipment
      a. Order in which the work is to be performed indicating the work sequence by stationing, regions, zones and seasons.
      b. Number, types, and capacity of equipment to be used.
      c. Hours of operation.

d. Method of operation and the time required to complete each activity.

2. Means and Methods For Importing, Transporting, and Handling
   a. Methods, procedures, and equipment to be used for construction.
   b. Methods, procedures, and equipment to be used for transport and placement of containment berm foundation material at the head of Slip 1.
   c. Methods, procedures, and equipment to be used for transport and re-handling of Slip 3 contaminated sediments into the CDF.
   d. Methods, procedures, and equipment for preventing sediment loss and uncontrolled release of effluent from the barge or scow.
   e. Methods, procedures, and equipment for loading, transport, and disposal of fill/dredge materials.
   f. Methods, procedures, and equipment for cleanup and removal of project staging areas.
   g. Methods and procedures to prevent interference with tenant activity.
   h. Methods and procedures to prevent damage to Port facilities.
3. Means and Methods for Operating the CDF
   a. Means and methods of transferring mechanically dredged material into the CDF
   b. Means and methods of placing hydraulically dredged sediments into the CDF
   c. Means and methods of directing incoming dredged material
   d. Means and methods of calculating the volume and tonnage of incoming dredge material
   e. Means and methods of water management in the CDF
   f. Methods, procedures, and equipment for preventing sediment loss and uncontrolled release of effluent at the offloading facility
   g. Means and methods of material placement
   h. Means and methods of facility maintenance
   i. Means and methods of preventative maintenance

1.6 SOUNDINGS

A. Soundings of the work area are shown on the drawings.

B. The Contractor will be provided with updated pre-construction soundings taken within one month of the scheduled start of the different elements of the CDF construction work.

C. Post-construction soundings will be taken by the Port after construction of the berm is completed.

D. Bathymetric surveys performed by the Port will be completed with a Reson SeaBat 8101 multibeam bathymetric sonar using a frequency of 240 KHz, or similar equipment. Multibeam data will be conducted by running lines on a 50-foot spacing parallel with the berthing lines of the project. The sonar swath will be clipped to 45 degrees either side of vertical. Post processing of multibeam data will be performed utilizing Caris HIPS multibeam analysis and presentation software, or similar equipment. A 3-foot shoal-biased dataset will be exported from accepted data and used for mapping of contours and calculations of volumes for Contractor's payment.

E. The vertical datum used in this project shall be National Geodetic Vertical Datum (NGVD).

F. The Contractor shall prepare a Survey Control Plan prior to beginning work. The plan shall describe the Contractor's methods, procedures, and equipment to be employed during all construction activities to control grades and locations. The Contractor is required to employ electronic positioning system (EPS), sonar sounding devices, automated electronic tide gauge, and tide gauges to accurately determine their dredging location at all times.

G. The Port will provide a tide gauge located at back of Slip 3.
   1. The Contractor shall supply temporary gauges and buoys at the dredge site.
   2. The Contractor shall establish and maintain a calibrated tide gauge or board consistent with the tide gauge provided by the Port in a location where it may be clearly seen during all in-water work specified throughout this section.

H. The Contractor shall conduct surveys using survey-grade depth sounder with a frequency of 200 KHz or other frequency as approved by the Port. The surveys will be performed using an EPS and a single-beam, dual frequency or multi-beam, single-frequency echosounder system.

I. The top return of the signal trace shall be the point of interpretation of the soundings.

J. Surveys shall be converted to bottom elevation with respect to NGVD, and plotted to the nearest 0.1 foot.

K. The Contractor shall provide weekly sounding cross sections of the previous work or after every 10,000 cy of berm material placed, at no greater than 20-foot trackline intervals using a survey-grade depth sounder. The volume of material placed and the area affected shall be determined. Progress surveys during filling within the CDF (behind the containment berm) shall be completed every 10th active day of filling. Accuracy for measured depth shall be +/- 0.25 foot; accuracy of horizontal positions shall be +/- 3 feet at the 95 percent confidence interval.

L. The Contractor shall submit an as-built survey after each construction season or after each unique unit (separate project source) of material is placed within the CDF.

M. Three complete sets of survey drawings shall be submitted to the Port after each survey. Drawings shall be prepared at a scale of 1 inch = 50 feet on plan sheets and shall depict the survey control lines. Cross section plots shall be prepared every 100 feet perpendicular to the stationing lines. The cross sections shall be depicted on plan sheets.

N. Survey Control – Accurate and precise methods of horizontal and vertical control shall be established by the Contractor before work begins. These control methods shall be used accordingly as specified in the CQCP and the Survey Control Plan. The Contractor shall lay out its work from horizontal and vertical control points indicated on the CQCP and the Contract Drawings and shall be responsible for all measurement taken from these points. The Contractor shall employ a suitable method to locate and control horizontal and vertical in-water work. The Contractor is required to have and use Real Time Kinematic (RTK) capability for survey control work.

O. Quality Control Supervisor – The Quality Control Supervisor shall be present on site at all times any survey activity specified in this section is taking place in accordance with the CQCP. Daily CQC reports shall be submitted to the Port each day on the previous day's activities specified in this section.

1.7 PERMITS

A. Permits, certifications, or orders for dredging and disposal work under this Contract will be issued by the following entities prior to commencement of the work (see Exhibit A):
   1. USEPA, Section 401 Water Quality Monitoring and Compliance Conditions Plan
   2. National Marine Fisheries Services (NMFS), Biological Opinion

B. The Contractor shall be responsible for adhering and conforming to all applicable provisions, conditions, and requirements of these agency documents.

C. All permits, certifications, or orders for dredging work under this Contract will be issued by the entities stated in this part prior to commencement of the work.

D. The Contractor is responsible for validation in writing of the receipt of these permits, certifications, or orders to the Port before commencement of the work.

PART 2 - PRODUCTS

2.1 GENERAL

A. The Contractor shall provide all required materials for the project. Materials shall be of the quality, size, shape, and gradation as specified in this part.

2.2 BORROW SOURCE AND MATERIALS CHARACTERIZATION

A. The Contractor shall provide all required materials for the project. Materials shall be of the quality, size, shape, and gradation as specified in this part. The following activities shall be performed by the Contractor on all imported materials from upland quarries, as specified below to assure that imported materials are natural, native, virgin materials and free of contaminants, including debris or recycled materials, and meet construction specifications. The Contractor shall provide assurance that imported materials are free of hazardous or otherwise objectionable materials. The Port maintains the right to reject any materials that have been determined to be substandard for any reason. In the event of rejections, it shall be the responsibility of the Contractor to remove all stockpiles of rejected material from the site.
   1. A characterization of any and all imported material shall be performed by the Contractor prior to any on-site placement. The characterization will include analysis of a borrow source sample, site inspection, and site characterization. The Contractor shall submit a Borrow Source Characterization report summarizing all the information contained within this section.
   2. Source Identification: Prior to borrow source sampling, The Contractor shall provide documentation of the origin of borrow source materials.
   3. The Contractor shall provide the Port with a 5-gallon sample of granular material from each borrow source. Note, samples of rock are not required. Each sample should be composed from no less than five sub samples taken throughout any one source. The Contractor shall assure that the samples are representative of all materials to be imported. Samples shall be provided to the Port at least 14 days before the materials represented by the samples are delivered to the site.

4. The borrow source shall be inspected by the Contractor. During such inspection, the Contractor shall assure that the materials to be delivered to the site are likely to meet the appropriate specifications. The Contractor shall provide the Port with two weeks notice of such inspections. At the Port's discretion, the Port or a representative may accompany the Contractor to witness such inspections. This witnessing shall in no way release the Contractor form complying with the specifications and shall in no way be construed as approval of any particular source of material.
5. Testing, Reporting, and Certification: The Contractor shall test samples of materials to be imported for the following:
   a. Grain Size Distribution (American Society for Testing and Materials [ASTM] method D422-63).
   b. In-situ Moisture Content (ASTM method D2216)
   c. Priority Pollutant Metals (USEPA publication SW 846, the 6000/7000 method series)
   d. Volatile Organic Compounds (USEPA publication SW 846, method 8270 as modified by PSEP)
   e. Polychlorinated Biphenyls (PCBs) (USEPA publication SW846, method 8082 as modified by PSEP)
   f. Pesticides (USEPA publication SW846, method 8081 as modified by PSEP)
   g. Total Organic Carbon (Standard Methods [SM] method 5310B).
6. The Contractor shall provide the results of such tests at least 2 weeks before delivery of the materials to the site. The results shall be provided in report form, with the reports clearly identifying the following:
   a. Source of samples.
   b. Sampling dates.
   c. Chain of custody.
   d. Sampling locations.
   e. Contractor's certification that the samples tested and the results provided is representative of materials that shall be delivered to the site.
7. Inspection of Materials at the Site: Truckloads of imported material shall be visually inspected by the Contractor upon delivery. Materials shall be inspected for the presence of foreign, recycled, or reprocessed material. The Port may at any and all times perform an independent inspection. Material may be rejected if identified as substandard or test results show it to be substandard. Materials may be segregated for testing based on appearance or odor. Segregated materials may be tested according to designated procedures at the Port's discretion.
8. The Contractor shall collect certified tickets form the borrow source for each load of material brought to the site. The tickets shall be supplied to the Port.
9. One sample for every 20 percent of the total volume of each material used shall be taken and submitted for grain size analysis.
10. The Port maintains the right to reject any materials that have been determined to be substandard for any reason. In the event of rejections, it shall be the responsibility of the Contractor to remove all stockpiles of rejected material from the site.

2.3 SELECT FILL

A. Material shall be clean, free-draining, granular material obtained from natural deposits. Individual particles shall be free from all objectionable coatings. The material shall contain no organic matter nor soft friable particles in quantities considered objectionable by the Port

B. Material shall be graded between the limits specified below:

Sieve Size	Percent Passing (by weight)
4 inch	90 to 100
¾ inch	50 to 75
U.S. No. 4	35 to 55
U.S. No. 10	25 to 45
U.S. No. 40	10 to 25
U.S. No. 200	0 to 4

2.4 TRAINING TERRACES MATERIAL

A. Material shall be clean, free-draining, granular material obtained from natural deposits. Individual particles shall be free from all objectionable coatings. The material shall contain no organic matter nor soft friable particles in quantities considered objectionable by the Port.

B. Material shall be graded between the limits specified below:

Sieve Size	Percent Passing (by weight)
8 inch	100
3 inch	40 max
¾ inch	10 max

2.5 TOE BUTTRESS MATERIAL

A. Material shall be clean, free-draining, granular material obtained from natural deposits. Individual particles shall be free from all objectionable coatings. The material shall contain no organic matter nor soft friable particles in quantities considered objectionable by the Port.

B. Material shall be graded between the limits specified below:

Sieve Size	Percent Passing (by weight)
8 inch	100
3 inch	40 max
¾ inch	10 max

2.6 DREDGED SEDIMENT FOR CONFINEMENT

A. Dredged sediment to be placed in the CDF shall meet the requirements of the Sediment Acceptance Criteria Memorandum. All materials used for filling shall be approved by the Port and USEPA.

2.7 IMPORT FILL

A. Import fill to be used for filling shall meet the requirements of the Sediment Acceptance Criteria Memorandum. All materials used for filling shall be approved by the Port and USEPA.

2.8 BERM ROADWAY BASE COURSE

A. Material shall meet the requirements of Dense-Graded Aggregate (2”-0)

2.9 BASE COURSE

A. Material shall meet the requirements of Dense-Graded Aggregate (1”-0)

2.10 TOP COURSE

A. Material shall meet the requirements of Dense-Graded Aggregate (3/4”-0)

2.11 ARMOR TYPE 5

A. Material shall be clean, free-draining, granular material obtained from natural deposits. Individual particles shall be free from all objectionable coatings. The material shall contain no organic matter nor soft friable particles in quantities considered objectionable by the Port.

B. Material shall meet the requirements of ODOT Type 700(E) riprap.

PART 3 - EXECUTION

3.1 EQUIPMENT AND STRUCTURES

A. Sediment Offloading and Conveyance Facility
   1. The Contractor shall design and submit to the Port for approval the sediment offloading and conveyance facility.
   2. The facility shall have the following minimum design elements:
      a. Spillage containment systems and methods to monitor for any spillage
      b. Any make up water used to slurry the dredged material for pumping shall be drawn from within the CDF.
      c. Sufficient capacity to handle the anticipated supply rates
      d. Ability to place materials to all locations of the CDF.

3. At the completion of the offloading, sediment sampling at the offloading facility shall be completed and the results compared to the baseline conditions. Any elevated sediment concentrations as a result of the offloading will be dredged and placed within the CDF.

3.2 BERM CONSTRUCTION

A. The Contractor shall use training terraces to construct the containment berm. Individual training terraces shall be limited to a 20-foot height. Inside slopes of the training terraces shall be between 2 horizontal to 1 vertical (2H:1V) and 1.5H:1V.

B. The face of the containment berm shall be armored as shown on the drawings. The armor layer shall be placed from the toe of the slope upward.

C. Once the elevation of the berm is 5 feet above the river level, place and compact materials per Article 3.7 of Section 312000—Site Clearing and Earthwork.

D. The berm shall be constructed to the limits, depth, lines, and grade, as shown on the drawings.

E. Construction tolerances are +1 foot and -1 feet from the required final elevation.

F. The berm shall be constructed to the minimum elevations. To assure filling to the minimum pay grades, the Contractor is allowed a 1-foot placement tolerance and a maximum pay depth to 0.5 foot higher than the minimum noted elevation.

G. The Contractor shall notify the Port when filling work is complete. A post-filling survey of the berm will be taken by the Port and used to verify completion of work to specified elevations, slopes, and tolerances, before the Contractor demobilizes. If the Port's post-fill hydrosurvey finds the Contractor's work not meeting contract plans and specifications, the Port will notify and provide the Contractor with hydrosurvey results. Any material found above the specified grade shall be regraded to within tolerance. All additional post-fill hydrosurveys necessary to confirm the Contractor's work shall be provided by the Port and withheld from payment to the Contractor.

H. The Contractor shall protect existing piling and structures in and near placement areas from damage. The Contractor shall submit a Settlement Monitoring Plan (SMP) prior to construction. The plan will identify the personnel, procedures, methods, and documentation required to monitor the movement of waterside structures and/or upland areas. The Contractor shall install survey monitoring points and perform monitoring at specified locations of critical structures as defined in the SMP. Prior to construction a baseline survey will be completed. During construction, surveying will be completed—movements of greater than 1 inch will require the Port to be notified and work will stop in that area.

I. Berm construction while the berm is submerged or with water-based construction equipment shall only occur during the in-water work periods. Construction of the berm may occur after the in-water work closure as long as the berm is not submerged and construction progresses from shore and does not impact the river.

3.3 DREDGED SEDIMENT FOR CONFINEMENT PLACEMENT

A. Mechanically dredged sediment being placed within the CDF shall be placed with the equipment described in Article 3.1.A.

B. The material shall be placed evenly across the site.

C. The Contractor shall notify the Port when filling work is complete. A post-filling survey of the CDF will be taken by the Port and used to verify completion of work to specified elevations, slopes, and tolerances, before the Contractor demobilizes. If the Port's post-fill survey finds the Contractor's work not meeting elevations and grades of the contract plans and specifications, the Port will notify and provide the Contractor with survey results. Any material found above the specified grade shall be regraded to within tolerance. All additional post-fill surveys necessary to confirm the Contractor's work shall be provided by the Port and withheld from payment to the Contractor.

3.4 NON-CONTAMINATED DREDGE FILL PLACEMENT

A. Any mechanically dredged fill being placed within the CDF shall be placed with the equipment described in Article 3.1.A.

B. The Contractor shall notify the Port when non-contaminated dredge fill placement work is complete. A post-filling survey of the CDF will be taken by the Port and used to verify completion of work to specified elevations, slopes, and tolerances, before the Contractor demobilizes. If the Port's post-fill survey finds the Contractor's work not meeting contract plans and specifications, the Port will notify and provide the Contractor with survey results. Any material found above the specified grade shall be regraded to within tolerance. All additional post-fill surveys necessary to confirm the Contractor's work shall be provided by the Port and withheld from payment to the Contractor.

3.5 CDF COVER LAYER CONSTRUCTION

A. Import materials shall be placed to the grades shown on the drawings.

B. Place and compact select fill per Article 3.7 of Section 312000—Site Clearing and Earthwork. Place and compact aggregate base course per Section 321123—Aggregate Base Course.

C. The Contractor shall notify the Port when CDF cover layer construction work is complete. A post-filling survey of the CDF will be taken by the Port and used to verify completion of work to specified elevations, slopes, and tolerances, before the Contractor demobilizes. If the Port's post-fill survey finds the Contractor's work not meeting contract plans and specifications, the Port will notify and provide the Contractor with survey results. Any material found above the specified grade shall be regraded to within tolerance. All additional post-fill surveys necessary to confirm the Contractor's work shall be provided by the Port and withheld from payment to the Contractor.

3.6 TRANSPORTING MATERIAL FOR CONSTRUCTION OF THE CDF

A. Bottom-dump, split-hull, or flat-deck barges shall be in good condition with no leaks in the hull or in the bottom dumping mechanism. The barge shall sail with sufficient freeboard inside the barge so that no water spills over the side walls while under way. Load lines shall be clearly shown on the barge and loading shall not take the barge below the load lines. The tug shall be of sufficient horsepower for moving the barge and maneuvering through the area, bridges, and marine traffic encountered between the borrow site and the placement site.

B. The Contractor shall provide the following information on each barge that will be used:
   1. Name of barge.
   2. Length, beam, and molded depth of each barge.
   3. The barge shall have clear and distinct draft marks.
   4. Material capacity of barge.
   5. Hydrostatic data certified by a naval architect for determining barge displacement in short tons, per each 1 foot of displacement between loaded and light drafts.
   6. Expected draft of barge loaded to capacity with dredge material.

3.7 WATER QUALITY AND TURBIDITY

A. Conduct dredging operations to ensure adherence to the turbidity and water quality requirements stipulated in the permits. Prevent resuspension of material in the vicinity of the site.

B. Work in the dredging area shall be done to minimize turbidity, erosion of banks or bottom, or other water quality impacts. The Contractor shall take all normal precautions to prevent turbidity at the dredging site and CDF. These include making each pass of the bucket complete including dredging and dumping to the barge, and bringing the bucket fully over the barge before discharging. There will be no filling of the barge which will result in water overflow from the barge. The bucket shall be placed on the bottom rather than dropped unless dropping is required to excavate the sediments. Vertical bucket retrieval shall be at moderate speed to minimize the erosion of materials from the bucket. Retrieval speed of the bucket shall be reduced if water quality monitoring indicates increased levels of turbidity.

C. The Contractor shall keep an operators log and a daily progress chart aboard the dredge at all times for inspection. The daily progress chart shall include data regarding work areas completed, names of barges used, and cubic yards loaded. These documents shall be submitted to the Port for retention with the contract file at the completion of the dredging work. The Contractor will be provided a copy of this log.

D. Water Quality Monitoring and Control Plan: The Contractor shall submit a plan with methods and procedures for controlling water quality during dredging.

E. Water Quality Monitoring and Control Contingency Plan: The Contractor shall submit a contingency plan with methods and procedures for modifications of methods which fail to meet water quality requirements.

F. The Contractor shall submit the plans described above to the Port 7 days before mobilization.

3.8 REPORTING REQUIREMENTS

A. A daily report of operations shall be prepared and maintained and copies submitted to the Port.

END OF SECTION 352027

DIVISION 40

PROCESS INTEGRATION

(See Anchor 2006)

EXHIBIT A

REGULATORY DOCUMENTS

(not included)

EXHIBIT B

SOIL/SEDIMENT DATA

(not included)

APPENDIX D
CONSTRUCTION QUALITY ASSURANCE PLAN

APPENDIX D
CONSTRUCTION QUALITY ASSURANCE PLAN
(PREFINAL 60 PERCENT TERMINAL 4 CDF DESIGN SUBMITTAL)
PORT OF PORTLAND, PORTLAND, OREGON

Prepared for

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Portland, Oregon

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LIST OF ACRONYMS AND ABBREVIATIONS

AOC	Administrative Order on Consent
ARARs	applicable or relevant and appropriate requirements
BMPs	best management practices
CDF	Confined Disposal Facility
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CIH	Certified Industrial Hygienist
COPC	contaminant of potential concern
CQAO	Construction Quality Assurance Officer
CQAP	Construction Quality Assurance Plan
CQC	Construction Quality Control
cy	cubic yards
DAR	Design Analysis Report
EPP	Environmental Protection Plan
EPS	electronic positioning system
HASP	Health and Safety Plan
NTCRA	Non-time-Critical Removal Action
Port	Port of Portland
PPE	personal protective equipment
QA	quality assurance
QA/QC	quality assurance/quality control
QC	quality control
RACR	Removal Action Completion Report
RAOs	Removal Action Objectives
RAWP	Removal Action Work Plan
SMP	Settlement Monitoring Plan
SOQ	Statement of Qualifications
SOW	Statement of Work

T4	Terminal 4
USEPA	U.S. Environmental Protection Agency
WQMP	Water Quality Monitoring Plan

1 INTRODUCTION

This Prefinal (60 Percent) Terminal 4 (T4) Confined Disposal Facility (CDF) Construction Quality Assurance Plan (CQAP) is an appendix to the Design Analysis Report (DAR), and one of the 60 Percent Design documents submitted to the U.S. Environmental Protection Agency (USEPA) for the Non-Time-Critical Removal Action (NTCRA) at T4. This document addresses the requirement of the Statement of Work (SOW; Appendix A to the AOC, USEPA 2003) to submit a site-specific CQAP. The purpose of this CQAP is to detail the CDF verification method and approach to quality assurance (QA) during construction activities in the project area, including compliance with applicable or relevant and appropriate requirements (ARARs). To accomplish this purpose, this document identifies the responsibilities for CDF construction performance and monitoring of the construction activities in accordance with the final design documents through a QA program. Additionally, this CQAP describes the methods used to measure compliance with performance objectives.

As noted above, the CQAP is an appendix to the DAR, which provides the details of the CDF design. Other appendices to the DAR provide additional details of the CDF design that are pertinent to the CQAP. These other documents, which are cited in the CQAP, include:

- Drawings (Appendix B to the DAR)
- Construction Specifications (Appendix C to the DAR)
- Construction Water Quality Monitoring Plan (WQMP; Appendix E to the DAR)
- CDF Sediment Management Plan (Appendix J to the DAR)

The remainder of the CQAP is organized into the following sections to address the document requirements detailed in the SOW:

- **Section 2 – Project Roles and Responsibilities** presents the roles and responsibilities of the parties involved in the construction of the T4 CDF, including USEPA.
- **Section 3 – Qualifications** describes the qualifications and experience required for the Contractor and any selected subcontractors, as well as the qualifications of the

Construction Quality Assurance Officer (CQAO) and supporting inspection personnel.

- **Section 4 – Quality Assurance Program** describes the performance objectives and criteria, QA measures, inspection and verification activities, and contingency actions for each construction activity.
- **Section 5 – Documentation and Reporting** describes the reporting requirements for construction QA activities. This includes daily and weekly summary reports, inspection data sheets, problem identification and corrective measures reports, design acceptance reports, and final documentation. A description of the provisions for final storage of all records consistent with the requirements of the Administrative Order on Consent (AOC; USEPA 2003) is also included in this section.
- **Section 6 – References** presents the references cited and used to generate this document.

2 PROJECT ROLES AND RESPONSIBILITIES

The roles and responsibilities of the parties involved in the T4 Removal Action are outlined below. An organization chart depicting general project administration, management, and oversight is presented on Figure 1.

Per the AOC, the Port of Portland (Port) is responsible for implementing the T4 Early Action, including conducting all construction activities; monitoring and reporting; and achieving all Removal Action Objectives (RAOs), performance standards, and compliance with ARARs and other goals, objectives, and legal requirements. This section details how others will assist the Port in completing the implementation.

2.1 U.S. Environmental Protection Agency

USEPA is the regulatory authority and is the responsible agency for overseeing and authorizing the remedial action described herein. In this capacity, USEPA will review information described in the DAR, the Drawings and Construction Specifications (Appendices B and C to the DAR, respectively), and this CQAP to ensure that the project is implemented in a manner consistent with applicable state and federal laws and regulations. The USEPA Project Coordinator, or a designee, will exercise project oversight for USEPA and coordinate with the Port and the Project Engineer. The groups involved (described below) will propose to USEPA and the USEPA Project Coordinator, response measures or recommendations as appropriate. USEPA, as appropriate, will make final decisions to resolve such issues or problems that may change the project scope.

USEPA is working cooperatively with other government agencies, including the Oregon Department of Environmental Quality, other federal agencies, and tribal governments. The other agencies will continue to review documents and participate in decision-making related to the Removal Action. Other agencies will provide their comments to the USEPA Project Coordinator for communication to the Port.

Access to Port facilities is restricted for security. Agency representatives should contact the CQAO to arrange for site visits. The CQAO will coordinate site access for site visitors with Port security in accordance with federal requirements per Transportation Security Administration and Transportation Worker Identification Credential programs.

2.2 Port of Portland

The construction project will be managed by the Port. The Port has ultimate responsibility for implementing the Removal Action and addressing the RAOs. The Port, or their consultant, will be responsible for construction management and contract administration. The Port will hire the Contractor and, indirectly, its subcontractors specializing in the required in-water/over-water Removal Action activities, including pile/structure demolition, containment berm construction, dredging, new structure/piping/outfall construction, construction of the CDF, CDF filling, and CDF covering. The Project Engineer and CQAO will also be contracted by the Port to fulfill the responsibilities identified in the following sections; the Port reviews all work products prepared by its contractors and consultants and take responsibility for the actions of its employees, contractors, and consultants. The Port shall identify any unforeseen issues or problems if they arise. The Port will communicate to the USEPA Project Coordinator concerns, if any arise, regarding the implementation of the Removal Action, including any proposed remedies, if warranted, to address unforeseen conditions.

2.3 Project Engineer

The Project Engineer is responsible for two primary tasks. First, the Project Engineer is responsible for preparing the design of the CDF such that successful implementation of the design will result in achieving the RAOs and construction activity-specific objectives.

Additionally, the Project Engineer will provide consultation and observations during construction to assist with implementation of the CDF design in conformance with the USEPA-approved design documents. During implementation of the CDF design, potentially noncompliant construction activities will be referred to the Project Engineer. The Project

Engineer is responsible for determining whether the allegedly noncompliant construction is acceptable within the design, unacceptable, or acceptable with a design modification. USEPA will have final authority to approve design modifications proposed by the Project Engineer.

2.4 Construction Quality Assurance Officer

The CQAO will be responsible for overseeing the implementation of the CQAP. In this role, the CQAO is responsible for monitoring construction performance for compliance with construction performance standards and design requirements during implementation of the CDF design, and is responsible for overseeing the required inspection and verification activities. The CQAO will review documentation submitted by and work completed by the Contractor for adherence to performance standards and design requirements. The CQAO will be sufficiently familiar with the final design and the construction operations to recognize deviations from that design. The CQAO will also have the ability to manage and maintain the integrity of the data generated during the CDF construction activities.

The CQAO will also be responsible for identifying those field conditions that may warrant deviation from the final design. In such circumstances, the CQAO will coordinate with the USEPA Project Coordinator to identify and agree upon any necessary deviations to meet the overall objectives of the design. Any agreed-upon deviations will be documented in the weekly progress reports to USEPA.

The CQAO may use inspectors with the requisite expertise and experience to help perform the duties described above.

2.5 Contractor

The Contractor will be responsible for the following tasks:

- On-site responsibility for construction management and contract administration. The Contractor will have total authority and responsibility to deal with all contractual matters and to ensure that the work complies with contract final design plans and

specification requirements and provides all necessary quality control (QC) information.

- Implementing the CDF design by either performing tasks or contracting with subcontractors. As part of this task, the Contractor will be responsible for implementing the CQAP, including the required monitoring, sampling, testing, and reporting. Included with this responsibility is the implementation of the QD activities to ensure that project construction is conducted in accordance with the contract Drawings and Construction Specifications (Appendices B and C to the DAR, respectively). In accordance with implementing the CDF construction activities, the Contractor will oversee the development of an Environmental Protection Plan (EPP).

The Contractor will use key personnel to help with the tasks described above, including an on-site Superintendent, Construction Quality Control (CQC) Manager, and a Health and Safety Manager.

2.5.1 Contractor On-Site Superintendent

Direction of the work for the Contractor will be through an on-site Superintendent, who will be responsible for executing the work in full compliance with the contract Drawings and Construction Specifications (Appendices B and C to the DAR, respectively). The Superintendent will work with the Contractor to resolve job-related problems and day-to-day project management. The Superintendent may utilize one or more foremen to directly supervise the major construction activities. The Superintendent will exercise supervision over subcontractors, if subcontractors are utilized.

2.5.2 Contractor Construction Quality Control Manager

The CQC Manager will be provided by the Contractor as required in the Construction Specifications (Appendix C to the DAR), who will develop and implement a CQC Plan through which the Contractor ensures compliance with the requirements of the contract final design drawings and specifications. The CQC Manager will have written CQC duties and responsibilities delegated by the Contractor, and will have a team to help implement the

CQC Plan elements. The CQC Plan will state the chain of command for the CQC team, including identification of responsibilities for each member, to ensure that any actions related to the quality of work will be executed in an accurate and expeditious manner.

2.5.3 Contractor Health and Safety Manager

The Contractor will employ a Health and Safety Manager to develop and implement a Health and Safety Plan (HASP). This plan will contain details of the chain of command and personnel responsibilities, as discussed in the Construction Specifications (Appendix C to the DAR).

2.6 Subcontractors

The Contractor will either perform construction elements or contract with subcontractors to perform selected phases of the work for which they have special expertise. The subcontractors are responsible to the Contractor for the quality of their work, protection of the environment, CQC Plan, EPP, and HASP. The subcontractor's principals will designate a job foreman with responsibility to see that the work is conducted in accordance with the contract requirements.

3 QUALIFICATIONS

As required by the SOW (Appendix A to the AOC, USEPA 2003), qualifications of the CQAO and supporting inspection personnel, including minimum training and experience required, are provided below. Additionally, the qualifications for the Contractor firm and personnel are also provided.

3.1 Port Project Manager

The Port Project Manager will have experience in managing environmental projects of a complexity and magnitude similar to or greater than the Removal Action. The Port Project Manager will be thoroughly familiar with the AOC, applicable environmental laws, and the requirements of the Removal Action design. The Port Project Manager will be supported by other Port personnel, such as an attorney and an engineer, assigned to the project.

3.2 CQAO and Inspector Qualifications

The CQAO will be determined prior to the start of work. The CQAO will have an engineering degree and experience managing Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)-related construction projects with similar QA requirements. The CQAO will be required to have current federal and state health and safety training. Additionally, the CQAO will be sufficiently familiar with the final design and the construction operations to recognize deviations from that design. The CQAO will also have the ability to manage and maintain the integrity of the data generated during the project. Additional inspectors may be used to help the CQAO. These inspectors will have experience inspecting construction activities for CERCLA-related projects and will have current federal and state health and safety training.

3.3 Contractor Qualifications

The Contractor will be selected through a competitive qualifications-based selection process. Each potential Contractor bidding for the project will be required to provide a Statement of

Qualifications (SOQ) to the Port with their bid. This SOQ will allow the Port to determine that the bidder is qualified, in terms of experience and capability, to perform the work.

The Contractor will employ, as part of its permanent organization, senior, knowledgeable, and experienced personnel to oversee the project. The journeyman operators, surveyors, and other Contractor personnel performing key jobs must also have the demonstrated ability and skills to satisfactorily perform their respective assignments.

The CQC Manager, and the Contractor as a whole, must have documented qualifications and experience to perform independent checks on the Contractor's operations as necessary to determine compliance with the contract provisions. These documented qualifications will be submitted to the Port for approval prior to identifying a CQC Manager. Additionally, any subcontractors utilized in the work must have demonstrated to satisfaction of the Port that they are qualified and have satisfactorily performed the type of work for which they will be engaged. However, responsibility for the subcontractor performance rests with the Contractor. All Contractor and subcontractor personnel will be required to have current federal and state health and safety training.

4 QUALITY ASSURANCE PROGRAM

The QA program to be implemented during the CDF construction to ensure compliance with the approved design documents is described in this section by construction activity. Specific activities to be implemented during CDF construction are described, along with specific performance objectives, performance criteria, QA measures, inspection and verification activities, and contingency actions. CDF construction elements include the following:

- Pile/structure demolition
- Containment berm construction
- Dredging
- New structure/piping/outfall construction
- CDF filling
- CDF covering

For each construction activity, inspection and verification activities will be implemented to confirm that performance objectives have been met. Table 1 summarizes the required construction inspection and verification activities and frequencies of inspection for each construction activity.

During the CDF construction, the QA process will progress as follows:

- The Contractor will submit a CQC Plan as detailed in Section 5.
- The Contractor will provide documentation to the CQAO to demonstrate that specific components of the final design have been properly implemented.
- The Contractor and the CQAO will conduct inspection and verification activities (i.e., sampling, testing, and monitoring) to ensure compliance with the approved design documents and that performance objectives have been met.

The remainder of this section details each construction element and associated performance objectives and criteria, along with QA measures and specific inspection and verification activities that will be performed to confirm that performance objectives have been met.

4.1 Pile/Structure Demolition

4.1.1 Task Description

This construction element involves the removal of two existing open berths located in Slip 1. Berths 405 and 408 are to be demolished and removed as described in the DAR and the Drawings and Construction Specifications (Appendices B and C to the DAR, respectively). This demolition also includes the removal of wood and concrete piles and superstructure with asphalt or concrete topping. Some piles will be broken off at the mudline and others will be completely removed. Debris from the demolition and pile removal will not be disposed of within the CDF, but will be disposed at an appropriate landfill.

4.1.2 Performance Objectives and Criteria

Construction performance objectives for pile/structure demolition include the following:

- **Remove Specified Structures and Piles and Protect Remaining Structures.** It is necessary to confirm that the piles and structures identified in the Drawings and Construction Specifications (Appendices B and C to the DAR, respectively) have been adequately removed, and that structures not requiring removal are not damaged during the demolition operation. Performance criteria include total removal of specified structures and piles, and less than 1 inch of movement of protected structures (i.e., structures not identified for removal).
- **Appropriate Disposal/Recycling of Demolition Materials.** Demolition material removed from the Removal Action area must be properly disposed or recycled. The performance criterion is disposal or recycling of demolition materials at the appropriate facility as detailed in the Construction Specifications (Appendix C to the DAR).
- **Achieve No Off-site Tracking of Contaminants During Transport of Disposal Materials.** It is necessary to confirm that there is no spreading of contamination during transit to an off-site disposal facility. The performance criterion is no statistical difference between samples collected before and after transit activities begin.

- **Minimize Short-term Water Quality Impacts.** Water quality monitoring activities are required to ensure compliance with federal and state water quality criteria. Performance criteria are specified in the WQMP (Appendix E to the DAR).
- **Minimize Potential Impacts to Cultural Resources and Historic Structures.** Archaeological monitoring activities are required to ensure that construction activities do not impact cultural resources and historic structures.

4.1.3 Quality Assurance Measures, Inspection and Verification Activities, and Contingency Actions

QA measures described below will be implemented during the CDF construction activities to ensure that performance objectives are met and construction is completed according to contract drawings and specifications. Inspection and verification activities will be implemented and compared to criteria to determine if performance objectives have been achieved. If performance standards have not been achieved, contingency actions, as described below, will be implemented.

4.1.3.1 Remove Specified Structure/Pile Removal and Protect Remaining Structures

QA measures to be implemented during structure/pile demolition to achieve specified structure/pile removal include completing a survey to locate all piles and structures and preparation of a Settlement Monitoring Plan (SMP) for monitoring movement of remaining waterside structures. Prior to the removal/demolition, the Contractor will be required to survey and locate all piles and structures, and to present this information on an as-built drawing. After pile removal, the Contractor will note which piles were unable to be removed as specified in the contract drawings, and the elevation of the top of any remaining piles. The Contractor will coordinate with the Project Engineer to determine additional measures to take to remove remaining piles, if necessary.

To verify that piles or structures not requiring removal or demolition are not damaged, the Contractor will submit a SMP prior to demolition. This plan will identify the personnel,

procedures, methods, and documentation required to monitor the movement of waterside structures and or upland areas. Separate baseline and structural condition surveys will be conducted to establish conditions prior to the commencement of work. The Contractor will also install survey monitoring points and perform monitoring at specified locations of critical structures adjacent to any demolition activities. If movements on a protected structure are greater than 1 inch, the Project Engineer will be notified and work will stop in that area. The Project Engineer and Port will determine what actions need to be taken to stabilize the structure in question.

4.1.3.2 Appropriate Disposal/Recycling of Demolition Materials

For QA purposes, the Contractor will develop a waste-tracking program to identify procedures and forms for tracking the disposal of materials. Demolition materials are to be disposed of at an approved landfill. The Contractor will collect disposal slips from the haulers to document disposal location, date, and time. Additionally, the CQAO will independently track material disposal for verification purposes.

4.1.3.3 Achieve No Off-site Tracking of Contaminants during Transport of Disposal Materials

QA measures that will be implemented during construction to prevent the off-site tracking of contaminants during transport of materials not suitable for the CDF include use of spill plates, visqueen, and tire washes (as appropriate). In addition, soil samples will be collected at unpaved areas of road shoulders at the loading and offloading areas to verify that no debris removed during dredging is spreading contamination during transit and offloading.

More detailed information will be provided to USEPA in the Final (100 Percent) Design submittal describing the specifics of the sampling approach, including sampling quantities, compositing schemes, approach to archiving samples, and contingency measures. Additionally, for off-site areas that are paved, an important component of the sampling investigation design will be to target catchment basins or other areas of topographic depression where contaminated material may have been released and accumulated. Another

important component of the investigation will be to adequately sample pre-transport conditions to be able to distinguish whether or not the presence of contaminated sediment in the post-transport condition can be attributed to the CDF construction activities.

The density of samples and area of sampling will be defined once the actual offloading facility is identified. Samples will be collected prior to the start of transit activities and once per week for the duration of disposal activities. The samples will be submitted to the laboratory for chemical analyses. Results from samples collected during transit activities will be compared to results obtained before any transit activities began.

Statistical analyses will be performed on the results to determine if there are any differences between samples collected during transit and prior to the beginning of any transit activities. If there are any statistical differences, the Port will coordinate with USEPA to determine an appropriate response action based on the sample results.

4.1.3.4 Minimize Short-term Water Quality Impacts

Details of the water quality monitoring that will be completed, criteria, and contingency actions that may be implemented if water quality criteria are not met during the pile/structure demolition activities are provided in the WQMP (Appendix E to the DAR).

4.1.3.5 Minimize Potential Impact to Cultural Resources and Historic Structures

Archaeological monitoring will be implemented for activities occurring within the archaeologically sensitive areas according to the Archaeological Monitoring Protocol as detailed in Attachment 1.

4.2 Containment Berm Construction

4.2.1 Task Description

The containment berm will be constructed across the mouth of Slip 1. Prior to constructing the berm, a small volume of soft sediment will be over-excavated below the berm footprint and backfilled with select fill as shown on the Drawings (Appendix B to the DAR). The berm will be constructed to the grades shown on the Drawings. Subsequent training dikes will be used at each edge of the berm to contain the select fill, while the surface of the berm crest will be constructed for vehicular access. Concurrently, a weir and outfall structure will be installed to allow CDF effluent discharge.

4.2.2 Performance Objectives and Criteria

Construction performance standards and criteria associated with the construction of the containment berm include the following:

- **Achieve Specified Grades and Extents.** Berm construction materials must be placed at the specified grades within 1 foot of the extents shown on the Drawings and Construction Specifications (Appendices B and C to the DAR, respectively).
- **Achieve Proper Stability of the Containment Berm**. Berm slopes must be constructed to the grades shown on the Drawings (Appendix B to the DAR) and need to be monitored for stability throughout construction.
- **Verify Import Material Quality.** Import material must meet specified physical and chemical properties, as outlined in the Construction Specifications (Appendix C to the DAR), prior to the use of any imported material.
- **Minimize Short-term Water Quality Impacts.** Water quality monitoring activities are required to ensure compliance with federal and state water quality standards. Water quality criteria for berm construction are described in detail in the WQMP (Appendix E to the DAR).
- **Minimize Potential Impacts to Cultural Resources.** Archaeological monitoring activities are required to ensure no impacts to cultural resources or historic structures.

4.2.3 Quality Assurance Methods, Inspection and Verification Activities, and Contingency Actions

QA measures described below will be implemented during the CDF construction activities to ensure that performance objectives are met and construction is completed according to contract drawings and specifications. Inspection and verification activities will be implemented and compared to criteria to determine if performance objectives have been achieved. If performance standards have not been achieved, contingency actions, as described below, will be implemented.

4.2.3.1 Achieve Specified Grades and Extents

As a QA measure to achieve specified grades and extents, the Contractor will present a work plan before construction that will describe the proposed methods for constructing and controlling the grades of the berm. They will also submit a Survey Control Plan prior to construction. The Contractor will be required to use an electronic positioning system (EPS) for locating and tracking movement of their equipment.

For verification purposes, bathymetric/topographic progress surveys will be completed on 25-foot spacing to confirm specified thicknesses. Progress surveys will be completed once per week or every 10,000 cubic yards (cy) placed during construction activities, whichever occurs first. Wherever the berm height or grade is less than that specified by greater than 1 foot, the Contractor will be required to add a sufficient amount of additional material or grade as necessary to achieve the specified thickness or height in accordance with the terms of the contract. This filling may be required to address berm settlement. Final berm grades will be checked at the end of berm construction and after CDF filling.

4.2.3.2 Stability of the Containment Berm

To ensure stability of the containment berm, the Contractor will present a work plan before construction that will describe the proposed methods for constructing and controlling grades of the berm. The Contractor will also submit a Survey Control Plan prior to construction. The design of the containment berm slopes is based on standard engineering practice,

including selection and control of backfill characteristics to an anticipated stable configuration during and following construction. Methods described in Section 4.2.3.1 will be used to monitor stability as well.

Additionally, visual inspections of the berm will be made daily to look for indications of slumps or movements. If slumps or movements are detected, the Project Engineer will be contacted and construction will stop until a mitigation plan is developed to address the instability.

4.2.3.3 Verify Import Material Quality

As a QA measure for verification of import material quality, the Contractor will submit a Borrow Source Characterization Report (geotechnical and chemical results) prior to construction for each import material type. Chemical and physical characteristics of imported materials must meet the requirements detailed in the Construction Specifications (see the acceptable concentrations table in Appendix C to the DAR). The Contractor will sample imported material for physical analysis throughout the project in accordance with the methods, analytical parameters, and testing frequencies presented in Construction Specification 352027, Part 2 (Appendix C to the DAR). The Contractor will obtain the certified tickets from the borrow source for each load of material delivered. Additionally, inspectors will visually inspect representative barge loads of import materials delivered to the project construction area. Inspectors will observe unsuitable coatings or materials (i.e., debris, organics, etc.), as well as general conformity with the specified gradation. If necessary, the inspectors may obtain representative samples for physical testing to confirm compliance with the gradation.

If import materials do not meet chemical criteria or physical requirements, material will be rejected and the Contractor will have to obtain a different material.

4.2.3.4 Minimize Short-term Water Quality Impacts

Details of the water quality monitoring that will be completed, water quality criteria, and contingency actions that may be implemented if criteria are not met during berm construction activities are provided in the WQMP (Appendix E to the DAR).

4.2.3.5 Minimize Potential Impact to Cultural Resources

Archaeological monitoring will be implemented for activities occurring within the archaeologically sensitive areas according to the Archaeological Monitoring Protocol as detailed in Attachment 1.

4.3 Dredging

4.3.1 Task Description

Dredging will occur at the mouth of Slip 1 for berm key construction. In the first year of construction, the berm foundation must be overexcavated and placed at the head of Slip 1. The overexcavation of the berm foundation will be done mechanically. Dredged material will be placed at the head of Slip 1 with a bottom-dump barge or by bucket lowered to the mudline.

4.3.2 Performance Objectives and Criteria

Performance objectives and criteria associated with dredging include the following:

- **Verify Placement of Dredged Material in Proper Location at the Head of Slip 1.** Material dredged from the berm key must be placed as described in the Construction Specifications (Appendix C to the DAR).
- **Achieve Specified Dredging Depths and Extents.** Confirmation must be obtained that the contaminated sediments were removed to the target elevations and full lateral extents as depicted on the Drawings and Construction Specifications (Appendices B and C to the DAR, respectively).
- **Achieve No Release of Material in Transport from Dredging Area to CDF.** This objective is discussed in more detail in Section 4.5.2 for the CDF filling activity.

- **Avoid Impacts on Adjacent Structures.** Dredging in front of existing sloped and waterfront structures shall not lessen the overall stability of the slopes and potentially cause movement in the structures. Performance criterion is no more than 1 inch of movement of waterfront structures.
- **Achieve No Off-site Tracking of Contaminants During Transport of Disposal Materials**. If any debris is encountered that cannot be placed into the CDF, it is necessary to confirm that there is no spreading of contamination during transit of those materials to the off-site disposal facility. The performance criterion is no statistical difference between soil sample results collected before and after transit activities begin.
- **Minimize Short-term Water Quality Impacts.** Water quality monitoring activities are required to ensure that federal and state water quality standards are met. Water quality criteria for dredging activities are described in detail in the WQMP (Appendix E to the DAR).
- **Minimize Potential Impacts to Cultural Resources.** Archaeological monitoring is required to ensure no impacts to cultural resources or historic structures.

4.3.3 Quality Assurance Methods, Inspection and Verification Activities, and Contingency Actions

QA measures described below will be implemented during the CDF construction activities to ensure that performance objectives are met and construction is completed according to contract drawings and specifications. Inspection and verification activities will be implemented and compared to criteria to determine if performance objectives have been achieved. If performance standards have not been achieved, contingency actions, as described below, will be implemented.

4.3.3.1 Achieve Specified Dredging Depths and Extents

QA measures to be implemented during dredging to achieve specified dredging depths and extents are described below. The Contractor will present a work plan before construction that will describe the proposed methods for dredging and controlling grades. The Contractor

will also submit a Survey Control Plan prior to construction. The Contractor will be required to employ EPS, sonar sounding devices, automated electronic tide gauge, and tide gauges to accurately determine the dredging equipment location at all times. The Contractor will perform hydrographic QC surveys, as described in the Construction Specifications (Appendix C to the DAR). The control for this system must meet 0.25-foot vertical accuracy. These surveys will be performed at a minimum of every 2 working days to establish actual excavated depths and extent of dredging. The surveys will be performed using an EPS and a single-beam, dual frequency or multi-beam, single-frequency echosounder system. If a single-beam system is used, the trackline spacing will be no greater than 25 feet to minimize interpolation error. Additionally, the CQAO will work closely with the Contractor's CQC Manager and hydrographic survey crew to independently verify the dredge's horizontal position and dredging depth. This may be done either by evaluation of the Contractor's daily QC surveys or positioning data, conducting independent surveys, or a combination of both methods.

If surveys show that dredge depths have not been achieved in surveyed areas, the Contractor will be required to continue dredging in those areas until target dredge depths are achieved.

4.3.3.2 Achieve No Release of Material in Transport from Dredging Area to CDF

This QA measure is discussed in more detail in Sections 4.5.3.2 and 4.5.3.3 for the CDF filling activity.

4.3.3.3 Verify Placement of Dredged Material at Head of Slip 1

The Contractor will be required to use EPS for locating and tracking movement of the equipment. The haul barge will also have EPS to track its location before placement occurs. Bathymetric progress surveys will be completed on 25-foot spacing to confirm that material is being placed in the proper location. Progress surveys will be completed once per week or every 10,000 cy placed during construction activities, whichever occurs first.

4.3.3.4 Avoiding Impacts on Adjacent Structures and Tenants

The design of the dredge prism has been tailored to lessen the potential for instability of slopes and adjacent structures. Prior to the start of dredging, the Contractor will submit an SMP. This plan will identify the personnel, procedures, methods, and documentation required to monitor the movement of waterside structures and/or upland areas. The Contractor will install survey monitoring points and perform monitoring at specified locations of critical structures. A baseline survey will be conducted to establish conditions prior to dredging. In addition, a structural condition survey will be performed on these structures to document their structural condition prior to commencing work. If movements on structures are greater than 1 inch, the Project Engineer will be notified and work will stop in that area. The Project Engineer will evaluate the situation and determine a mitigation plan to stabilize the affected structure.

4.3.3.5 Achieve No Off-site Tracking of Contaminants During Transport of Disposal Materials

QA measures will be implemented during construction to prevent the off-site tracking of contaminants during transport of materials not suitable for the CDF (most likely debris removed as part of the dredging operations). These measures include use of spill plates, visqueen, and tire washes (as appropriate). In addition, soil samples will be collected at unpaved areas of road shoulders at the loading and offloading areas to verify that no debris removed during dredging is spreading contamination during transit and offloading.

More detailed information will be provided to USEPA in the Final (100 Percent) Design submittal describing the specifics of the sampling approach, including sampling quantities, compositing schemes, approach to archiving samples, and contingency measures. Additionally, for off-site areas that are paved, an important component of the sampling investigation design will be to target catchment basins or other areas of topographic depression where contaminated material may have been released and accumulated. Another important component of the investigation will be to adequately sample pre-transport

conditions to be able to distinguish whether or not the presence of contaminated sediment in the post-transport condition can be attributed to the CDF construction activities.

The density of samples and area of sampling will be defined in a sampling and analysis plan once the actual offloading facility is identified. Samples will be collected prior to the start of transit activities and once per week for the duration of disposal activities. The samples will be submitted to the laboratory for chemical analyses. Results from samples collected during transit activities will be compared to results obtained before any transit activities began.

Statistical analyses will be performed on the results to determine if there are any differences between samples collected during transit and prior to the beginning of any transit activities. If there are any statistical differences, the Port will coordinate with USEPA to determine an appropriate response action based on the sample results.

4.3.3.6 Minimize Short-term Water Quality Impacts

Details of the water quality monitoring that will be completed, water quality criteria, and contingency actions that may be implemented if criteria are not met during dredging activities are provided in the WQMP (Appendix E to the DAR).

4.3.3.7 Minimize Potential Impact to Cultural Resources

Archaeological monitoring will be implemented for activities occurring within the archaeologically sensitive areas according to the Archaeological Monitoring Protocol as detailed in Attachment 1.

4.4 New Structure/Piping/Outfall Construction

4.4.1 Task Description

There are several components of the project that will require new construction; these tasks are described as follows:

- **Replacement Berth Construction.** The new barge berth will be constructed parallel to the Willamette River at the mouth of Slip 1 and connected to the containment berm that will extend across the mouth of the slip. The berth will include a concrete platform supported by steel pipe piling with a vehicle access trestle to shore. This platform will be capable of supporting a future grain unloading tower, as well as future usage as required by the Port. A number of ship berthing dolphins will be installed with the catwalk access from the main platform. The majority of this work must be completed in water.
- **Stormwater and Outfall Structure Relocation.** Currently, five storm drain mains are known to outfall into the most inward (eastern) portion of Slip 1 at T4. Four of these are Port-owned and operated storm lines, while the fifth outfall is the property of the City of Portland. When Slip 1 is filled, these discharge points will be covered; therefore, these pipes must be relocated to provide a suitable point of discharge into the Willamette River. It is the Port's intent to keep the City- and Port-owned pipes separate.

4.4.2 Performance Objectives and Criteria

Performance objectives and criteria associated with new structure/piping/outfall construction include the following:

- **Verify Construction Materials.** The materials must be consistent with Construction Specifications (Appendix C to the DAR) for each specific construction activity.
- **Achieve Specified Grades and/or Dimensions.** The construction materials are to be placed to the specified limits, and structures should be constructed in the proper location as shown on the Drawings and detailed in the Construction Specifications (Appendices B and C to the DAR, respectively).
- **Achieve Watertightness of Pipe.** Finished pipe installation associated with stormwater outfall reroutes must be watertight and conform to specifications.
- **Achieve Pipe Loading.** Finished pipe installation should not be out-of-round or overloaded and should conform to specifications.

- **Achieve Proper Compaction.** Backfill and bedding should be properly compacted and conform to specifications.
- **Protect Aquatic Species During Installation of Pipe Piles with an Impact Hammer.** If pipe piles will be installed using an impact hammer, a bubble curtain or some other sound attenuation device must be used to protect aquatic species. The performance criterion for this objective is no distressed or dead fish resulting from the activity.
- **Minimize Short-term Water Quality Impacts.** Water quality monitoring activities are required to ensure compliance with federal and state water quality standards. Water quality criteria for new structure/piping/outfall construction activities are described in detail in the WQMP (Appendix E to the DAR).
- **Minimize Potential Impacts to Cultural Resources.** Archaeological monitoring is required to ensure no impacts to cultural resources and historic structures.

4.4.3 Quality Assurance Measures, Inspection and Verification Activities, and Contingency Actions

QA measures described below will be implemented during the CDF construction activities to ensure that performance objectives are met and construction is completed according to contract drawings and specifications. Inspection and verification activities will be implemented and compared to criteria to determine if performance objectives have been achieved. If performance standards have not been achieved, contingency actions as described below will be implemented.

4.4.3.1 Verify Construction Materials

The Contractor will be required to submit samples and test results of all proposed materials to be used for construction to the Project Engineer for review and approval. The Contractor will also inspect all materials brought to the CDF construction area for conformance to the Construction Specifications (see the acceptable concentrations table in Appendix C to the DAR).

If inspections and sample/test results determine that construction materials do not meet the details of the specifications, the Contractor will be required to find a different material.

4.4.3.2 Achieve Specified Grades and/or Dimensions

As a QA measure, the Contractor will present a work plan before construction that will describe the proposed methods for constructing the new structures/piping/outfall lines and controlling grades. The Contractor will also submit a Survey Control Plan prior to construction. The Contractor will be required to perform surveys and measurements as described in the Construction Specifications (Appendix C to the DAR) to confirm that construction tolerances are as required, and submit measurements to the Project Engineer. If construction tolerances are not as required, then the Contractor will have to fix the issue before construction will be deemed complete. The Contractor will be required to use EPS and licensed surveyors to lay out the location of the work. The CQAO will complete independent measurements of construction items to confirm compliance.

4.4.3.3 Achieve Watertightness of Pipe

Hydrostatic and/or air testing of pipe and manholes will be done by the Contractor to confirm watertightness. If watertightness is not confirmed, the Contractor will be required to fix the pipe until watertightness is confirmed.

4.4.3.4 Achieve Pipe Loading

Mandrel tests will be performed for finished small diameter storm mains by the Contractor to confirm pipe loading. Visual assessment and in-pipe measurements will be used for the large diameter systems to confirm pipe loading. If pipe loading is not confirmed, the Contractor will be required to provide pipe that meets the criteria.

4.4.3.5 Compaction

Field nuclear gauge testing (NDG) or equivalent will be done for compacted materials by the Contractor to confirm required compaction has occurred.

4.4.3.6 Protect Aquatic Species During Installation of Pipe Piles with an Impact Hammer

If installation of pipe piles is accomplished by using an impact hammer, a bubble curtain or other type of sound attenuation device will be required. If a bubble curtain is used, it must meet criteria defined in the Construction Specifications (Appendix C to the DAR). If distressed or dead fish are identified related to the pile installation activity, the activity will stop and additional sound attenuation devices will be implemented as best management practices (BMPs).

4.4.3.7 Minimize Short-term Water Quality Impacts

Details of the water quality monitoring that will be completed, water quality criteria, and contingency actions that may be implemented if criteria are not met during construction activities are provided in the WQMP (Appendix E to the DAR).

4.4.3.8 Minimize Potential Impact to Cultural Resources

Archaeological monitoring will be implemented for activities occurring within the archaeologically sensitive areas according to the Archaeological Monitoring Protocol as detailed in Attachment 1.

4.5 Confined Disposal Facility Filling

4.5.1 Task Description

The CDF will be filled with contaminated sediment from T4 dredging, as well as other approved sites in Portland Harbor. Any material placed within the CDF must meet the sediment acceptance criteria listed in the CDF Sediment Management Plan (Appendix J to the DAR). Contaminated sediment from any potential sources could be transported by either mechanical or hydraulic methods.

4.5.2 Performance Objectives and Criteria

Performance objectives and criteria associated with the filling of the CDF include the following:

- **Verify Fill Material Quality.** Material being placed in the CDF will be in accordance with the sediment acceptance criteria listed in the CDF Sediment Management Plan (Appendix J to the DAR), and the sediment geochemical characteristics evaluated in the CDF groundwater model (Appendix A to the DAR).
- **Prevent Release of Dredged Material (Mechanical Transport).** Action must be taken to minimize the potential for, and prevent releases of, dredged material during the filling of the CDF. Releases outside the CDF could also occur during transport.
- **Prevent Release of Dredged Material (Hydraulic Transport).** Action must be taken to minimize the potential for, and prevent releases of, dredged material during the filling of the CDF. Action must also be taken to prevent releases of material outside the CDF during transport.
- **Minimize Spillage of Material at the Transfer/Offload Facility.** Action must be taken to minimize the potential for releases of dredged material during the transfer or offloading into the CDF. The performance criterion is no statistical difference between sediment sample results collected before and after transfer activities begin.
- **Achieve Specified Placement Elevations.** Materials must be placed to the specified grades within the specified extents as shown on the Drawings (Appendix B to the DAR) and as determined by the process for accepting and sequencing sediment placement from other dredging sites in Portland Harbor.
- **Achieve Expected CDF Consolidation.** Confirmation that settlement and consolidation of placed material is occurring as predicted in the design is necessary.
- **Minimize Short-term Water Quality Impacts.** Water quality monitoring activities are required to ensure compliance with federal and state water quality standards. Water quality criteria for CDF filling activities (i.e., transport of material to the CDF for mechanical dredging and effluent discharge through the weir) activities are described in detail in the WQMP (Appendix E to the DAR).

4.5.3 Quality Assurance Measures, Inspection and Verification Activities, and Contingency Actions

QA measures described below will be implemented during the CDF construction activities to ensure that performance objectives are met and construction is completed according to contract drawings and specifications. Inspection and verification activities will be implemented and compared to criteria to determine if performance objectives have been achieved. If performance standards have not been achieved, contingency actions, as described below, will be implemented.

4.5.3.1 Verify Fill Material Quality

As a QA measure for verifying CDF fill material quality, all material placed within the CDF will conform with the sediment acceptance criteria and approval process described in the CDF Sediment Management Plan (Appendix J to the DAR). Sediment acceptance criteria will be more fully developed for the T4 CDF 100 Percent Design submittal. The CQAO will independently confirm the source of all materials placed within the CDF. Any materials determined to not be approved for placement within the CDF will not be placed within the CDF.

4.5.3.2 Prevent Release of Dredged Material (Mechanical Transport)

To prevent the release of dredged material during mechanical transport, the contract specifications will require the Contractor to follow certain QA measures related to mechanical transport of dredged material. Such requirements will include sealing of barges during transport and not overfilling barges. The Contractor will be required to document that all flat-deck barges, scows, and/or haul barges that transport dredged sediment to the CDF for placement have been checked for proper sealing action to prevent leakage during transport. Any barges or scows that are determined not to seal properly will be removed from operation until satisfactory repairs are made.

Water quality monitoring and criteria, as described in the WQMP (Appendix E to the DAR) will be used to monitor sediment loss during transport.

4.5.3.3 Prevent Release of Dredged Material (Hydraulic Transport)

To prevent the release of dredged material during hydraulic transport, the contract specifications will require the Contractor to follow certain QA measures. These measures will include requirements on pipe types, pipe testing and monitoring, and visual inspections. The contract specifications will require the discharge pipe from the dredge to Slip 1 to be built with welded or cemented connections. The Contractor will conduct daily walks of the portion of the line that is above ground. If leakage is evident from the discharge pipe, the Contractor will immediately cease dredging and repair the leak to the satisfaction of the CQAO before dredging resumes. To demonstrate watertightness, the pipe must be hydrostatically tested at 1.5 times the working pressure. The CQAO will monitor the results of the testing. If the Contractor must break the line for any reason, the Contractor will be required to pump clear water though the line until all of the dredged sediment slurry is evacuated from the line.

4.5.3.4 Minimize Spillage of Material at the Transfer/Offload Facility

The contract specifications will require the Contractor to follow certain QA measures related to offloading of dredged material into the CDF. The Contractor will be required to develop an EPP for the offloading facility to minimize the potential for spillage. The Contractor will be required to use spill plates to capture drips from the bucket and to use non-tooth re-handling buckets if the material is transferred mechanically. The Contractor will be required to use spill containment measures if the material is transferred hydraulically into the CDF.

For verification purposes, the Contractor will be required to sample the sediments beneath the existing transfer station before transferring occurs to establish baseline sediment quality. A sampling and analysis plan will be submitted by the Contractor before offloading occurs. The plan shall present the number of samples and locations. Samples will be submitted to the laboratory for analysis of contaminant of potential concern (COPC) analytes appropriate for the material being offloaded to establish baseline conditions. At the completion of the sediment transfer process, sampling will be completed to compare to baseline conditions. If

there is a significant difference between the pre- and post-offloading samples, their appropriate remedial measures, including dredging, enhanced natural recovery (i.e., thin-layer capping), or natural recovery, will be discussed with USEPA and implemented to clean the area beneath the offloading site.

4.5.3.5 Achieve Specified Placement Elevations

For QA purposes, the Contractor will be required to employ an EPS for accurately locating and tracking the material placed within the CDF. Appropriate placement of material will be determined on a site-specific basis as required by the sediment acceptance criteria and approval process described in the CDF Sediment Management Plan (Appendix J to the DAR). Wherever the placed material is out of tolerance, the Contractor will be required to correct the situation by moving the material to the correct location.

For verification purposes, the Contractor will be required to complete a bathymetric survey of the filling area every 10 days of active filling to monitor material elevations. The Contractor will be required to create an as-built survey of the top elevation of each different layer, or the top elevation of each material from a unique source, whichever is more frequent. Additionally, the CQAO will work closely with the Contractor's CQC Manager and hydrographic survey crew to independently verify the material's horizontal position and elevation. This may be done by either evaluation of the Contractor's positioning data, conducting independent surveys, or a combination of both methods.

4.5.3.6 Achieve Proper CDF Consolidation

As a QA measure to be implemented during the filling of the CDF to achieve proper consolidation, the Contractor will install settlement monitoring equipment to monitor settlement during filling. In addition, The Contractor will install settlement plates within the cover material to monitor settlement of the dredged fill as a result of cover placement. The results from this monitoring will enable determination of how much consolidation has occurred within and below the CDF, how much remains to occur, and how long total settlement will take.

4.5.3.7 Minimize Short-term Water Quality Impacts

Details of the water quality monitoring that will be completed, water quality criteria, and contingency actions that may be implemented if criteria are not met during CDF filling activities (i.e., transport of material to the CDF for mechanical dredging) are provided in the WQMP (Appendix E to the DAR).

4.6 Confined Disposal Facility Covering

4.6.1 Task Description

After contaminated sediment placement in the CDF is completed to its capacity, imported fill will be placed to raise the site to grade. This fill will consist of two layers. The lower layer will be imported fill material. The upper surface layer will be structural fill designed to support surface loading conditions.

4.6.2 Performance Objectives and Criteria

Performance objectives and criteria associated with covering of the CDF include the following:

- **Verify Quality of Import Material.** Import material must meet specified physical and chemical properties, as detailed in the Construction Specifications (Appendix C to the DAR).
- **Achieve Specified Cover, Thickness, and Extent.** The cover materials must be placed to meet the specified limits and thickness.

4.6.2.1 Verify Quality of Import Material

For QA of import material, all material placed within the CDF will conform with specified physical and chemical properties, as detailed in the Construction Specifications (Appendix C to the DAR). The CQAO will independently confirm the source of all materials placed within the CDF. Any materials determined to not be approved for placement within the CDF will not be placed within the CDF.

The Contractor will submit a Borrow Source Characterization Report (geotechnical and chemical results) prior to construction for each import material type. Chemical and physical characteristics of imported materials must meet the requirements detailed in the Construction Specifications (Appendix C to the DAR). The Contractor will sample imported material for physical analysis throughout the project (one sample per 20 percent of import volume will be analyzed) for confirmation to specifications. The Contractor will obtain the certified tickets from the borrow source for each load of material delivered. Additionally, inspectors will visually inspect representative barge and/or truck loads of import materials delivered to the CDF construction area. Inspectors will observe unsuitable coatings or materials (i.e., debris, organics, etc.), as well as general conformity with the specified gradation. If necessary, the inspectors may obtain representative samples for physical testing to confirm compliance with the gradation.

If import materials do not meet chemical criteria or physical requirements, material will be rejected and the Contractor will have to obtain a different material.

4.6.2.2 Achieve Specified Cover, Thickness, and Extent

As a QA measure for achieving specified cover, thickness, and extent during placement of CDF cover material, the Contractor will present a work plan before construction that will describe the proposed methods for placing the CDF cover layers and controlling grades. The Contractor will also submit a Survey Control Plan prior to construction. The Contractor will be required to use EPS for locating and tracking their equipment. The CQAO will work closely with the Contractor's CQC Manager to independently verify the horizontal position of cover placement equipment. If the CQAO determines that the Contractor is not placing cover materials in the correct location, the Contractor will be immediately contacted to correct the situation.

Bathymetric/topographic surveys will be completed on 25-foot spacings to confirm specified thicknesses and/or elevations (the same survey controls as described for dredging).

Wherever the cover thickness is less than the specified amount, the Contractor will be required to add a sufficient amount of additional material to achieve the specified thickness.

5 DOCUMENTATION AND REPORTING

Documentation and reporting for construction QA activities will include pre-construction documentation, construction documentation, and post-construction documentation as detailed below. The Contractor and the CQAO will work closely on a daily basis during the CDF construction to complete the project as specified in the final design, and to collect the required documentation as described in the following sections. Table 2 summarizes the list of submittals that are required of the Contractor in the Construction Specifications (Appendix C to the DAR).

5.1 Pre-Construction Documentation

The Contractor will be required to submit a Removal Action Work Plan (RAWP) for approval by the Port and USEPA. The RAWP will contain the following elements:

- Project Work Plan
- CQC Plan
- HASP
- Construction EPP
- Project Construction Schedule
- SMP
- Survey Control Plan
- Procedures for processing design changes and securing USEPA review and approval of such changes to ensure that changes are consistent with the RAOs
- Procedures for coordinating with USEPA regarding compliance with USEPA's Off-Site Rule, as applicable

USEPA's approval authority for these plans is defined in the Consent Decree and SOW (Appendix A to the AOC, USEPA 2003) for the Removal Action. Construction quality assurance/quality control (QA/QC) procedures will be addressed in various elements of the RAWP. A brief description of the contents of each plan component of the RAWP is provided below.

5.1.1 Project Work Plan

The Project Work Plan will describe, in narrative form, the methods to be employed in the CDF construction including equipment types, modes of operation, schedules, sequence of activities, and other aspects necessary to describe how and when the specified work will be performed. The Work Plan will have specific sections detailing how the following elements will be completed:

- CDF berm
- Dredging and placement into the CDF
- Capping
- CDF filling
- CDF covering
- Construction of new structures

The Work Plan will describe how each of the QA measures and verification activities identified in Section 4 will be addressed in the field.

5.1.2 Construction Quality Control (CQC) Plan

The CQC Plan will present the system through which the Contractor ensures that construction activities are being implemented in compliance with the requirements of the contract. The CQC Plan will identify personnel, procedures, methods, instructions, inspections, records, and forms to be used in the CQC system. Specifically, the CQC Plan will include a description of procedures for maintaining and updating daily activity logs, procedures for reporting out-of-spec conditions, recordkeeping procedures for personnel, equipment maintenance and calibration, and daily and weekly reporting requirements.

5.1.3 Construction Health and Safety Plan (HASP)

The Contractor will submit its HASP presenting the minimum health and safety requirements for job site activities, and the measures and procedures to be employed for protection of on-site personnel. The Contractor will employ a Certified Industrial Hygienist (CIH), whose proof of certification and resume will be submitted along with the HASP, to

produce this plan. The plan will cover the controls, work practices, personal protective equipment (PPE), and other health and safety requirements that will be implemented by the Contractor in connection with the CDF construction activities.

5.1.4 Construction Environmental Protection Plan (EPP)

The Contractor will be required to submit an EPP describing the environmental protection measures and monitoring activities that will accompany all construction activities. The plan will cover potential environmental releases as a result of the Contractor operations, as well as monitoring and corrective actions necessary to control such releases. The EPP will contain separate sections addressing contamination prevention, containment and cleanup, erosion and turbidity control, sound level control, air pollution and dust control, and water quality monitoring as they pertain to the pertinent construction activities described in Section 4.

5.1.5 Project Construction Schedule

A detailed project schedule will be submitted by the Contractor for each construction element prior to construction. Periodic schedule updates will be submitted by the Contractor following progress meetings.

5.1.6 Settlement Monitoring Plan (SMP)

The Contractor will submit an SMP prior to construction that describes specific procedures, personnel, and recordkeeping methods for installing settlement monitoring equipment and for monitoring settlements (and lateral movements) on existing structures adjoining the dredging and capping areas. The intent of this monitoring is to ensure that adjacent structures do not undergo excessive movement or structural damage associated with earthwork activities. In the event that cumulative movements exceed 1 inch, the Contractor will temporarily cease activities in the area and contact the Project Engineer.

5.1.7 Survey Control Plan

The Contractor will submit a Survey Control Plan prior to construction. The plan will detail the specific procedures, equipment, and personnel to be used for all upland and in-water surveying work. The plan will also discuss the QA/QC measures to confirm surveying results.

5.2 Construction Documentation

During construction activities, the Contractor will be required to provide a variety of documentation to the CQAO, including testing results of materials received, weigh tickets for shipments of materials removed, survey results, and documentation of pay items completed. The Contractor will also maintain a daily log of activities, as described below. The CQAO will maintain a field report of daily activity and complete an internal weekly report. The contents of the reports are described below. Weekly progress reports will be submitted to USEPA. The records described in this section will be maintained in the project files. Monitoring data will be provided electronically to USEPA in the Removal Action Completion Report (RACR).

5.2.1 Contractor's Daily Quality Control Report

During construction activities, the Contractor shall prepare a Daily Quality Control Report and submit it to the CQAO. The Contractor's daily report will record the following, at a minimum:

- Identification of personnel on site
- Activities completed
- Any changes to BMPs or environmental controls
- Materials delivered or used
- Equipment used
- Materials dredged and placed in the CDF
- Debris and demolition material removed and disposed off site
- Surveys completed
- Results of any QC inspections, tests, or other monitoring activities

- Problems encountered and resolution of problems
- Any USEPA-authorized deviations from the final design

Daily QC Reports will be sent to USEPA on a weekly basis as part of the Weekly Summary Report, as discussed below.

5.2.2 CQAO's Daily Report

The CQAO will maintain a daily field log to record observations, measurements, inspections completed, data received, communications with other members of the project team or USEPA, any water quality exceedances, additional environmental controls that were implemented, problems encountered, and resolutions. The daily field log will be supported by submittals received from the Contractor, such as survey results and weigh tickets, chain-of-custody forms for water quality monitoring samples collected, laboratory data received, inspection reports, and written communication from members of the project team or USEPA. Water quality results will also be separately recorded and reported as defined in the WQMP (Appendix E to the DAR).

5.2.3 Weekly Summary Reports

The CQAO, in cooperation with the Contractor, will prepare weekly summaries of progress. These summaries will facilitate the preparation of the RACR. The weekly summary will identify progress organized by activity as follows:

- Demolition
  - Area worked
  - Weight/volume of material disposed
  - Weight/volume of material placed
  - Problems encountered
  - Corrective actions
- Berm Construction
  - Area worked (supported by Contractor's log)

  - Weight/volume of material placed
  - Problems encountered
  - Corrective actions

- Dredging and placement of material into the CDF
  - Area worked (supported by Contractor's log)
  - Volume of material removed (supported by Contractor's log)
  - Surveys completed (supported by Contractor's log)
  - Problems encountered
  - Corrective actions

- New Structure Construction
  - Area worked
  - Materials imported
  - Materials placed
  - Weight/volume of material placed
  - Problems encountered
  - Corrective actions

- Environmental Controls
  - Samples collected
  - Summary of analytical results
  - Problems encountered
  - Corrective actions

5.2.4 Weekly Construction Meetings

Weekly progress meetings will be coordinated with USEPA and its partner agencies including pre-notification of time and place of meetings. Conference call access will be provided as needed and requested by those agencies, and meeting minutes will be prepared and made available to attendees.

5.2.5 Import Material Characterization

Prior to any on-site placement of import materials, the Contractor shall submit a Borrow Site Characterization Report to the CQAO. The characterization report will include identification of the source (including a map documenting the origin of the material), site inspection, and material sample and characterization (physical and chemical testing, as specified) to ensure that the import material will uniformly meet the physical specifications of its intended use.

5.3 Post-Construction Documentation

As stated in the SOW, within 60 days after completion of the construction phase of the Removal Action, the Port will submit a RACR (Appendix A to the AOC, USEPA 2003). The RACR will contain the following information:

- Introduction
  - Site location
  - Environmental setting
  - Relevant operational history
  - Summary of previous investigations and actions
- Removal Action Background
  - Basis for the Removal Action (i.e., the AOC)
  - Context within Portland Harbor remedial program
  - RAOs
  - Summary of design basis
  - Summary of deviations from the design, if any
- Construction Activities
  - Description of dredging for the containment berm
  - Description of containment berm construction
  - Description of CDF filling
  - Description of CDF closure

  - Description of completion and demobilization

- Chronology of Events
  - Description of the timing of construction activities, identifying milestones with reference to a tabular summary of a more detailed construction timeline

- Performance Standards and Construction Quality Control
  - Description of performance objectives (as stated in Sections 4.1.2, 4.2.2, 4.3.2, 4.4.2, 4.5.2, and 4.6.2 of the CQAP) and verification activities performed to confirm the Removal Action was implemented in accordance with the Specifications and Drawings.
  - Description of actual construction performance relative to performance objectives, including a summary of the results of construction QA measurements and analyses
  - Description of contingency actions implemented, if any were necessary
  - Description of USEPA's oversight activities
  - (Note: QA for water quality monitoring analytical data will be included in the Final Water Quality Monitoring Report)

- Final Inspection and Certifications
  - Description of final inspections, including the scope of inspections and noting any deficiencies identified and corrective actions implemented
  - Summary of health and safety monitoring during the implementation of the Removal Action with notation of deviations or incidents, if applicable
  - Identification of any institutional or engineering controls that are implemented to maintain the integrity of the Removal Action, including identification of parties responsible for maintaining and enforcing controls

- Operation and Maintenance Activities
  - Description of post-construction monitoring and maintenance requirements
  - Description of contingency measures that would be implemented if post-construction monitoring indicates such measures are warranted

- Summary of Project Costs
  - Identification of the actual final costs incurred to comply with the provisions of the AOC
  - Identification of costs previously estimated for implementation of the Removal Action and an update of the cost estimate for post-construction monitoring and maintenance costs
- Observations and Lessons Learned
  - Identification of problems encountered, if any, in implementing the Removal Action and corrective actions implemented
  - Identification of successes in implementing the Removal Action
  - Analysis of lessons learned that may be applied to future activities
- Removal Action Contact Information
  - Identification of individuals (contact names, addresses, phone numbers) for design and remediation contractors, USEPA oversight contractors, and key personnel at the Port, USEPA, and other agencies

The RACR will also include copies of as-built drawings, summaries of waste disposal and analytical results, the Final Water Quality Monitoring Report, and the certification statement required by the AOC.

6 REFERENCES

USEPA. 2003. Administrative Order on Consent for Removal Action in the Matter of Portland Harbor Superfund Site, Terminal 4, Removal Action Area, Portland, Oregon.

TABLES

Table 1
Summary of Construction Monitoring and Testing Requirements

Construction Element*	Specification Section	Specification Reference	Monitoring, Testing, and Inspection Requirements	Monitoring Frequency
Safety and Health	011110	3.1	Inspect site to determine protection requirements	Before mobilization
		3.1	Monitoring work efforts for additional protection	After mobilization
		3.1	Assess integrity of all appropriate structures	Prior to work
		3.1	Site Safety Meetings	Weekly
Construction Progress Documentation	013200	3.4	Schedule monitoring	Continuously
Environmental Protection	015710	3.3.C	Inspection of equipment and materials for environmental protection	Every 2 weeks
Temporary Erosion, Sediment, and Pollution Control	015713	3.3.B	Inspect erosion control measures	Daily
		3.3.C	ESPC measures during inactive work	Once every 14 days when inactive and within 24 hours after a storm with 0.5-inches precipitation per 24-hour period
Site Clearing, Earthwork, and Shoreline Stabilization	312000	3.1	In-Place Moisture Density Testing	Each lift
		3.1, 3.7	Compaction testing	Each lift
Trees, Shrubs, and Ground Covers	329300	1.3.D	Inspect plants, etc. (Port)	Give 24 hours notice
Dredging, Transportation, and Disposal	352023	1.4	Post-dredge soundings (Port) – Berm key dredging completion	After completion of dredging activity
		1.4.J	Daily survey	Daily
		3.1.A	Monitor hull displacement of scows	During filling, transport, and offloading
		3.1.D	Monitor sediment offloading facility for spillage	During offloading
		3.2.E	Monitor dredge work for vertical and lateral tolerances	Throughout dredging
		3.6	Water quality and turbidity monitoring	Daily
Confined Disposal Facility (CDF) Construction	352027	1.6	Post fill soundings (Port) – Berm key filling, training dike construction, berm filling, and berm crest	Daily

Note:
* This table summarizes those Divisions of the Construction Specifications that are most relevant to the CQAP.

Table 2
Terminal 4 Confined Disposal Facility Contractor List of Submittals

Construction Element*	Specification Section	Specification Reference	Submittal	Due Date
Safety and Health	011110	1.2	Contractor Health and Safety Plan (CHASP)	Within 14 days of receiving the Notice to Proceed
		1.2	Amendment to CHASP	As appropriate
		3.2	Employee Training and Medical Certificates	Prior to work
Construction Progress Documentation	013200	1.2	Statement of Critical Path Method (CPM) capability	Within 10 days of contract
		1.2	Work Progress Schedule	One week after preconstruction meeting
		3.2	Monthly Update Report	Within 30 days after contract schedule acceptance
		3.2	Applications for Payment	
		3.3	Progress Meeting Schedules	24 hour advance
		3.5	Contract Schedule Revisions	
		3.7	As-Built Schedule and Documentation	Within 15 days of substantial completion
Submittal Procedures	013300	1.8	Interim Operation and Maintenance Manuals	45 days prior to anticipated date of beneficial use of system and maintenance instruction
		1.8	Final Operation and Maintenance Manuals	45 days prior to anticipated date of substantial completion
		1.9	As-Constructed Drawings	Upon completion of work
		1.10	Proof of registration with the Bureau of Labor and Industries Apprenticeship and Training Division as a training agent	Prior to work where apprentices will be employed
Marine Terminal Security, Safety, and Operating Regulations	013553	1.4	Contact information and vehicle information for all personnel that will enter Port facilities	Prior to work
		1.4	Documentation that personnel have received training from Port marine security department	Prior to work
Quality Control	014500	1.3	Contractor's Quality Control (CQC) Plan	14 days prior to beginning work
		1.3	Proposed Project Administrator's qualifications	
		1.3	Daily CQC Reports (includes Daily Inspection Reports and Daily Test Reports) submitted as part of the Contractor's Daily Construction Report	Daily
		1.3	Certified test reports	As required
Temporary Facilities and Controls	015000	1.5	Work Plan for any work that will generate dust (review dust control procedures with Port)	Prior to beginning work
		1.7	Solid Waste Management Documentation	Upon request
		1.16	Confined Space Entry Procedure	Upon request
Tree and Plant Protection	015639	3.1	Results of inspection with documentation of unusual conditions	Prior to beginning work
Environmental Protection	015710	1.3	Environmental Protection Plan (EPP)**	4 weeks prior to start of scheduled construction activities
		3.3.C	Written inspection report	Every 2 weeks
Temporary Erosion, Sediment, and Pollution Control	015713	1.6	Erosion, Sediment, and Pollutant Control (ESPC) Plan	Prior to beginning work
		1.6	Construction start and completion dates	Pre-construction meeting
		1.6	Dates when ESPC measures will be in place	Pre-construction meeting
		1.6	Projected date of removal of erosion control structures (after soil is stabilized by vegetation or pavement)	Pre-construction meeting
		1.6	Description of control procedures to prevent the discharge of all wash water from concrete trucks into the storm sewer system	Pre-construction meeting
		1.6	Description of procedures for prompt maintenance or repair of ESPC measures utilized on-site	Pre-construction meeting
		1.6	Description of clearing and grading practices, including a schedule of implementation, that will minimize the area of exposed soil throughout the duration of the project. (Whenever practicable, clearing and grading shall be phased to prevent exposed inactive areas from becoming a source of erosion.)	Pre-construction meeting
		1.6	Description of best management practices that will be used to prevent or minimize storm water from being exposed to pollutants from spills, cleaning and maintenance activities, and waste handling activities. These pollutants include fuel, hydraulic fluid, and other oils from vehicles and machinery as well as debris, leftover paints, solvents, and glues from construction operations	Pre-construction meeting
		1.6	Name, title, and telephone number of designated employee to perform the Contractor's inspection and monitoring of ESPC measures.	Pre-construction meeting
		1.6	Any requested changes or modifications to the ESPC measures shown on the drawings shall be submitted to the Port for approval prior to implementation	
		3.3	ESPC Inspection Reports	Completion of work

Table 2
Terminal 4 Confined Disposal Facility Contractor List of Submittals

Construction Element*	Specification Section	Specification Reference	Submittal	Due Date
Execution Requirements	017000	1.2.A	Notification of Intent to Commence Work	2 days prior to beginning work
		1.3.F	Field Notes	Upon request
		1.3.G	Sealed survey of replaced monuments and verification that survey was recorded in Multnomah County	Completion of work
Construction Waste Recycling	017419	1.4	Initial Pre-Construction Estimate (site waste recycling form)	Before site work begins
		1.4	Monthly Reports (updated site waste recycling forms)	Monthly
		1.4	Closeout Project Summary	Prior to contract closeout
Closeout Procedures	017700	1.1	Drawing set	Upon completion of work
		1.7	Certificates of approval	Prior to final payment
		1.8	Confined spaces informational submittal form	
Site Demolition and Debris Removal	024113	3.4	Names and locations of disposal facilities	Prior to beginning work
		3.4	EPP**	
Site Clearing, Earthwork, and Shoreline Stabilization	312000	2.2.A	Borrow Source Characterization Report	
		2.2.A	Borrow Material Test Results	2 weeks prior to delivery
		2.2.A	Certified Tickets from Borrow Source	After each load delivered
Soil Preparation	329113	1.3	Certification of qualities of topsoil and composted amendment	
		1.3	Sample of yard debris compost and topsoil	
		1.3	Notify Engineer of source of topsoil and composted amendment and provide sample	Before installation
Seeding	329219	1.3	Seed Certification	Prior to delivery
		3.6	Request for Inspection	5 working days before requested inspection date
Trees, Shrubs, and Ground Covers	329300	1.4	Certify confirmed orders for plants and provide quantity, location, telephone number, and address of growers; submit color and dated photograph of each species	Within 5 days of Notice to Proceed
		1.4	Material Samples (bark mulch)	10 days prior to delivery
		1.4	Fertilizer product information and material certification. Certificates required by law	10 days prior to delivery
		1.6.B	Notification of delivery schedule	24 hour advance
Dredging, Transportation, and Disposal	352023	1.3.H	CQC Plan	
		1.3.I	EPP**	
		1.3.J	HASP	
		1.4.F	Survey Control Plan	Before beginning work
		1.4.J	Sounding Cross Sections	Daily
		1.4.K	Survey Drawings	After each survey
		1.5.D	Validate receipt of Permits	Before commencement of work
		1.6.G	Dredging and Disposal Workplan (part of the Early Action Workplan)	Before dredging begins
		3.2.I	Dredge Work Complete Notification	
		3.4.A	Certification that Barges are Seaworthy and Sealed	Prior to construction
		3.4.B	Dredge Material Barge Information	
		3.5.B	Name and Location of Proposed Landfill	Prior to construction
		3.5.C	Disposal Verification	After each load
		3.5.D	Sampling and Analysis Plan (SAP)	
		3.5.E	EPP**	
		3.6.B	Fueling Plan (part of HASP)	
		3.7.C	Operations Log and Daily Progress Chart	Completion of work
		3.7.D	Water Quality Monitoring and Control Plan	7 days before mobilization
		3.7.E	Water Quality Monitoring and Control Contingency Plan	7 days before mobilization
Woody Debris Structures	353200	1.5.A	Source of habitat logs	Prior to transport to the site
		1.5.B	Anchor and chains product literature	
		3.3.B	Notification of Habitat Log Placement	48 hours notice

Notes:
* This table summarizes those Divisions of the Construction Specifications that are most relevant to the CQAP.
** These submittals constitute the Terminal 4 Confined Disposal Facility submittals required of the CM/GC, and will be approved by USEPA prior to the start of work.

FIGURES

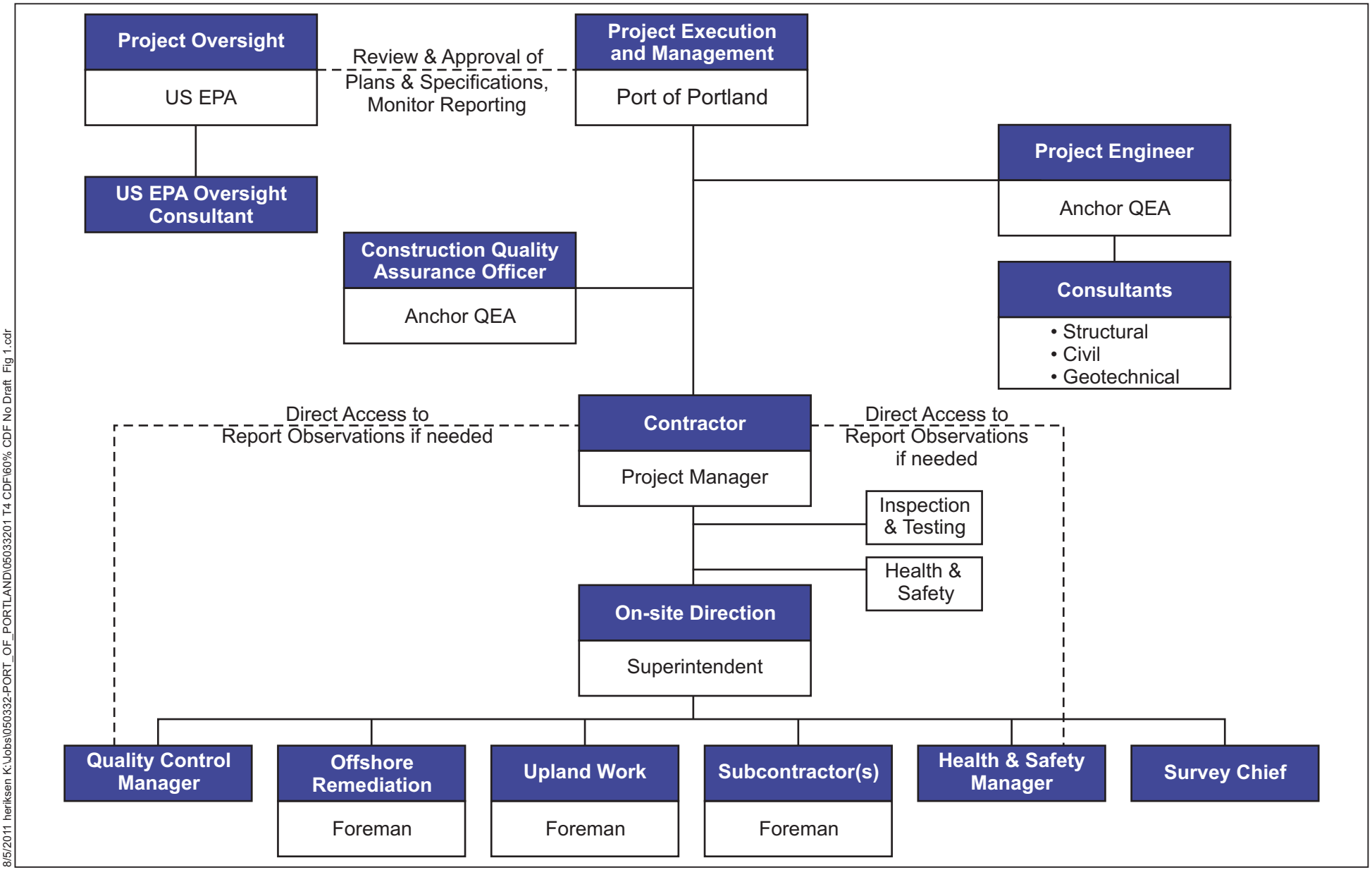

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Figure 1
Organization Chart
Terminal 4 Confined Disposal Facility Design
Portland, Oregon

ANCHOR QEA

ATTACHMENT 1
ARCHAEOLOGICAL MONITORING PROTOCOL

ARCHAEOLOGICAL PROTOCOL

TERMINAL 4
PORTLAND, OREGON

December 2006

Port of Portland
Portland, Oregon

BACKGROUND

The Port of Portland operates three marine terminals on the Willamette and Columbia rivers, one of which is Terminal 4 located on the east bank of the Willamette River at about River Mile 4.4-5.7. As a state port district and in connection with its investigation and cleanup of contamination, the Port has responsibilities under state law to properly manage the archaeological, historical, and other cultural resources that may be located at Terminal 4. The cultural resources survey of Terminal 4 (Ellis and O'Brien 2003) has identified locations within Terminal 4 that are considered to have a high potential for archaeological resources. In addition to its responsibilities under state law and several agreements with Oregon Department of Environmental Quality ("DEQ") under the Oregon Voluntary Cleanup Program, the Port has responsibilities under federal law arising out of the Port's Administrative Order on Consent for Removal Action at Terminal 4 with the United States Environmental Protection Agency ("USEPA") and the Port's Administrative Order on Consent for an RI/FS of the Portland Harbor, also with USEPA.

Six Tribal governments are also interested in the protection of cultural resources at Terminal 4:

- Confederated Tribes of the Grand Ronde Community of Oregon,
- Confederated Tribes of Siletz Indians of Oregon,
- Confederated Tribes of the Warm Springs Reservation of Oregon,
- Confederated Tribes of the Umatilla Indian Reservation,
- Confederated Tribes and Bands of the Yakama Indian Nation, and
- The Nez Perce Tribe.

Conducting archaeological surveys prior to any ground-disturbing activity associated with contamination investigation and cleanup projects is intended to determine if the proposed activity is likely to affect significant archaeological resources. There is, however, a possibility that archaeological resources may be encountered during project-related activity, even with a thorough and systematic survey, through inadvertent discovery. In addition, it is important that any "discovered" human remains, including the remains of Native Americans, and associated cultural materials and deposits be treated with care and respect and protected from further disturbance and exposure to weather, as outlined in these protocols. These clarify and establish mutually acceptable protocols to process inadvertent discoveries of possible historic properties, human remains, funerary objects, objects of cultural patrimony, and other cultural items during ground-disturbing activities undertaken at Terminal 4.

FORMALIZING PROTOCOLS

These protocols are modeled after the protocols developed for the cleanup of the McCormick and Baxter Superfund Site in the lower Willamette River. They have been developed with input from affected stakeholders. It is the intent of the Port to seek

letter acknowledgements from the stakeholder regulatory agencies and governments to assure that all agree to abide by these protocols for future ground-disturbing activity at Terminal 4.

ARCHAEOLOGICAL SENSITIVITY AREAS

The archaeological sensitivity areas at Terminal 4 are those defined in the 2003 archaeological survey report, subsequently refined with the results of additional research, and shown in Figure 1. The Port may retain the services of a professional archaeologist to periodically update the definition of the sensitivity areas as new information comes to light. Revisions of boundaries of these areas will be made by the Port in consultation with affected stakeholders.

ON-SITE PROCEDURES WITHIN TERMINAL 4 ARCHAEOLOGICAL SENSITIVITY AREAS

To assure compliance with the National Historic Preservation Act (16 USC 470) and applicable Oregon statutes (ORS 97.740 et seq., 358.905 et seq., and 390.235 et seq.), the following procedures have been developed to address potential discoveries, including inadvertent discoveries, of cultural materials and deposits (including sacred objects, funerary objects, and objects of cultural patrimony as defined in ORS 358.905) and Indian burials and human remains (as defined in ORS 358.905) during ground-disturbing contamination investigation and removal or remedial actions within the archaeological sensitivity areas at Terminal 4. These procedures also apply to ground-disturbing activities that are associated with or an outcome of removal or remedial actions (e.g., construction of new outfalls or removal of existing outfalls) for which the Port is responsible.

Ceremonies Prior to Ground-Disturbing Activity
Tribal governments may desire to perform ceremonies prior to ground-disturbing removal or remedial actions at Terminal 4. The Port will give two weeks notice, by e-mail or by letter, of planned ground-disturbing removal or remedial actions that are considered likely to encounter or extend into native soils or sediments. Tribes will coordinate with the Port so that scheduling and logistics of such ceremonies will not delay project schedules.

Notification of Ground-Disturbing Activity
The Port will notify the six interested Tribes by e-mail or by letter in advance of any planned ground-disturbing removal or remedial actions that are expected to encounter or extend into native soils or sediments within the archaeological sensitivity areas at Terminal 4.

The notice will be given in as much advance of the activity as is possible. Attachment A provides the list of Tribal members and who will be notified by the Port and their contact information. Changes to this list will be made if requested by the respective Tribes.

Professional Archaeologist On-Site
The Port will retain the services of a professional archaeologist as defined in ORS 97.740 and ORS 390.235(6) (b) to provide on-site monitoring when ground-disturbing activity is conducted within the boundaries of the archaeological sensitivity areas at Terminal 4 (Figure 1) and is expected to encounter or extend into native soils or sediments.

Tribal Representatives On-Site
Interested Tribes are welcome to provide Tribal monitors during on-site activity within the archaeological sensitivity areas on Figure 1. Since the planned activity will likely occur at locations that are known or considered likely to be contaminated with hazardous substances, Tribal representatives will be required to comply with OSHA requirements provided in 29 CFR 1910.120 (aka, HAZWOPER). The application of these requirements will vary, depending on the type of activity at the site, and the proximity of the monitors to the activity. The requirements may include:

- Supervision by someone who is appropriately trained for hazardous substance sites, a briefing on Health and Safety issues, and sign–in;
- Restriction from the immediate area of the work;
- Prohibition of handling contaminated material;
- Use of personal protective equipment (PPE) such as rubber booties, that will be provided at the site; and
- 24- or 40-hour Hazardous Waste Operations (HAZWOPER) health and safety training.

Additionally, all on-site personnel, including Tribal monitors, are subject to the directions of the on-site Health and Safety Officer at all times.

Discovery
At the discretion of the on-site monitoring archaeologist, excavation or other ground-disturbing activities may be slowed or halted at any time a suspected archaeological object or archaeological site (as defined in ORS 358.905) is encountered. The objective of this slowing or halting of ground-disturbing cleanup activity is to allow the archaeologist to confirm and/or make a preliminary assessment of the discovery. All requests for such slowing or halting of construction activity must be communicated to the contractor's personnel through the Port's on-site personnel and must be cleared with the Port's project manager.

Figure 2 identifies the steps to be taken in the event of a potential discovery. Should the on-site monitoring archaeologist determine that a possible significant cultural resource has been encountered, he or she may direct the immediate cessation of all ground-disturbing activity in the vicinity of the discovery. The monitoring archaeologist will work with Port's contractor and Port personnel to determine when and where work may continue.

For discovery situations in which CERCLA does not provide the chief legal framework, the monitoring archaeologist will promptly apply for a State of Oregon Archaeological Permit on behalf of the Port requesting an expedited review process and permit per

OAR 736-51-080(9). Further excavation and/or recovery of artifacts or other archaeological deposits will not proceed until the permit has been issued.

At the request of the monitoring archaeologist, the Port's contractor and Port personnel will either:

- assist in securing access to the location of the discovery and take appropriate measures to protect the location of the discovery from rain, stormwater, and other possible disturbances, or
- assist the archaeologist in moving the artifacts to a protected and secure area of the site away from the immediate construction area.

The monitoring archaeologist will immediately notify the Port's project manager of the discovery. The Port will also promptly notify the Oregon State Historic Preservation Office, and representatives of the six Tribes – through the contacts listed below – of any discovery of likely or demonstrated cultural materials or deposits.

It has been suggested that there may be Native American remains in the Terminal 4 area. In the event that likely or confirmed human remains are encountered, the monitoring archaeologist will be responsible for immediately notifying the Port project manager. The Port will then notify the Oregon State Police, the Oregon State Historic Preservation Office (SHPO), the six Tribes referenced above, and the Commission on Indian Services (pursuant to ORS 97.745(4)).

The Port will also promptly notify the Multnomah County Medical Examiner if it cannot be clearly determined that the remains are those of a prehistoric individual. Human remains and associated funerary objects shall remain in place, with minimal disturbance by the county medical examiner in completing his or her work.

If the site is determined not to be a crime scene, and the human remains are identified as Native American, the Port shall continue to secure the remains and any associated funerary objects in place, until a decision is made regarding the appropriate course of action to address the discovery. The Port shall give due consideration to and honor, to the extent practicable, any request by the Tribe to leave the remains and/or other cultural items in place.

ON-SITE PROCEDURES FOR CERCLA-RELATED GROUND-DISTURBING ACTIVITY WITHIN TERMINAL 4 ARCHAEOLOGICAL SENSITIVITY AREAS

To assure compliance with the National Historic Preservation Act (16 USC 470) and applicable Oregon statutes (ORS 97.740 et seq., 358.905 et seq., and 390.235 et seq.), the following procedures have been developed to address potential discoveries, including inadvertent discoveries, of cultural materials and deposits (including sacred objects, funerary objects, and objects of cultural patrimony as defined in ORS 358.905) and Indian burials and human remains (as defined in ORS 358.905) during

remedial investigations and removal and remedial actions at Terminal 4. These procedures will also apply to CERCLA-related field sampling activities.

Media Samples

A professional archaeologist will examine core samples collected as part of removal or remedial actions from within the archaeological high-probability areas (Figure 1) at Terminal 4. This examination will consist of inspecting the samples as they are opened as described in the appropriate Field Sampling Plan (FSP). The archaeologist will determine if evident or likely artifacts are present or if other deposits are present that are likely to be cultural in origin. If artifacts or likely archaeological deposits are present, the archaeologist will record the location of the materials within the sample and photograph and sketch the materials in place in such a manner to provide information on provenience within the sample.

The evident or suspected artifact(s) or archaeological deposits and surrounding matrix totaling 1 liter in volume will be removed and screened through a set of nested sieves (12.7-, 6.3-, and 3.3-mm mesh) to recover any artifacts or archaeological materials that may be present. All recovered artifacts and other archaeological materials will be placed in an appropriate container or containers, labeled with all pertinent provenience information, and sealed. The recovered materials will be stored in a secure location pending disposition. The inspection, documentation, and removal of any archaeological materials present will be completed prior to the subsampling procedure outlined in the appropriate FSP. If artifacts or archaeological deposits are clearly associated with modern activity or with activities associated with use of Terminal 4, the archaeologist will document the materials but no collection will occur.

Should archaeological deposits be encountered that appear to total more than 1 liter in volume, a 1-liter sample will be extracted for screening and the remaining deposit will be removed in a manner that does not compromise the remedial investigations subsampling and placed in an appropriate container or containers, labeled with all pertinent provenience information, and sealed. The recovered materials will be stored in a secure location pending disposition.

Geotechnical Samples and Monitoring Wells

A professional archaeologist will monitor the geotechnical borings and monitoring wells excavated as part of cleanup activities within the archaeological high-probability areas on Figure 1. The monitoring will consist of on-site inspection of the excavations as they occur to determine if evident or likely artifacts are present or if other deposits are present that likely to be cultural in origin. If artifacts or likely archaeological deposits are present, the archaeologist will record the depth and—if appropriate—the thickness of any artifacts or archaeological deposits encountered in the excavations. The archaeologist will also photograph any materials as they are discovered and provide a written description. Artifacts and a sample of any archaeological deposits exposed in the excavations will be collected and placed in an appropriate container or containers, labeled with all pertinent provenience information, and sealed. The recovered materials will be stored in a secure location pending disposition.

At the discretion of the monitoring archaeologist and based on his or her professional judgment, excavations for a geotechnical boring or monitoring well may be slowed to

allow a more thorough examination of possible archaeological materials or may be halted if it is clear that the excavations are encountering archaeological materials or deposits that are clearly significant.

On-Site Staging and Coordination
An area of Terminal 4 will be designated as a staging area for the archaeologist and Tribal representatives to more closely examine artifacts. If artifacts are associated with contaminated deposits, the Port and the archaeologist will consult with the Tribes regarding whether artifacts are to be decontaminated and what decontamination options are available. Also, a location will be identified in consultation with the Tribes for reburial of discovered artifacts that are contaminated and unlikely to successfully undergo decontamination procedures, such as textiles and basketry. The location of this area would be known only to the Tribes, the Port, the SHPO, and the USEPA and/or DEQ, depending on which agency has jurisdiction over the investigation and cleanup.

Removal and Remedial Actions
When planned removal or remedial actions have been determined or are considered likely to affect archaeological resources, the Port will consult with the Tribes and the SHPO to define an appropriate course (or courses) of action to avoid or mitigate for adverse project effects. Courses of action may include archaeological monitoring that is implemented within the framework of this protocol or may require a protocol that is specific to the proposed remedial action and the archaeological resources known or considered likely to be present. Use of the present protocol or a project-specific protocol should be implemented within the framework of a Memorandum of Understanding (MOU) with Tribes, the SHPO, and other appropriate agencies or of a Memorandum of Agreement (MOA) if significant resources will be adversely affected by the planned actions.

If planned removal or remedial actions at Slip 1 would require removal of piers or pilings, the Port will have any of these structures that are known or likely to be 50 years or older in age recorded as historical or archaeological resources and evaluated to determine if any are eligible for listing in the National Register of Historic Places (unless they have been previously recorded and evaluated). If any piers or pilings are considered eligible, appropriate mitigation measures will be developed in consultation with the appropriate Tribes, the SHPO, and appropriate agencies.

If planned removal or remedial actions would affect any buildings or structures at Terminal 4 that have been recommended as eligible for listing in the National Register of Historic Places, the Port will have Section 106 Documentation Forms prepared for the affected building(s) or structure(s) and will submit these forms to the SHPO for review. The Port will coordinate and consult with the appropriate Tribes, the SHPO, and appropriate agencies to define appropriate measures as needed to address effects to the eligible buildings and structures.

Human Remains
If evidence of human remains is observed in any of the samples, no further processing will occur with the specific sample. After documentation of the find, the sample will be closed, sealed, and stored at a secure location. If evidence of human remains is

encountered in the geotechnical boring or monitoring well excavations, the monitoring archaeologist will immediately halt the excavations and no further excavation will occur at that location. Provenience data on the evidence of human remains will be recorded and then the remains and any associated funerary objects and soil matrix placed in an appropriate container, labeled, sealed, and placed in a secure location.

If evidence of human remains is encountered in any of the samples or excavations, the monitoring archaeologist will immediately notify representatives of the contractor directing the excavations and the Port's project manager. A representative of the Port will then promptly notify the Oregon State Police, the appropriate Tribes, the Legislative Commission on Indian Services, and the Oregon State Historic Preservation Office to comply with ORS 97.745(4), through the contacts below. The Port will then coordinate with these agencies and the appropriate Tribes to define a response to the discovery.

Other Issues

When the presence of artifacts or other archaeological deposits is confirmed, the appropriate Tribes and the SHPO will be notified and an appropriate response to the discovery defined by the Port in consultation with the appropriate Tribes and the SHPO. The materials observed will be documented as archaeological isolates or sites on the appropriate SHPO forms. The Oregon Department of State Lands (DSL) will be notified of any archaeological resources encountered on lands administered by DSL.

Artifacts and other archaeological deposits recovered during investigation and removal or remedial actions will be stored in a secure location as noted above. Those materials that can be successfully decontaminated (if necessary) will be curated at the Oregon Museum of Anthropology in accordance with ORS 358.920 and 390.235, with the exception of human remains, funerary objects, sacred objects, and objects of cultural patrimony. Alternative curation arrangements may be made by the Port in consultation with the Oregon State Museum of Anthropology, the appropriate Tribes, and the SHPO in accordance with ORS 390.235-390.240. Disposition of human remains, funerary objects, sacred objects, and objects of cultural patrimony will be determined in accordance with ORS 390.235-390.240. Alternative procedures for the disposition of contaminated human remains, funerary objects, sacred objects, objects of cultural patrimony, and other artifacts, including on-site reburial, will be developed by the Port in consultation with the appropriate Tribes, the Oregon State Museum of Anthropology, and the SHPO.

PROCEDURES FOR INADVERTENT ARCHAEOLOGICAL DISCOVERIES AT TERMINAL 4 OUTSIDE ARCHAEOLOGICAL SENSITIVITY AREAS

The Port recognizes that while the previous archaeological research has identified areas within Terminal 4 considered to have a moderate to high potential for archaeological resources, artifacts and other archaeological deposits may be encountered during ground-disturbing investigation and removal or remedial actions elsewhere at Terminal 4. This section of the protocol addresses procedures to be

followed for inadvertent discoveries outside of the archaeological sensitivity areas on Figure 1.

Should suspected or evident artifacts or other archaeological deposits be encountered during ground-disturbing investigation and removal or remedial actions at Terminal 4 that are not being monitored by a professional archaeologist, further ground-disturbing activity will be halted in the immediate vicinity of the discovery and the location secured from further disturbance. The Port will arrange for the location of the discovery to be examined by a professional archaeologist in a timely manner. If the archaeologist confirms the presence of artifacts or other archaeological deposits, the procedures defined above for discoveries made during ground-disturbing activity monitored by an archaeologist will be implemented.

The procedures defined for responding to inadvertent discoveries of human remains or suspected Indian burials will be implemented for similar discoveries that may occur outside of the designated archaeological sensitivity areas.

CONFIDENTIALITY

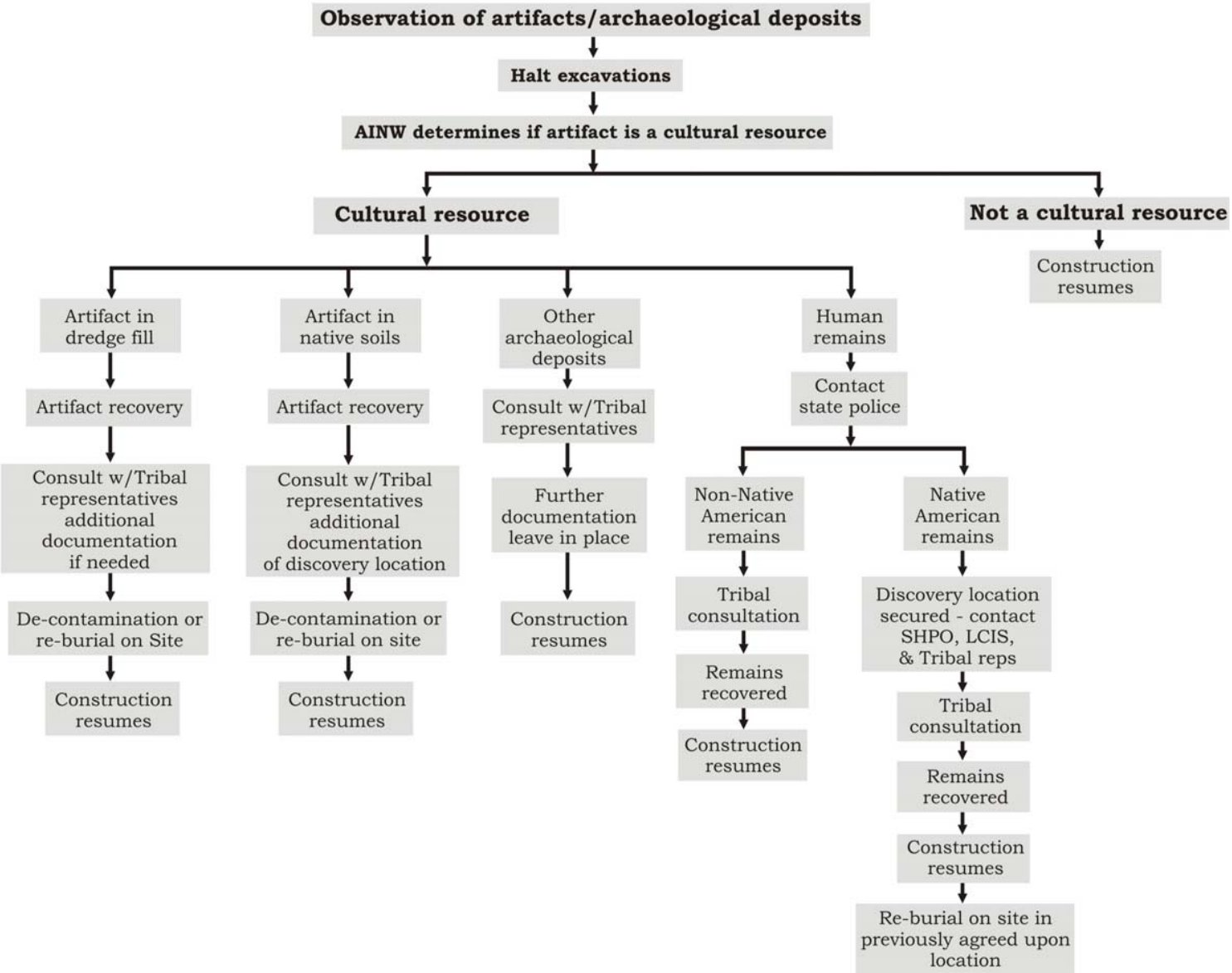
The Port shall make its best efforts, in accordance with state and federal law, to ensure that its employees and investigation and cleanup contractors keep the discovery of any found or suspected human remains, other cultural items, and potential historic properties confidential. Pertinent Port employees and contractors will be instructed that they are prohibited from contacting the media or any third party or otherwise sharing information regarding the discovery with any member of the public, and that they should immediately notify the Port of any inquiry from the media or public. To the extent permitted by law, prior to any release of information, the Port, the SHPO, and the Tribes shall concur on the amount of information, if any, to be released to the public, any third party, and the media and the procedures for such a release.

DISPUTE RESOLUTION

All Parties will strive to address and resolve disagreements informally and with the Port project manager. In the event agreement is not reached to the satisfaction of the regulatory agency and Tribal representative(s), the matter will be raised to the level of the Port's Marine Director and equivalent regulatory agency and Tribal management. Should the matter remain unresolved, the matter will be raised to the Port's Executive Director, the heads of the regulatory agencies, and the Chair of the Tribe(s). Each Party reserves any and all rights it may otherwise have to enforce its rights or seek resolution of the dispute under applicable law.

Figure 2

Archaeological Protocol Flow Chart
Terminal 4, Portland, Oregon



Attachment A
Contact Information for Archaeological Protocol
Terminal 4, Portland, Oregon

Tribe/Agency	Contact Name	Email Address	Phone Number
AINW	David Ellis	dellis@ainw.com	503-761-6605
SHPO	Dennis Griffin	dennis.griffin@state.or.us	503-978-0674
Oregon State Police	Steve Lane (NWR Office in Woodburn)	Not applicable	503-682-0208 x 228 (phone) 503-370-1114 (pager) 503-931-7273 (cell)
EPA	Chip Humphrey	humphrey.chip@epa.gov	503 326-2678
	Eric Blischke	blischke.eric@epa.gov	503 326-3250
DEQ	Thomas E. Roick	roick.tom@deq.state.or.us	503 229-5502
	Jim Anderson	anderson.jim@deq.state.or.us	503 229-6825
Commission on Indian Services	Karen Quigley	Karen.m.quigley@state.or.us	503-986-1068
Grand Ronde	Steve Kelly	stephen.kelly@grandronde.org	503-879-2339
	Khani Schultz	khani.schultz@grandronde.org	503 879-2185
Siletz	Tom Downey	tomd@ctsi.nsn.us	
	Robert Kentta	rkentta@ctsi.nsn.us	541-444-8244
	Billy Barquin	wbarquin@lwilder.com	503-242-0705
Warm Springs	Sally Bird	sbird@wstribes.org	541-553-2006
	Brian Cunninghame	cunninghame@gorge.net	541-490-2009
Umatilla	Audie Huber	audiehuber@ctuir.com	541-966-2334
	Catherine Dickson	CatherineDickson@CTUIR.com	541-276-3629
Yakama	Johnson Meninick	johnson@yakama.com	509-865-5121
	Paul Ward	ward@yakama.com	509-865-5121
Nez Perce			
	Kevin Cannell	kevinc@nezperce.org	208-843-7400

APPENDIX E
WATER QUALITY MONITORING PLAN

APPENDIX E
WATER QUALITY MONITORING PLAN
(PREFINAL 60 PERCENT TERMINAL 4 CDF DESIGN SUBMITTAL)
PORT OF PORTLAND, PORTLAND, OREGON

Prepared for

Port of Portland

Portland, Oregon

Prepared by

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LIST OF ACRONYMS AND ABBREVIATIONS

°C	degrees Celsius
µg/L	micrograms per liter
AOC	Administrative Order on Consent
AOPCs	Areas of Potential Concern
BMPs	best management practices
CCR	Construction Completion Report
CDF	Confined Disposal Facility
COCs	chemicals of concern
CQAO	Construction Quality Assurance Officer
CQAP	Construction Quality Assurance Plan
cy	cubic yards
DAR	Design Analysis Report
DGPS	differential global positioning system
DO	dissolved oxygen
FS	Feasibility Study
GPS	global positioning system
mg/L	milligrams per liter
MNR	monitored natural recovery
NGVD	National Geodetic Vertical Datum
NTCRA	Non-time-Critical Removal Action
NTU	Nephelometric Turbidity Units
ODEQ	Oregon Department of Environmental Quality
PAHs	polycyclic aromatic hydrocarbons
Port	Port of Portland
QA/QC	quality assurance/quality control
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
T4	Terminal 4

TSS	Total Suspended Solids
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
WQMCCP	Water Quality Monitoring and Compliance Conditions Plan
WQMP	Water Quality Monitoring Plan

1 INTRODUCTION

This document presents a Draft Water Quality Monitoring Plan (WQMP) to address substantive requirements of a Clean Water Act Section 401 water quality certification that may arise because of activities associated with construction of a Confined Disposal Facility (CDF) in Slip 1 at the Port of Portland's (Port) Terminal 4 (T4) facility in Portland, Oregon.

The Port entered into an Administrative Order on Consent (AOC) with the U.S. Environmental Protection Agency (USEPA) in October 2003 to perform a Non-Time-Critical Removal Action (NTCRA) at the T4 site on the Willamette River in Portland, Oregon (Figure 1) (USEPA 2003a). The AOC requires the Port to perform an Early Action to address known contamination found in T4 sediment samples during a Remedial Investigation (RI) directed by the Oregon Department of Environmental Quality (ODEQ). USEPA, in consultation with its federal, state, and tribal partners, evaluated and selected a Removal Action for T4 that included a combination of monitored natural recovery (MNR), capping, and dredging, with placement of contaminated sediment in a CDF to be built on site. The USEPA-selected Removal Action was detailed in an Action Memorandum prepared by USEPA in 2006 (Action Memo; USEPA 2006).

As described in Section 1.1 of the Design Analysis Report (DAR), implementation of the Action Memo is occurring in phases because many of the design issues required for full implementation are linked to the overall Portland Harbor Remedial Investigation/Feasibility Study (RI/FS) process, which is taking more time than what was anticipated when the Action Memo was issued. The Port is now submitting the 60 Percent Design for the T4 CDF using performance criteria provided by USEPA so that this information can be included as a sediment disposal option in the development of the Harbor-wide FS.

Construction of the CDF will require discharge of fill materials into Slip 1 to construct a containment berm, placement of contaminated dredged sediments into the CDF for final isolation, demolition of pier structures in the slip to allow unobstructed sediment placement, and construction of a new berth along the outer margin of the containment berm. This

document details the water quality monitoring activities and protections that will be implemented to minimize adverse impacts to water quality from the construction of the CDF.

The remainder of this document provides the following information related to water quality monitoring during construction:

- **Section 2—Water Quality Monitoring Program** describes the monitoring objectives, monitoring approach, compliance boundaries, station locations and depths, and applicable water quality criteria.
- **Section 3—Activity-Specific Monitoring Requirements** presents specific monitoring activities and schedules for each construction activity.
- **Section 4—Sampling and Analysis Methods** describes the details of sampling and analysis including station identification, sample location and depth control, monitoring and sampling methods and equipment, decontamination procedures, monitoring equipment calibration and maintenance, measurement documentation, sample handling and custody, and contingent laboratory analytical parameters and methods.
- **Section 5—Reporting Requirements** describes the requirements for water quality data submittals and documentation required for the Construction Completion Report (CCR).
- **Section 6—Contingency Plan** describes exceedance notification requirements, contingency response actions, and best management practices (BMPs) to be implemented to minimize adverse water quality effects from construction activities.
- **Section 7—Monitoring Personnel and Key Contacts** details the responsibilities of key monitoring personnel.

2 WATER QUALITY MONITORING PROGRAM

The objective of the water quality monitoring program is to confirm that water quality standards and criteria are met at the boundary of the compliance zone during CDF construction, and if an exceedance of any standard or criterion is observed, the source of the exceedance will be identified and appropriate contingency actions, including additional BMPs or engineering controls, will be implemented in a timely manner to mitigate the adverse conditions. To meet this objective, water quality monitoring will occur during the following in-water construction activities:

- Structure and pile demolition in Slip 1
- Berm key dredging at the mouth of Slip 1
- Berm construction at the mouth of Slip 1
- Replacement berth construction at the mouth of Slip 1
- Offloading of Portland Harbor sediment at the new replacement berth

The details of the water quality monitoring program, including monitoring parameters, compliance boundary locations, monitoring station locations and depths, monitoring schedules, and applicable water quality criteria are described below. The rationale supporting the design of the water quality monitoring program is presented in Section 6.3 of the DAR, and is based on an evaluation of Slip 1 contaminants, elutriate test results, and monitoring results during the Phase I Removal Action. However, it should be noted that final water quality monitoring methods, parameters, standards, locations, and other relevant requirements will be specified in the Water Quality Monitoring and Compliance Conditions Plan (WQMCCP) to be issued by USEPA during final design, and may differ from the draft monitoring elements presented herein.

2.1 Monitoring Parameters

The following parameters will be monitored during CDF construction activities (see Table 1):

- Visual Parameters
  - Visual observation for turbidity plumes

- Field Parameters
  - Turbidity (in Nephelometric Turbidity Units [NTU])
  - Dissolved oxygen (DO; in milligrams per liter [mg/L])
  - pH (pH units)
  - Temperature (degrees Celsius [°C])
- Contingent Laboratory Parameters
  - Total Suspended Solids (TSS; in mg/L)
  - Target Metals (i.e., cadmium, lead, and zinc; in micrograms per liter [µg/L])
  - Polycyclic aromatic hydrocarbons (PAHs; in µg/L)

Monitoring of visual observations and field parameters will be conducted for all construction activities, as summarized in Table 1. If an exceedance of a visual or field parameter criterion is measured and confirmed to be associated with construction activities, water column samples will be collected and analyzed for target chemical parameters. Target chemical parameters are established for specific areas and activities within Slip 1 based on a review of existing sediment quality data and knowledge of historical operations.

In response to an exceedance of a visual or field parameter criterion, contingent TSS analysis will be performed for all construction activities with the potential to cause a release of suspended sediments during filling, dredging, or other sediment disturbing activities. Contingent PAH analysis will be performed during dredging of the berm key because of locally elevated PAH concentrations in sediments from this area. Contingent metals analysis will be performed during demolition of the Slip 1 piers because of potential residuals from historical ore handling operations (Table 1).

2.2 Ambient Background Conditions

Ambient background values in the Willamette River for both conventional and chemical parameters will be considered in the evaluation of construction monitoring data. No construction-related impacts are indicated when conventional measurements or analytical

results are at or below background levels, even if these levels exceed water quality criteria (i.e., if background conditions exceed water quality criteria).

Background conditions in the Willamette River are determined using: 1) the U.S. Geological Survey (USGS) monitoring record at the Willamette River at Portland (Station #14211720); and 2) field measurements and laboratory analytical results for background monitoring stations during the T4 Phase I Removal Action, conducted in August through October 2008 (Anchor QEA 2009). The background values listed in Table 2 for conventional and chemical parameters are based on the 90th percentile values of the background dataset (except DO, which is based on the 10th percentile value).

In addition, a background reference station will be established upstream of T4, and this station will be monitored concurrent with the monitoring of CDF construction activities (Figure 2). The background monitoring station should be placed a minimum distance of 150 meters upstream from the T4 Removal Action area, and to the extent possible, in an area representative of the compliance locations (e.g., at similar water depths and distances from the shoreline). Ongoing monitoring of this background station will be performed to detect any excursions of ambient river conditions (e.g., excessive turbidity caused by high flow events, etc.) that are not caused by the construction of the CDF, but which may, nevertheless, affect water quality in the vicinity of the construction site. Ambient background statistics will be regularly updated with the background monitoring data collected during CDF construction.

2.3 Compliance Boundaries

The proposed compliance boundaries for the Slip 1 CDF construction are:

- Pier Demolition. 100 meters radially from the pier structures in Slip 1 during demolition activities.
- Berm Key Excavation, Berm Construction. 100 meters radially from the berm key.
- Replacement Berth 405 Construction. 100 meters radially from the edge of the replacement berth.

- Sediment Offloading. 100 meters radially from the edge of the replacement berth, which will be used to offload barges carrying dredged sediment from other sites in Portland Harbor.
- Effluent from the CDF Pond. The CDF pond will be managed such that there will be no direct discharge of effluent into the river; as a result, no compliance boundary is needed.

The configurations of the compliance boundaries are shown on Figure 2.

The boundaries proposed for this project are consistent with those recently applied in other sediment remedial actions in Portland Harbor and in USEPA Region 10, including Phase I of the Removal Action at T4. The boundaries are consistent with state regulations, which allow for limited turbidity exceedances for "dredging, construction, or other legitimate activities" [OAR 340-041-0036(b)].

Dredging elutriate tests, which are used to evaluate the potential for contaminant releases during dredging, show that dissolved chemical concentrations in the vicinity of the dredge are expected to be undetected, below water quality criteria, or comparable to ambient background levels (see Section 6.2.1 and Table 6-2 of the DAR). Water quality modeling of the berm key dredging area indicates that elevated suspended sediment concentrations will be well controlled, remaining close to the dredge and within the compliance boundaries, and diminishing rapidly with distance from the dredge (see Section 6.3.1 and Figure 6-1 of the DAR).

2.4 Monitoring Station Locations and Depths

Three monitoring stations will be symmetrically placed around the compliance boundary, 100 meters from the construction activity, as shown on Figure 2. In addition, an "early warning" station will be placed at the midpoint of the compliance zone, 50 meters from the construction activity. The station configuration should be adjusted to capture flow reversals if they occur, and realigned in the general downcurrent direction. If there is a visible turbidity plume, the stations will be adjusted to sample within the plume.

The background monitoring station will be located at least 150 meters upstream of the T4 Removal Action area, and approximately 1/2-mile upstream of Slip 1 construction activities. Additional background monitoring stations may be added at the Port's discretion to better understand the spatial distribution of background conditions in the river.

At each station, monitoring will occur at three depths:

- Surface – 3 feet below the surface
- Middle – Center of the water column
- Bottom – 3 feet above the bottom

In water depths less than 15 feet, only two depths (surface and bottom depths) will be monitored. In water depths less than 10 feet, only one depth (middle depth) will be monitored.

Monitoring of field parameters (i.e., turbidity, DO, pH, and temperature) will occur at three compliance boundary stations, the early warning station, and the background station. At each station, field parameters will be monitored at the surface, middle, and bottom water depths. If there is a confirmed exceedance of a visual or field parameter, water samples will be collected at the background station and the compliance boundary station with the highest turbidity reading for laboratory analysis.

2.5 Monitoring Tiers and Schedules

Water quality monitoring schedules are divided into two tiers, as summarized in Table 3. Tier I reflects "intensive monitoring" that will be performed at the beginning of a new construction activity or when there is a significant change in construction methods. Tier II reflects "routine monitoring" that will occur after an activity has been underway for a period of time and no water quality exceedances have been detected in 3 consecutive days of monitoring. Monitoring will revert back to a Tier I schedule if an exceedance occurs during

Tier II monitoring. Additional information on monitoring schedules that will apply to specific construction activities is provided in Section 3 and Table 3.

2.6 Water Quality Monitoring Criteria

Water quality monitoring criteria are summarized in Table 2 and discussed below. These criteria will form the basis for evaluating water quality at the compliance boundary.

Three types of water quality standards will be employed during CDF construction:

- **Visual Standards.** Continuous visual monitoring of the construction site will be performed for evidence of construction-related impacts. Visual monitoring will be performed during all in-water activities.
- **Conventional Standards.** Turbidity, pH, temperature, and DO will be measured in real time using a field probe, and compared to the water quality standards listed in Table 2. Monitoring of conventional parameters will be performed during all in-water activities.
- **Acute Water Quality Criteria.** Laboratory analysis of target metals (i.e., cadmium, lead, and zinc) and PAHs will be performed if an exceedance of a conventional standard is observed in certain construction areas. TSS would also be analyzed. Analytical results for metals and PAHs will be compared to the acute water quality criteria listed in Table 2.

In addition, background water quality related to ambient conditions in the Willamette River will be considered in the compliance evaluation.

2.6.1 Visual Standards

Visual monitoring for water quality impacts during construction activities will take place whenever construction is underway. Visual monitoring will confirm that the construction site meets the following conditions:

- No oily sheen or other visible contamination in the water
- No distressed or dying fish

- No significant turbidity plume outside the compliance boundary

2.6.2 Conventional Standards

The conventional standards that will be used to monitor construction of the T4 CDF are listed below. Conventional parameters are measured in real time using a multi-parameter field instrument.

Turbidity. State water quality standards allow for limited turbidity exceedances for "dredging, construction, or other legitimate activities" [OAR 340-041-036(b)]. The following turbidity standards will apply at the point of compliance:

- Turbidity shall not exceed 5 NTU above background if background is less than 50 NTU.
- Turbidity shall not exceed 10 percent above background if background is greater than 50 NTU.

At no time should turbidity exceed 50 NTU over background.

Dissolved Oxygen. At the point of compliance, DO shall exceed 6.5 mg/L. At no time should DO drop below 6.0 mg/L at any station.

pH. At the point of compliance, pH will remain between 6.5 and 8.5 (standard units).

Temperature. At the point of compliance, the 7-day average temperature shall not exceed 18.0°C. When ambient conditions exceed 18.0°C, no temperature increases will be allowed that will raise the receiving water temperature greater than 0.3°C.

2.6.3 Chemical Criteria

Water quality criteria for contingent chemical monitoring parameters are listed below. Laboratory analysis of chemical parameters will be performed in certain areas of the CDF if an exceedance of a conventional parameter is observed at the point of compliance and

confirmed to be a result of construction activities. Laboratory analysis will be performed at an off-site analytical laboratory with an accelerated 72-hour turnaround from the time of sample delivery.

TSS. There are no formal water quality criteria for TSS. However, TSS is potentially a more accurate indicator of construction-related sediment resuspension compared to turbidity.

Acute Metals Criteria. Contingent laboratory analysis of cadmium, lead, and zinc will be performed if an exceedance of one or more field parameters is observed during the demolition of piers in Slip 1. Acute water quality criteria for these metals are derived from Oregon Table 33A (ODEQ 2005) and the USEPA National Recommended Water Quality Criteria (USEPA 2010). The criteria have been adjusted to a hardness value of 25 mg/L based on average measurements in the Lower Willamette River (USGS Station #14211720).

PAH Guidance Values. Contingent laboratory analysis of PAHs will be performed if an exceedance of one or more field parameters is observed during dredging of the berm key. Aquatic life criteria for PAHs are not available in either federal or state standards. However, acute and chronic guidance values for PAHs have been developed by USEPA (USEPA 2003b and Table 2).

2.6.4 Ambient Background Conditions

Ambient background values in the Willamette River for conventional and chemical parameters will be considered in the evaluation of construction monitoring data. No construction-related impacts are indicated if conventional measurements or analytical results are at or below background levels, even if these levels exceed water quality criteria (i.e., when background conditions exceed water quality criteria).

Background conditions in the Willamette River are determined using: 1) the USGS monitoring record at the Willamette River at Portland (Station #14211720); and 2) field measurements and laboratory analytical results at background monitoring stations during the T4 Phase I Removal Action, conducted in August through October 2008 (Anchor QEA 2009).

The background values listed in Table 2 for conventional and chemical parameters are based on the 90th percentile values of the background dataset.

A background reference station will be established upstream of T4, and this station will be monitored concurrent with the monitoring of CDF construction activities. To the extent possible, the background monitoring station will be placed in an area comparable to the compliance locations (e.g., at similar water depths and distances from the shoreline). Ongoing monitoring of this background station will be performed to detect any excursions of ambient river conditions (e.g., excessive turbidity caused by high flow events, etc.) that are not caused by the construction of the CDF, but which may nevertheless affect water quality in the vicinity of the CDF. Ambient background statistics will be regularly updated with the background monitoring data collected during construction.

3 ACTIVITY-SPECIFIC MONITORING REQUIREMENTS

In this section, specific monitoring requirements and schedules are described for each construction activity that will be implemented during CDF construction. General monitoring schedules are outlined in Table 3.

3.1 Pile and Structure Demolition

Description. Existing overwater structures in Slip 1 will be demolished. Each berth structure includes wood and concrete piles and superstructure with asphalt or concrete topping.

Monitoring Parameters. Visual observations and monitoring of conventional field parameters (i.e., turbidity, DO, temperature, and pH) will be conducted. If any water quality standards are exceeded based on visual or field parameter monitoring, and not caused by background conditions, water samples will be collected at the compliance boundary and early warning boundary and submitted to a contract laboratory for analysis of TSS and target metals (i.e., cadmium, lead, and zinc).

Compliance Boundaries. The compliance boundaries for pile and structure demolition are 100 meters from the edge of the piers at Berths 405 and 408. The early warning boundaries are 50 meters from the edge of the piers.

Monitoring Schedule. Visual observations will be conducted every hour during all pile and structure demolition. At the start of pile and structure demolition, conventional field parameters (i.e., turbidity, DO, temperature, and pH) will be measured once every 6 hours (Tier I) beginning 1 hour after demolition begins. If no exceedances occur following 3 days of monitoring, the sampling frequency will be reduced to once per day (Tier II).

If any exceedances are detected during Tier II monitoring or a significant construction modification is made, monitoring will revert back to Tier I requirements.

3.2 Berm Key Dredging

Description. A new containment berm at the mouth of Slip 1 must be constructed to support the containment of sediment and fill material in the CDF. To support the berm, an approximately 5- to 10-foot deep key will be mechanically dredged beneath the footprint of the berm at the mouth of Slip 1. This dredge volume is approximately 39,000 cubic yards (cy). This material will be removed from its current location and placed at the head of Slip 1 prior to containment berm construction.

Monitoring Parameters. Visual observations and monitoring of conventional field parameters (i.e., turbidity, DO, temperature, and pH) will be conducted. If any water quality standards are exceeded based on visual or field parameter monitoring, and not caused by background conditions, water samples will be collected at the compliance boundary and early warning boundary and submitted to a contract laboratory for analysis of TSS and PAHs.

Compliance Boundary. The compliance boundary for berm key dredging will be 100 meters from the edge of the berm key, and the early warning station will be 50 meters from the edge of the berm key (Figure 2).

Monitoring Schedule. Visual observations will be conducted every hour during berm key dredging. At the start of berm key dredging, conventional field parameters (i.e., turbidity, DO, temperature, and pH) will be measured once every 6 hours (Tier I) beginning 1 hour after dredging begins. If no exceedances occur following 3 days of monitoring, the sampling frequency will be reduced to once per day (Tier II).

If any exceedances are detected during Tier II monitoring or a significant construction modification is made, monitoring will revert back to Tier I requirements.

3.3 Containment Berm Construction

Description. The new containment berm will be created by placing material across the mouth of Slip 1 and parallel to the riverbanks. The berm will be constructed across the

existing mouth of Slip 1 and will extend between the existing north and south corners of the Slip 1 banks, for a total distance of approximately 600 horizontal feet. The height of the berm will be equivalent to the height of the adjacent riverbanks at an elevation of approximately 30 to 35 feet National Geodetic Vertical Datum (NGVD). The berm will be approximately 20 feet wide at the top and a maximum of 300 feet wide at the base.

Monitoring Parameters. Visual observations and monitoring of conventional field parameters (i.e., turbidity, DO, temperature, and pH) will be conducted. If any water quality standards are exceeded based on visual or field parameter monitoring, and not caused by background conditions, water samples will be collected at the compliance boundary and early warning boundary and submitted to a contract laboratory for analysis of TSS.

Compliance Boundary. The compliance boundary for containment berm construction will be 100 meters from the edge of the berm, and the early warning station will be 50 meters from the edge of the berm (Figure 2).

Monitoring Schedule. Visual observations will be conducted every hour during containment berm construction. At the start of containment berm construction, conventional field parameters (i.e., turbidity, DO, temperature, and pH) will be measured once every 6 hours (Tier I) beginning 1 hour after construction begins. If no exceedances occur following 3 days of monitoring, the sampling frequency will be reduced to once per day (Tier II).

If any exceedances are detected during Tier II monitoring or a significant construction modification is made, monitoring will revert back to Tier I requirements.

3.4 Replacement Berth 405 Construction

Description. A replacement for Berth 405 will be constructed near the face of the new containment berm. The berth will include a pre-cast concrete platform supported by steel pipe piling with a vehicle access trestle from shore. Four ship berthing dolphins will be installed (two on either side of the berth), each with a catwalk access from the main platform. The structure will require approximately 80 steel pipe piles and will include

approximately 6,272 square feet of new overwater structure in the river. The pile caps for the new structure will be cast-in-place concrete, but construction of these caps will occur out of water and no uncured concrete will be in contact with the water at any time.

Monitoring Parameters. Visual observations and monitoring of conventional field parameters (i.e., turbidity, DO, temperature, and pH) will be conducted. If any water quality standards are exceeded based on visual or field parameter monitoring, and not caused by background conditions, water samples will be collected at the compliance boundary and early warning boundary and submitted to a contract laboratory for analysis of TSS.

Compliance Boundary. The compliance boundary for berth construction will be 100 meters from the edge of the berth, and the early warning station will be 50 meters from the edge of the berth (Figure 2).

Monitoring Schedule. Visual observations will be conducted every hour during berth construction. At the start of berth construction, conventional field parameters (i.e., turbidity, DO, temperature, and pH) will be measured once every 6 hours (Tier I) beginning 1 hour after construction begins. If no exceedances occur following 3 days of monitoring, the sampling frequency will be reduced to once per day (Tier II).

If any exceedances are detected during Tier II monitoring or a significant construction modification is made, monitoring will revert back to Tier I requirements.

3.5 Sediment Offloading

Description. After USEPA and the Port designate the material as acceptable for placement in the CDF, sediment from approved Areas of Potential Concern (AOPCs) in Portland Harbor will be transported to the new Berth 405 for offloading into the CDF. Mechanically dredged sediment will most likely be brought to the CDF via haul barge, then transferred into the CDF with a pumping system. The contractor will be required to design a system that includes spillage containment systems and methods to monitor for spillage, draws any make-up water used to slurry the dredged material for pumping from within the CDF, has

sufficient capacity to handle the anticipated supply rates, and has the ability to place materials at all locations in the CDF.

Monitoring Parameters. Visual observations and monitoring of conventional field parameters (i.e., turbidity, DO, temperature, and pH) will be conducted. If any water quality standards are exceeded based on visual or field parameter monitoring, and not caused by background conditions, water samples will be collected at the compliance boundary and early warning boundary and submitted to a contract laboratory for analysis of target chemicals of concern (COCs). The target COC list will be determined on a project-specific basis considering the source of the dredged material.

Compliance Boundary. The compliance boundary for sediment offloading will be 100 meters from the edge of the berth, and the early warning station will be 50 meters from the edge of the berth (Figure 2).

Monitoring Schedule. Visual observations will be conducted every hour during sediment offloading. Conventional field parameters (i.e., turbidity, DO, temperature, and pH) will be measured once every 6 hours (Tier I) beginning 1 hour after offloading begins. If no exceedances occur following 3 days of offloading activities, the sampling frequency will be reduced to once per day (Tier II).

If any exceedances are detected during Tier II monitoring or a significant construction modification is made, monitoring will revert back to Tier I requirements.

3.6 Groundwater Seepage at the Berm Face

It is expected that a majority of the AOPCs will be mechanically dredged and barged to the CDF. Then, they will either be mechanically transferred over the berm, or hydraulically transferred with a high-solids pump using pond water as make-up water. In either case, there will be no significant rise in the pond level of the CDF. Therefore, this is not a pathway of concern for this project.

In the event that hydraulically dredged sediment is pumped directly into the CDF, causing a significant water level difference across the berm, this WQMP will be amended to specify, as appropriate, monitoring requirements for groundwater seepage.

3.7 CDF Effluent Discharge

In the event that hydraulically dredged sediment is pumped directly into the CDF, the dredging will be managed such that there will be no overflow and no direct effluent discharge back to the river. Therefore, this is not a pathway of concern for this project.

4 SAMPLING AND ANALYSIS METHODS

4.1 Methods and Equipment

Monitoring will be conducted from a self-propelled vessel equipped with a differential global positioning system (DGPS) and a handheld global positioning system (GPS) unit as backup if necessary. Field parameters (i.e., turbidity, DO, temperature, and pH) will be measured using a calibrated field probe deployed to the appropriate depth (surface, middle, and deep intervals) as described in Section 2.4.

Contingent water column grab samples will be collected, as necessary, using a decontaminated van Dorn bottle or similar device. Water sampled from the appropriate depth will be transferred immediately to laboratory-provided pre-labeled, pre-cleaned sample containers. Water column samples will be collected in accordance with *Methods for Collection, Storage, and Manipulation of Sediments for Chemical and Toxicological Analyses: Technical Manual* (USEPA 2001).

4.2 Sample Location and Depth Control

Compliance boundary distances will be verified by a high-accuracy (+/- 3 feet accuracy) laser rangefinder. A minimum of two readings will be taken at each station to ensure that the laser is obtaining reproducible data, and to monitor any drift in the sampling vessel location.

Depth to the bottom will be determined using a lead line. From this measurement, the appropriate monitoring depths will be determined. Both the water depth and the monitoring depths will be recorded at each monitoring station.

4.3 Decontamination Procedures

Sample containers, instruments, working surfaces, personal protective gear, and other items that may come into contact with the water sample must meet high standards of cleanliness. A van Dorn water sampler, or equivalent, will be used to collect contingent grab samples for laboratory analysis of TSS and activity-specific COCs. The van Dorn sampler will be

decontaminated prior to each day's use and between sampling events. The decontamination procedure is as follows:

- Pre-wash rinse with site water
- Wash with solution of laboratory-grade non-phosphate based soap (brush)
- Rinse with site water
- Rinse three times with laboratory-grade distilled water
- Cover (no contact) all decontaminated items with aluminum foil
- Store in clean, closed container for next use

Additionally, the laboratory will provide pre-cleaned and labeled sample containers.

4.4 Sample Identification

All field parameter measurements and water column samples will be properly identified on field monitoring forms, bottle labels, and related documentation. Identification of field parameter measurements will follow an identification scheme consisting of 8 alphanumeric characters (see Figure 2):

1. The first two characters will be "T4" to identify the samples as Port of Portland Terminal 4 samples.
2. The next four characters will be used to identify the particular water quality monitoring area as listed below:
    - BERM = CDF containment berm, for berm key dredging and berm construction activities
    - B405 = Replacement Berth 405, for berth construction activities and sediment offloading at the new berth
    - P405 = Pier 405, for demolition of the old pier structure in Slip 1
    - P408 = Pier 408, for demolition of the old pier structure in Slip 1
3. The next character will be a letter (N, M, S, or E) indicating the position along the compliance boundary arc or early warning arc, as follows:
    - N = the station on the north side of the compliance boundary arc

- M = the middle station along the compliance boundary arc
- S = the station on the south side of the compliance boundary arc
- E = the early warning station at the mid-point of the compliance zone

4. The next character will indicate the water depth of the measurement or sample:

- A = surface measurement/sample collected within 3 feet of the surface
- B = measurement/sample collected at mid-depth
- C = bottom measurement/sample collected 3 feet from the sediment surface
- D = sample composited from the surface, middle, and bottom depths

Identification of water column samples will include an additional 6 trailing alphanumeric characters denoting the date of sampling: YYMMDD.

For example, "T4-BERM-NA" identifies a field parameter measurement obtained from the surface of the water column ("A" depth) adjacent to the CDF berm (i.e., during berm key dredging or berm construction) at the station on the north side of the compliance boundary arc ("N" location). "T4-BERM-NA-120801" identifies a water column sample collected from the same location on August 1, 2012.

4.5 Measurement Documentation

The water quality monitoring data (e.g., station coordinates, water depths sampled, date, time, field parameter measurements, and other observations) will be recorded on the Water Quality Monitoring Form (Attachment 1).

4.6 Monitoring Equipment Calibration and Maintenance

Monitoring equipment will be calibrated prior to its use in the monitoring program following manufacturers' instructions. The calibration will be conducted once at the beginning of each sampling day for all equipment. Where not covered by manufacturers' instructions, calibration procedures will follow Standard Methods 2130-b (turbidity), 4500-O (DO), 2550 (temperature), and 4500-H^+ (pH) (AWWA 1998).

For the turbidity meter, at the end of each day of monitoring a post-calibration procedure will be performed by measuring one of the calibration standards (preferably the standard whose value is closest to the river turbidity during that day). In addition, standards may be measured to check the calibration throughout the day, especially if higher or lower than expected turbidity values occur.

All calibration information will be recorded in the field notebook. Equipment that does not properly calibrate will not be used.

Instruments and equipment will be tested and inspected before each sampling event. Any field equipment that is faulty or not functioning properly will not be used for sampling.

4.7 Sample Handling and Custody

If a contingent water column grab sample is collected, it will be immediately transferred to a pre-cleaned container provided by the analytical laboratory and placed in a cooler with ice. All containerized water samples will be transported to the analytical laboratory. Specific sample shipping procedures will be as follows:

1. Each cooler or container containing the water samples will be shipped to the laboratory within 24 hours of being sealed.
2. The shipping containers will be clearly labeled with sufficient information (name of project, time and date container was sealed, person sealing the container, and consultant's office name and address) to enable positive identification.
3. Glass bottles will be separated in the shipping container by shock-absorbent material (e.g., bubble wrap) to prevent breakage.
4. A generous amount of ice (or blue ice) will be sealed in separate plastic bags and placed into the cooler.
5. A sealed envelope containing chain-of-custody forms will be enclosed in a plastic bag and taped to the inside lid of the cooler.
6. If sending via FedEx, the cooler lids will be secured by wrapping the coolers in strapping tape.

7. Signed and dated chain-of-custody seals will be placed on all coolers prior to shipping.

Upon transfer of sample possession to the analytical laboratory, the persons transferring custody of the sample container will sign the chain-of-custody form. Upon receipt of samples at the laboratory, the shipping container seal will be broken and the condition of the samples recorded by the recipient. Chain-of-custody forms will be used internally in the laboratory to track sample handling and final disposition.

4.8 Analytical Laboratory Parameters and Methods

Water column grab samples may be collected for laboratory analysis of TSS, target metals (i.e., cadmium, lead, and zinc), PAHs, or other project-specific COCs. The water samples will be submitted to a qualified laboratory for analysis within 72 hours from receipt at the laboratory. Laboratory methods, criteria, and reporting limits are summarized in Table 4.

4.9 Quality Assurance/Quality Control Procedures

Field and laboratory quality assurance/quality control (QA/QC) procedures are discussed further in the Construction Quality Assurance Plan (CQAP; Appendix D to the DAR).

5 REPORTING REQUIREMENTS

5.1 Data Submittals

Data will be collected and recorded in the field on the Water Quality Monitoring Form (Attachment 1). These data will be reported to USEPA in the following communications and submittals:

- **Daily Reporting** – Any exceedances of the water quality criteria specified in Section 2.6 and Table 2 will be reported verbally or by email to USEPA on a daily basis as specified by USEPA.
- **Weekly Reporting** – Results from each week's Water Quality Monitoring Forms will be compiled into a summary table with a comparison to criteria values, and provided to USEPA on a weekly basis.
- **Monthly Reporting** – Background water quality values (90th percentile values) will be updated at the end of every month to include ongoing background data collected during construction activities; a summary table of background measurements and supporting statistics (e.g., 90th percentile values) will be provided to USEPA on a monthly basis.
- **Final Reporting** – Once all construction is complete, results for the entire construction period will be compiled and reported to USEPA along with supporting documentation in a CCR, as described in Section 5.2.

Daily and weekly reporting will be the responsibility of the Water Quality Monitoring Field Leader. All reporting will include both regularly scheduled monitoring and any additional monitoring results that may have been triggered by exceedances of water quality criteria.

5.2 Construction Completion Report

After all construction is complete, the results of water quality monitoring will be provided to USEPA in the draft CCR. The CCR will be revised to address USEPA comments, as appropriate, and submitted as a final report. The results section of the CCR will include:

- Any deviations from this WQMP and reasons for deviations

- Tabular summaries of all water quality monitoring data with comparisons to water quality standards and criteria
- Narrative text on results of water quality monitoring related to each operation (e.g., pier demolition, berm key dredging, etc.)
- Discussion of water quality criteria exceedances and any additional monitoring that may have been triggered by the exceedances, the suspected cause of the exceedances, additional BMPs or other control measures that may have been implemented and the effectiveness of those control measures, and final mitigation of the exceedance
- An appendix containing all completed Water Quality Monitoring Forms

6 CONTINGENCY PLAN

6.1 Notification Requirements

The primary purpose of water quality monitoring during construction is to determine when water quality impacts may be occurring so that additional contingency actions can be implemented, if necessary, as described in this document. Consequently, immediate notification of water quality measurements that exceed the criteria specified in this plan is necessary. Upon obtaining results that exceed any criteria, the Water Quality Monitoring Field Leader will notify the Construction Quality Assurance Officer (CQAO) as quickly as possible. The CQAO will notify the Port Project Coordinator, who, in turn, will immediately notify the USEPA Project Coordinator (Sean Sheldrake) by telephone. Contact information for the USEPA Project Coordinator is provided below:

Mr. Sean Sheldrake
USEPA, Region 10
Environmental Cleanup Office
1200 Sixth Avenue, Suite 900
Mailstop: ECL-115
Seattle, WA 98101-3140
(206) 553-1220 Telephone
(206) 553-0124 Fax
Sheldrake.Sean@epamail.epa.gov

6.2 Contingency Response Actions (If Water Quality Criteria are Exceeded)

6.2.1 Exceedance of Visual Monitoring Criteria

If visual monitoring criteria are exceeded, the following contingency actions will be implemented:

- Determine if the turbidity plume is attributed to the construction activity versus other activities occurring within the river (e.g., wind waves, boat wakes, etc.).

- Determine if the turbidity plume is of sufficient extent (i.e., width of the compliance zone) and sufficient duration (i.e., 1 hour or more) to trigger a response action.
- If the turbidity plume is attributed to the construction activity, and is of sufficient extent and duration, implement field parameter monitoring to determine if the visual exceedance is also an exceedance of turbidity or other field criteria.
- If turbidity or other field criteria are exceeded, inform the CQAO.
- Immediately retake measurements at all depths at the station. If no exceedance occurs, retake measurements within 45 minutes of initial reading to confirm the pass. If the pass is confirmed, inform USEPA of the resolved exceedance.
- If an exceedance is confirmed, inform USEPA of the exceedance, the probable cause of the exceedance, and identify a plan for implementing BMPs. BMPs for specific construction activities are listed in Section 6.3.
- Monitoring will revert back to a Tier I schedule.

6.2.2 Exceedance of Conventional Parameters

If conventional parameters (i.e., turbidity, DO, temperature, or pH) are exceeded at the compliance boundary during construction activities, the following actions will occur:

- Determine if the exceedance is attributed to the construction activity versus other activities occurring within the river (e.g., wind waves, boat wakes, barge/ship traffic, etc.).
- If it is determined that the exceedance is attributed to the construction activity, inform the CQAO.
- Immediately retake measurements at all depths at the station. If no exceedance occurs, retake measurements within 45 minutes of the initial reading to confirm the pass. If the pass is confirmed, inform USEPA of the resolved exceedance.
- If an exceedance is confirmed, inform USEPA of the exceedance, the probable cause of the exceedance, and identify a plan for implementing BMPs. BMPs for specific construction activities are described in Section 6.3.
- Monitoring will revert to a Tier I schedule.

6.2.3 Exceedance of Laboratory Analytical Parameters

If chemical criteria are exceeded, USEPA will be notified as soon as possible upon receipt of the analytical data. The Port and USEPA will discuss if and what additional BMPs may need to be implemented to minimize the potential for any future exceedances of chemical criteria.

6.3 Construction Best Management Practices

Examples of BMPs for specific construction activities are listed below:

- **Dredging** – BMPs for mechanical dredging may include reducing the velocity of the ascending loaded bucket through the water column, pausing the bucket at the bottom after impact but before closing the bucket, pausing the bucket at the waterline during ascent, using an environmental (closed) bucket, and using a silt curtain.
- **Demolition Activities** – BMPs for piling removal may include altering pile removal activities, such as slowing the rate of extraction, and using booms and/or silt curtains.
- **Berm Construction** – BMPs for berm construction may include slowing the rate of material placement.
- **Sediment Offloading** – BMPs for mechanical offloading may include use of a spill plate, and BMPs for hydraulic pumping may include routine inspection of the pumping system for leaks.

7 MONITORING PERSONNEL AND KEY CONTACTS

Personnel to fulfill the following roles will be designated at least 1 week prior to the start of monitoring:

- Water Quality Monitoring Field Leader
- Monitoring personnel
- CQAO
- USEPA Project Coordinator – Sean Sheldrake (for receipt of reports)

Contact information for key personnel will be provided once personnel assignments have been made. All monitoring personnel in these roles will be experienced in the collection and measurement of water quality parameters.

The Water Quality Monitoring Field Leader is responsible for:

- Oversight of visual observations
- Oversight of field parameter monitoring and water column sampling activities
- Verification that results are properly recorded and forms are completely and accurately filled out
- Verification that appropriate calibration and QA/QC procedures are conducted
- Notification to CQAO in the event that water quality criteria are exceeded
- Daily and weekly reporting of water quality results to USEPA's designated contact

Monitoring personnel are responsible for conducting the field activities, instrument calibrations, QA/QC procedures, and recording of results as directed by the Water Quality Monitoring Field Leader.

The CQAO is responsible for acting upon water quality information as provided by the Water Quality Monitoring Field Leader, and conveying this information to the Port and USEPA as appropriate.

8 REFERENCES

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TABLES

Table 1
Water Quality Monitoring Parameters

Subarea	Construction Activity	FIELD					ANALYTICAL					
		Visual	Turbidity	DO	Temperature	pH	TSS	Cadmium	Lead	Zinc	PAHs	Other COCs[1]
Slip 1	Structure and Pile Demolition	X	X	X	X	X	C	C	C	C	-	-
	Berm Key Dredging	X	X	X	X	X	C	-	-	-	C	-
	Berm Construction	X	X	X	X	X	C	-	-	-	-	-
	Replacement Berth Construction	X	X	X	X	X	C	-	-	-	-	-
	Sediment Offloading	X	X	X	X	X	C	-	-	-	-	C

Notes:
C = Laboratory analysis is contingent on exceedance of visual or field parameter criterion
[1] COCs selected for contingent laboratory analysis during sediment offloading are AOPC specific.

Table 2
Short-Term Water Quality Criteria and Background Criteria

Parameter	Units	Background Criteria			Short-Term Criteria			BMP Trigger	
		USGS Station 14211720[1]	T4 Phase I (2008)[2]	LWG Upstream (2009)[3]	Narrative Standard[4]	Acute WQC[5]	Acute Guidance Value[6]	Chronic WQC[5]	Chronic Guidance Value[6]
Field Parameters									
Turbidity	NTU	32	9.8	--	BG <50 NTU: BG+5 NTU BG >50 NTU: BG+10%	--	--	--	--
Temperature	deg C	22	22	--	<18°C (7-day avg); if BG >18°C: BG+0.3°C	--	--	--	--
Dissolved Oxygen	mg/L	--	7.0	--	> 6.5	--	--	--	--
pH	s.u.	--	7.5	--	6.5 to 8.5	--	--	--	--
Laboratory Conventionals									
Total Suspended Solids	mg/L	22	7.6	--	--	--	--	--	--
Metals									
Cadmium (Total)	µg/L	--	--	--	--	--	--	--	--
Cadmium (Dissolved)	µg/L	0.05	< 0.2	--	--	0.5	--	0.09	--
Copper (Total)	µg/L	--	--	3.1	--	--	--	--	--
Copper (Dissolved)	µg/L	1.5	--	--	--	4.4	--	2.7	--
Lead (Total)	µg/L	--	--	0.74	--	--	--	--	--
Lead (Dissolved)	µg/L	0.14	~1	0.032	--	14	--	0.54	--
Zinc (Total)	µg/L	--	--	6.1	--	--	--	--	--
Zinc (Dissolved)	µg/L	--	12	1.9	--	36	--	36	--
Polycyclic Aromatic Hydrocarbons (PAHs)									
Naphthalene	µg/L	--	< 0.1	0.024	--	--	807	--	194
Acenaphthylene	µg/L	--	< 0.1	--	--	--	1277	--	307
Acenaphthene	µg/L	--	< 0.1	--	--	--	233	--	56
Fluorene	µg/L	--	< 0.1	--	--	--	162	--	39
Phenanthrene	µg/L	--	< 0.1	--	--	--	79	--	19
Anthracene	µg/L	--	< 0.1	--	--	--	87	--	21
Fluoranthene	µg/L	--	< 0.1	--	--	--	30	--	7.1
Pyrene	µg/L	--	< 0.1	--	--	--	42	--	10
Benzo(a)anthracene	µg/L	--	< 0.1	0.00034	--	--	9.2	--	2.2
Chrysene	µg/L	--	< 0.1	0.00088	--	--	8.3	--	2.0
Benzo(b)fluoranthene	µg/L	--	< 0.1	0.00059	--	--	2.8	--	0.68
Benzo(k)fluoranthene	µg/L	--	< 0.1	0.00047	--	--	2.7	--	0.64
Benzo(a)pyrene	µg/L	--	< 0.1	0.00050	--	--	4.0	--	0.96
Indeno(1,2,3-cd)pyrene	µg/L	--	< 0.1	0.00033	--	--	1.2	--	0.28
Dibenzo(a,h)anthracene	µg/L	--	< 0.1	0.00011	--	--	1.2	--	0.28
Benzo(g,h,i)perylene	µg/L	--	< 0.1	--	--	--	1.8	--	0.44

Notes:

[1] 90th percentile values; USGS Morrison Street Bridge gage; field parameters 1998-2006; metals 2004-2005.

[2] 90th percentile values (except DO = 10th percentile); combined pre-construction and construction background stations, June - October 2008; see T4 Phase I Removal Action Completion Report (Anchor QEA 2009).

[3] LWG Remedial Investigation Report 2009, Table 7.4-4; Upper Prediction Levels (UPLs) with outliers removed

[4] As per Water Quality Monitoring and Compliance Conditions Plan (WQMCCP) for T4 Phase I Removal Action (USEPA 2008).

[5] ODEQ 2005, Table 33A; and USEPA 2010, National Recommended Water Quality Criteria; copper based on Biotic Ligand Model; all other metals based on Willamette River hardness of 25 mg/L.

[6] USEPA 2003b, aquatic life guidance values.

Table 3
Monitoring Locations and Schedules

Construction Activity	Compliance Boundary	Monitoring Activity and Frequency						Trigger to Switch from Tier I to Tier II
		Tier I (Intensive Schedule)			Tier II (Routine Schedule)			
		Visual	Field	Chemistry	Visual	Field	Chemistry	
Structure and Pile Demolition	100 m from edge of construction activity	1/ hr	1/ 6 hr	Contingent[1]	1/ hr	1/ day[2]	-	No confirmed exceedances of visual or field parameter criteria for 3 consecutive days
Berm Key Dredging	100 m from edge of construction activity	1/ hr	1/ 6 hr	Contingent[1]	1/ hr	1/ day[2]	-	No confirmed exceedances of visual or field parameter criteria for 3 consecutive days
Berm Construction	100 m from edge of construction activity	1/ hr	1/ 6 hr	Contingent[1]	1/ hr	1/ day[2]	-	No confirmed exceedances of visual or field parameter criteria for 3 consecutive days
Replacement Berth Construction	100 m from edge of construction activity	1/ hr	1/ 6 hr	Contingent[1]	1/ hr	1/ day[2]	-	No confirmed exceedances of visual or field parameter criteria for 3 consecutive days
Sediment Offloading	100 m from edge of construction activity	1/ hr	1/ 6 hr	Contingent[1]	1/ hr	1/ day[2]	-	No confirmed exceedances of visual or field parameter criteria for 3 consecutive days

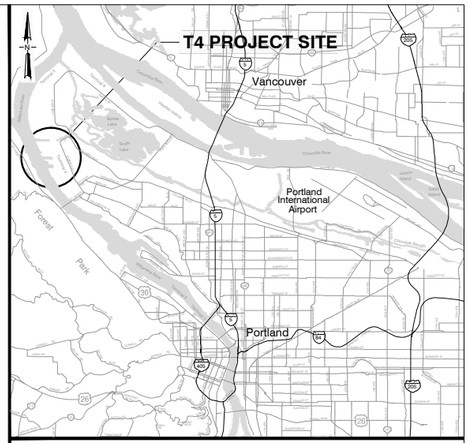
Notes:

1. Laboratory analysis is contingent on confirmed exceedance of a visual or field parameter criterion at compliance boundary.
2. May be reduced to 1/week with USEPA approval.

Table 4
Field and Analytical Parameters and Methods

Field Parameter	Method	Criteria	Accuracy
Turbidity	Field Meter	BG <50 NTU: BG+5 NTU BG >50 NTU: BG+10%	+/- 2% NTU
Dissolved Oxygen (DO)	Field Meter	>6.5 mg/L	+/- 0.2 mg/L
pH	Field Meter	6.5 to 8.5	+/- 0.2 pH units
Temperature	Field Meter	<18°C (7-day avg); if BG >18°C: BG+0.3°C	+/- 0.15 degrees Celcius
Analytical Parameter	**Method**	**Criteria**	**Reporting Limit Goal**
Total Suspended Solids (TSS)	USEPA 160.2	no criteria	1.0 mg/L
Cadmium	USEPA 200.8	0.09	0.02 µg/L
Lead	USEPA 200.8	0.5	0.02 µg/L
Zinc	USEPA 200.8	36	0.5 µg/L
Polycyclic Aromatic Hydrocarbons (PAHs)	USEPA 8270C	0.3 - 300	0.1 µg/L

FIGURES



VICINITY MAP
SCALE: N.T.S.

0 300
Scale in Feet

K:\Jobs\050332-PORT_OF_PORTLAND\05033201 T4 CDF\60% CDF\T4 60% CDF Design GI-2_GI-3.dwg WQMP FIG 1

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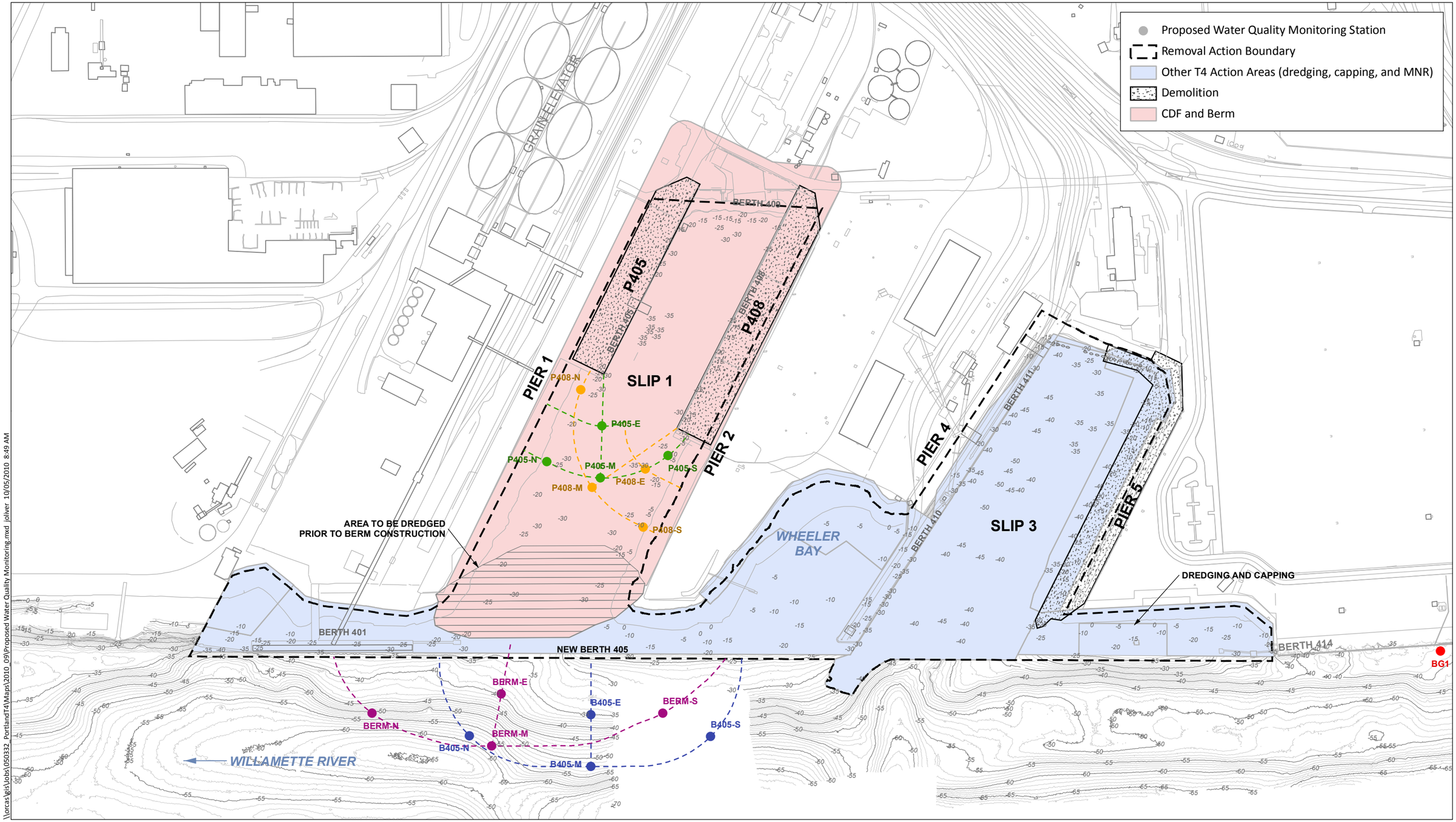
ANCHOR QEA

Figure 1
Site Plan and Vicinity Map
Terminal 4 Confined Disposal Facility Design
Portland, Oregon



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ANCHOR QEA

Bathymetry and base map from Port of Portland,
2007 and 2006, respectively.
Bathymetric elevations in feet NGVD.

Feet
0 125 250 375 500

Figure 2
Proposed Water Quality Monitoring Plan
Terminal 4 Confined Disposal Facility Design
Portland, Oregon

ATTACHMENT 1
WATER QUALITY MONITORING FORM

ANCHOR QEA

720 Olive Way, Suite 1900
Seattle, Washington 98101
Phone 206.287.9130
Fax 206.287-9131
www.anchorqea.com

Water Quality Monitoring Form

Station ID:		**Date:**	**Time:**
Project Name:		**Project Number:**	
Coordinates Datum:			
Lat/Northing:		Long/Easting:	

Weather/River Stage/Flow Observations:

Status/Description of Operation at Time of Sampling:

Depth to Bottom: _____ (m)

	Dissolved Oxygen (mg/L)	Temperature (C)	Turbidity (NTU)
Depth 1: ____ (m)			
Depth 2: ____ (m)			
Depth 3: ____ (m)			
Other:			

Evidence of floating or suspended materials:	
Evidence of oil/hydrocarbon sheen: (Thickness, contiguous?, size, rate of dissipation)	
Discoloration and Turbidity:	
Velocity at stated depth:	
Color:	
Odor:	
Other Observations:	

Comments:

Recorded by: Other Monitoring Personnel:

ATTACHMENT 2
LABORATORY COMMUNICATION PLAN, TERMINAL 4 PHASE I REMOVAL ACTION

LABORATORY COMMUNICATION PLAN

TERMINAL 4 PHASE I REMOVAL ACTION
PORT OF PORTLAND, PORTLAND OREGON

Prepared for

Port of Portland

Portland, Oregon

Prepared by

Anchor Environmental, L.L.C.

6650 SW Redwood Lane, Suite 333

Portland, Oregon 97224

August 2008

LABORATORY COMMUNICATION PLAN

TERMINAL 4 PHASE I REMOVAL ACTION
PORT OF PORTLAND, PORTLAND OREGON

Prepared for

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August 2008

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1 INTRODUCTION

This document summarizes the plan for communication and reporting of analytical results between the U.S. Environmental Protection Agency (USEPA); Anchor Environmental, L.L.C. (Anchor); Analytical Resources, Incorporated (ARI); and Apex Laboratories (Apex) during the upcoming Port of Portland (Port) Terminal 4 Phase I Removal Action project.

1.1 Purpose

The objective of water quality monitoring during Phase I Removal Action construction activities is to confirm that water quality criteria are met, or to ensure approval to allow temporary exceedances of water quality standards during any construction activity that may affect the water column. This plan was requested by USEPA to ensure that project-specific turnaround times for reporting of analytical results will be achieved throughout the project.

1.2 Water Quality Monitoring Overview

Water quality monitoring will occur during the following in-water construction activities:

- Berth 411 "Plus" dredging (Slip 3 and Berth 414)
- Berth 411 sand layer placement
- Capping in Slip 3
- Berth 410 dredging
- Transport and transfer of materials from barge to upland transport at an upland transfer facility
- Wheeler Bay shoreline stabilization

Appendix B of the Phase I Design Analysis Report (Anchor 2008) details the water quality monitoring activities and protections that will be implemented during the Phase I Removal Action to minimize adverse impacts to water quality during Phase I capping and dredging operations.

The parameters to be monitored are total suspended solids (TSS); dissolved cadmium, lead, and zinc; and polynuclear aromatic hydrocarbons (PAHs). Samples will be collected daily for the Tier I schedule and once per week for the Tier II schedule (see Appendix B of Anchor 2008 for criteria for tiered collection).

One hundred and fifty (150) chemistry samples are estimated during the anticipated 7-week duration of the in-water portion of the project, assuming, at a minimum, that chemical analysis will follow the Tier I schedule for the entire 7 weeks (i.e., three discrete samples from the compliance boundary station with the highest turbidity readings and three discrete samples from the background station, for a total of six analyses per day, for an estimated 25 days of monitoring). The expected number of samples that may be generated each day following the Tier I schedule would be six, assuming only one construction activity will be occurring at any one time. For the purposes of this plan, it is conservatively assumed that a Tier I schedule will be followed throughout the project.

2 PROJECT ORGANIZATION AND RESPONSIBILITIES

2.1 USEPA

USEPA's responsibilities include:

- Identifying a primary and secondary USEPA project manager.
- Ensuring the primary or secondary USEPA contacts are available when results or updates on data are expected. Contingent response actions may need to be determined immediately.

2.2 Port

The Port's responsibilities include:

- Coordinating and communicating regularly with USEPA.
- Notifying USEPA of deviations from the requirements listed in the Laboratory Communication Plan, Water Quality Monitoring Plan, and Water Quality Monitoring and Compliance Conditions Plan (WQMCCP).

2.3 Anchor

Anchor's responsibilities include:

- Managing the analytical laboratories and the reporting of results on behalf of the Port.
- Identifying a project manager, laboratory communication designee, and an alternate designee.
- Attending a project kick-off meeting.

- Providing a copy of the WQMCCP to the laboratories to aid in their understanding of the actions thresholds for the project, and to aid in their early reporting regarding whether sample concentrations are above these thresholds.
- Communicating with the laboratory project managers daily in a status phone call as to sample status, issues encountered, and sample loading concerns, as well as any other pertinent project concerns.
- Conducting a daily status meeting after the laboratory status meeting and receipt of sample data for that day. During the status meeting, the Anchor project manager and Anchor designee will review current sampling status to laboratories, data status, analytical issues (if necessary), and quality assurance/quality control (QA/QC) issues (if necessary).

2.4 Primary Laboratory (ARI)

ARI's responsibilities include:

- Identifying a laboratory project manager and an alternate designee.
- Attending a project kick-off meeting.
- Dedicating one primary and one back-up instrument and chemist to perform each analysis type.
- Analyzing samples according to the specifications in the project Quality Assurance Project Plan (QAPP; Appendix I of Anchor 2008).
- Communicating with the Anchor designee daily in a status phone call as to sample status, issues encountered, and sample loading concerns, as well as any other pertinent project concerns.
- Providing primary and contingent procedures to deal with out-of-control data that could have bias on the data prior to project initiation. More complex issues will be dealt with on a daily basis by the laboratories and Anchor designee.
- Identifying cleanup procedures prior to the start of the project, which will allow the chemist to perform the approved cleanup procedures as they occur under normal foreseeable circumstances (e.g., internal standard problems, matrix effects), rather than wait.

2.5 Secondary Laboratory (Apex)

Apex's responsibilities include all of the same responsibilities as the primary laboratory, other than dedicating one primary and one back-up instrument and chemist to perform each analysis type.

2.6 Key Staff

Contact information for key staff (and secondary contacts) identified by USEPA, Anchor, ARI, and Apex is provided in Table 1.

3 TURNAROUND TIMES AND REPORTING SPECIFICATIONS

Preliminary, unvalidated laboratory chemical analytical results (TSS, target metals, and PAHs) will be reported to USEPA no more than 3 days (72 hours) following sample receipt by the laboratory. Any change between preliminary results and final results will be reported as soon as possible. USEPA will be informed and updated daily on the status of the data during a daily status call. These reporting timelines will apply to samples collected on both weekdays and weekends.

In addition, Anchor will report to USEPA when detections have been made, as well as information on calibrations that have been exceeded. This information can be useful in approximating a chemistry "hit" that can be used to begin to trigger low cost best management practices (BMPs) while awaiting quantitative laboratory confirmation. The laboratories will notify the Anchor designee at the earliest possible time of identification of significant high concentration results in water quality samples that are expected to be clean.

3.1 Plan for Meeting Project Turnaround Times

ARI, as the primary laboratory, will dedicate one primary and one back-up instrument and chemist to perform each analysis type to facilitate meeting the project turnaround times. Figure 1 provides a flowchart illustrating the laboratory communication plan for meeting turnaround times, beginning with an assessment of laboratory capacity. At the time of collection of samples in the field, the Anchor designee will contact ARI to determine if the laboratory has the capacity to handle the collected samples. The samples will be transported to ARI unless they do not have the capacity to handle the samples. If this happens, the samples will be transported to Apex. Daily status calls will be held between

Anchor, ARI, and Apex to determine the status of analyses and if any issues have arisen that will affect the laboratory's ability to meet the specified turnaround time. If, during the meeting, it is determined that ARI is not meeting its goals, Apex will be utilized until ARI is on track again. Anchor and ARI will discuss the reason for delayed sample results, if any, and a path forward for continuing the analyses. This information will be reviewed with USEPA during the daily status call.

Additionally, any instrument malfunctions must be communicated to the Anchor project manager or their designee on the day they occur. This will allow for Apex to receive samples the same day that they are taken. Any QA/QC issues will be brought to the attention of the Anchor project manager on the day they occur so that resolution can be made the same day, preventing the delay of sample processing.

3.2 Sample Handling and Transport

Once samples have been collected, they will be transported to the laboratory by a courier service. The Anchor designee will contact ARI (or Apex) when it is known that there will be samples to be picked up by the courier service at the field site. Samples will be transported such that they arrive at the laboratory within 14 hours of the time of sampling.

For weekend sample receipt, the laboratories will identify a phone number and person(s) responsible for receiving the samples, logging in the samples, and communicating any log-in issues. This will prevent log-in delays during the off-hour shifts. The Anchor designee will be responsible for following up with the laboratory on the daily sample receipts.

4 REPORTING

Prior to release, data will be reviewed by the analyst to verify initial calibration, continuing calibrations, tunes, internal standards, surrogates, and compliance of the Method Blank and Laboratory Control sample. If all QC requirements pass and the Laboratory Manager or Laboratory Supervisor is in attendance, the data will be reviewed by the Laboratory Manager or Laboratory Supervisor, released to the Laboratory Information Management System (LIMS), printed, and signed before distribution to USEPA.

There may be occasions where a data reviewer may not always be available within a reasonable timeframe. In those circumstances, assuming the QC requirements pass, USEPA will occasionally accept receiving the data in a preliminary format with information that the QC requirements were met and that a final review is still required and will be forwarded as soon as reasonably practical.

Results compared against applicable water quality criteria will be reported to the Anchor project manager or designee within 72 hours of sample receipt via email (Adobe PDF or Microsoft Excel format). The template for reporting the results is described below in Section 4.1.1. Occasional unreviewed data will be accepted as preliminary results. A final review must occur within a timeframe that is reasonably practical, and reviewed results reported to Anchor. The data will be forwarded to USEPA immediately.

4.1 Submittals

Field parameter data will be collected by Anchor and recorded in the field on water quality monitoring forms. Additional data will be reported by the analytical laboratories. All data will be reported as described below.

4.1.1 Daily Reporting

Field and laboratory sampling results, including any exceedances of the water quality criteria specified in Section 2.6 and Table 2 of Anchor 2008, Appendix B, will be reported verbally or by email to USEPA on a daily basis. A Daily Reporting Template for Field Parameters that will be utilized by Anchor is provided as Attachment A. A Daily Reporting Template for Analytical Parameters that will be utilized by the laboratories and Anchor is provided as Attachment B.

4.1.2 Weekly Reporting

The daily reports will be compiled into a summary report that will be provided to USEPA on a weekly basis.

4.1.3 Follow-up Reporting

Follow-up reports related to any pending data or data that has been updated will be provided along with the daily reporting schedule.

5 SAMPLING AND REPORTING SCHEDULE

See Figure 2 for a schedule that depicts the expected sampling days when construction activity is expected to be monitored, as well as which days data are expected to be reported. Sampling and reporting activity will occur on weekend days.

6 REFERENCES

Anchor. 2008. Final Design Analysis Report: Terminal 4 Phase I Removal Action. Prepared for the Port of Portland by Anchor Environmental, L.L.C. June 2008.

ATTACHMENTS

Table 1
Contact Information for Key Staff

Role	Company	Contact	Address	Cell	Office	Email
USEPA Project Manager	USEPA	Sean Sheldrake	1200 Sixth Avenue Suite 900 M/S ECL-115 Seattle, WA 98101	Note[1]	(206) 553-1220	Sheldrake.Sean@epamail.epa.gov
USEPA Project Manager – Secondary contact	USEPA	To Be Determined	To Be Determined	To Be Determined	To Be Determined	To Be Determined
Anchor Project Manager	Anchor Environmental, L.L.C.	Ben Hung	6650 SW Redwood Lane Suite 333 Portland, OR 97224	(971) 678-2100	(503) 670-1108 Ext. 21	bhung@anchorenv.com
Anchor Project Manager – Secondary contact	Anchor Environmental, L.L.C.	Elizabeth Appy	6650 SW Redwood Lane Suite 333 Portland, OR 97224	(503) 460-7504	(503) 670-1108 Ext. 22	eappy@anchorenv.com
Anchor Designee	Anchor Environmental, L.L.C.	Julie Fox	6650 SW Redwood Lane Suite 333 Portland, OR 97224	--	(503) 670-1108 Ext. 20	jfox@anchorenv.com
Q.A. Manager	Anchor Environmental, L.L.C.	Delaney Peterson	1423 Third Avenue Suite 300 Seattle, WA 98101	--	(206) 287-9130	dpeterson@anchorenv.com
Q.A. Manager – Secondary contact	Anchor Environmental, L.L.C.	Joy Dunay	1423 Third Avenue Suite 300 Seattle, WA 98101	(206) 909-0776	(206) 287-9130	jdunay@anchorenv.com
Anchor Database	Anchor Environmental, L.L.C.	Lisa Allen	1423 Third Avenue Suite 300 Seattle, WA 98101	--	(206) 287-9130	lallen@anchorenv.com
Primary Laboratory	Analytical Resources, Inc.	Sue Dunnihoo	4611 South 134th Place Suite 100 Tukwila, WA 98168	(425) 273-3536	(206) 695-6200	sue@arilabs.com
Primary Laboratory – Secondary contact	Analytical Resources, Inc.	Kelly Bottem	4611 South 134th Place Suite 100 Tukwila, WA 98168	--	(206) 695-6200	Kelly@arilabs.com
Primary Laboratory – Sample receiving	Analytical Resources, Inc.	Brian Kagel	4611 South 134th Place Suite 100 Tukwila, WA 98168	(360) 970-8866	(206) 695-6200	sue@arilabs.com

Table 1
Contact Information for Key Staff

Role	Company	Contact	Address	Cell	Office	Email
Secondary Laboratory	Apex Laboratories, LLC	Darwin Thomas	12232 SW Garden Place Tigard, OR 97223	(503) 970-5500	(503) 718-2323	dthomas@apex-labs.com
Secondary Laboratory – Secondary contact	Apex Laboratories, LLC	Philip Nerenberg	12232 SW Garden Place Tigard, OR 97223	(503) 523-6123	(503) 718-2323	PNerenberg@Apex-Labs.com
Secondary Laboratory – Sample receiving	Apex Laboratories, LLC	Darwin Thomas	12232 SW Garden Place Tigard, OR 97223	(503) 970-5500	(503) 718-2323	dthomas@apex-labs.com

Note:

1. Sean Sheldrake's cell phone number will be provided to key staff for use when reporting water quality exceedances.

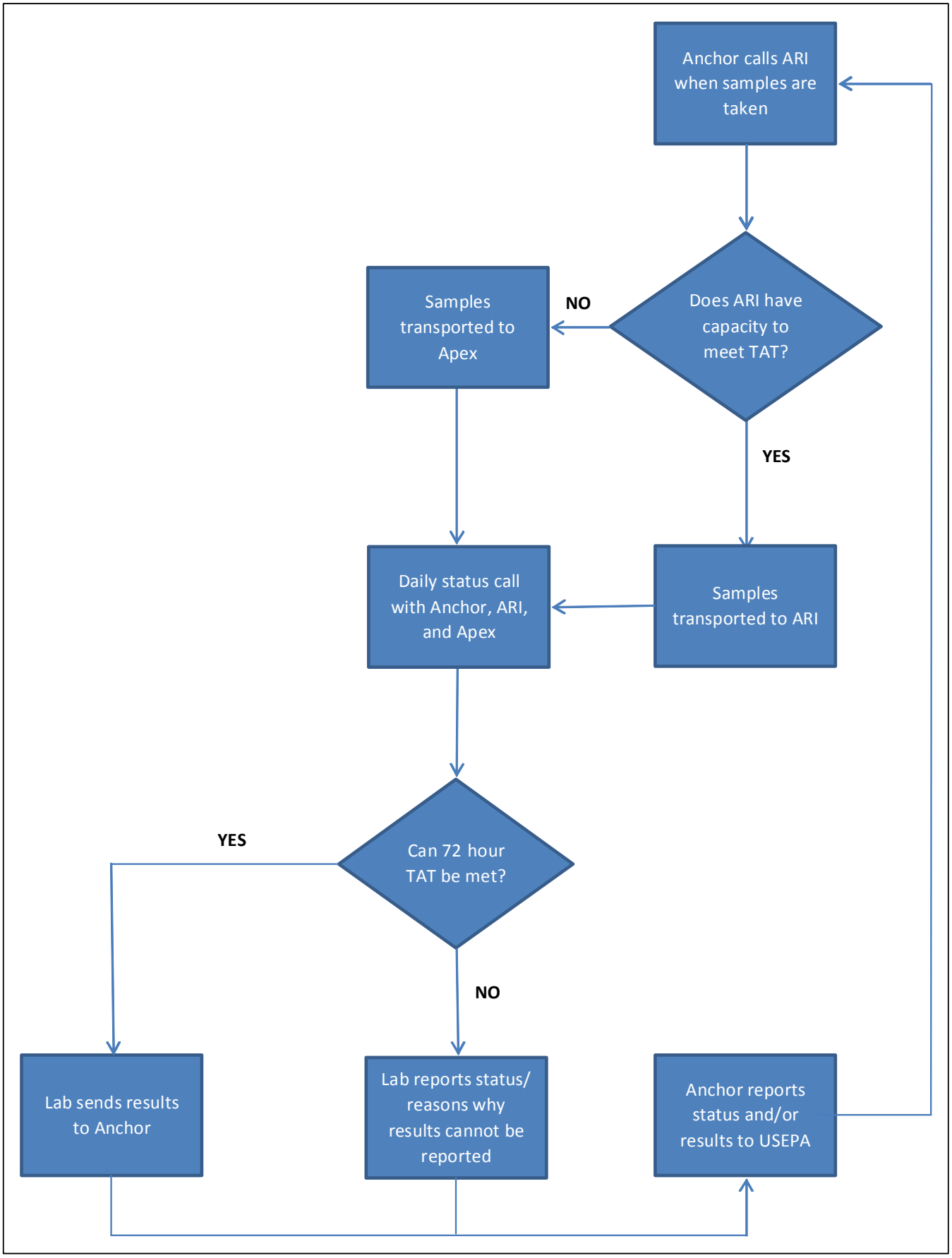

Figure 1
Laboratory Communication and Reporting Flow Chart
Terminal 4 Phase I Removal Action – Laboratory Communication Plan
Portland, Oregon

Sampling and Reporting Field Schedule for Port of Portland Terminal 4 Phase I Removal Action

Sun		Monday		Tuesday		Wednesday		Thursday		Friday		Sat	
3		**4**		**5**		**6**		**7**		**8**		**9**	
August													
10		**11**	Dredge B414	**12**	Dredge Center Square	**13**		**14**		**15**		**16**	
		Sampling Scheduled		Sampling Scheduled				*Expect results from 8/11 sampling*		*Expect results from 8/12 sampling*			
17		**18**		**19**	Dredge B411	**20**	Dredge B411	**21**	Dredge B411 Clean-up	**22**	Dredge B411	**23**	Dredge B411
		Water and **Soil** Sampling Scheduled		Sampling Scheduled		Sampling Scheduled		Sampling Scheduled *Expect Water and **Soil** results from 8/18 sampling*		Sampling Scheduled *Expect results from 8/19 sampling*		Sampling Scheduled *Expect results from 8/20 sampling*	
24	Dredge B411	**25**	Dredge B411	**26**	Dredge B411 AM Survey PM	**27**	B411 Analysis	**28**	Dredge B411 Clean-up	**29**		**30**	
Sampling Scheduled *Expect results from 8/21 sampling*		Sampling Scheduled *Expect results from 8/22 sampling*		Sampling Scheduled *Expect results from 8/23 sampling*		*Expect results from 8/24 sampling*		Sampling Scheduled *Expect results from 8/25 sampling*		*Expect results from 8/26 sampling*			
31		**1**		**2**		**3**		**4**	Sand Layer	**5**	Sand Layer	**6**	Dredge B410
Expect results from 8/28 sampling		September						Sampling Scheduled		Sampling Scheduled		Sampling Scheduled	
7	Dredge B410	**8**	Dredge B410	**9**	Slip 3 Cap (Base)	**10**	Slip 3 Cap Survey	**11**	Slip 3 Cap (Armor)	**12**	Slip 3 Cap (Armor)	**13**	Slip 3 Cap Survey
Sampling Scheduled *Expect results from 9/4 sampling*		Sampling Scheduled *Expect results from 9/5 sampling*		Sampling Scheduled *Expect results from 9/6 sampling*		*Expect results from 9/7 sampling*		Sampling Scheduled *Expect results from 9/8 sampling*		Sampling Scheduled *Expect results from 9/9 sampling*		Sampling Scheduled	
14		**15**		**16**	Dredge B410	**17**	Dredge B410	**18**	Dredge B410	**19**	Dredge B410	**20**	Dredge B410
Sampling Scheduled *Expect results from 9/11 sampling*		Sampling Scheduled *Expect results from 9/12 sampling*		Sampling Scheduled *Expect results from 9/13 sampling*		Sampling Scheduled *Expect results from 9/14 sampling*		Sampling Scheduled *Expect results from 9/15 sampling*		Sampling Scheduled *Expect results from 9/16 sampling*		Sampling Scheduled *Expect results from 9/17 sampling*	
21		**22**		**23**		**24**	B410 Survey	**25**	B410 Analysis	**26**	Dredge B410 Clean-up	**27**	
Expect results from 9/18 sampling		*Expect results from 9/19 sampling*		*Expect results from 9/20 sampling*						Sampling Scheduled			
28		**29**		**30**		**1**		**2**		**3**		**4**	
		Expect results from 9/26 sampling		**Soil** Sampling Scheduled		October				*Expect results from 9/30 **Soil** sampling*			

Attachment A
Daily Reporting Template for Field Parameters

Date:					
Time:					
Construction Activity:					
Round of Sampling for Day (eg., 1st of 3 events):					
Additional Comments:					
Water Velocity (fps)					
Station ID: Background					
Water Depth (ft)		Parameters			
Depth to Bottom		DO (mg/L)	Temp (°C)	Turb. (NTU)	pH
Depth 1					
Depth 2					
Depth 3					
Station ID: Early Warning					
Water Depth (ft)		Parameters			
Depth to Bottom		DO (mg/L)	Temp (°C)	Turb. (NTU)	pH
Depth 1					
Depth 2					
Depth 3					
Station ID: North					
Water Depth (ft)		Parameters			
Depth to Bottom		DO (mg/L)	Temp (°C)	Turb. (NTU)	pH
Depth 1					
Depth 2					
Depth 3					
Station ID: Middle					
Water Depth (ft)		Parameters			
Depth to Bottom		DO (mg/L)	Temp (°C)	Turb. (NTU)	pH
Depth 1					
Depth 2					
Depth 3					
Station ID: South					
Water Depth (ft)		Parameters			
Depth to Bottom		DO (mg/L)	Temp (°C)	Turb. (NTU)	pH
Depth 1					
Depth 2					
Depth 3					
Station ID: Turbidity -- Early Warning					
Water Depth (ft)		Parameters			
Depth to Bottom		DO (mg/L)	Temp (°C)	Turb. (NTU)	pH
Depth 1					
Depth 2					
Depth 3					
Station ID: Turbidity -- North					
Water Depth (ft)		Parameters			
Depth to Bottom		DO (mg/L)	Temp (°C)	Turb. (NTU)	pH
Depth 1					
Depth 2					
Depth 3					
Station ID: Turbidity -- Middle					
Water Depth (ft)		Parameters			
Depth to Bottom		DO (mg/L)	Temp (°C)	Turb. (NTU)	pH
Depth 1					
Depth 2					
Depth 3					
Station ID: Turbidity -- South					
Water Depth (ft)		Parameters			
Depth to Bottom		DO (mg/L)	Temp (°C)	Turb. (NTU)	pH
Depth 1					
Depth 2					
Depth 3					

Notes:

If turbidity criteria are not exceeded at the monitoring locations 100 meters from the center of the construction activity, then field parameter monitoring of turbidity 100 meters from the harbor line will not be performed or reported.

results may trigger response actions if deemd to have been caused by construction activities.

Trigger:

Water Velocity (fps)	1.0 fps or higher
DO (mg/L)	< 6.5 modify operations; < 6.0 cease operations
Turbidity (NTU)	> 5 NTU over background (where background < 50 NTU) or 10% over background (where background > 50 NTU); > 50 NTU over background, cease operations
pH (Standard Units)	< 6.5 or > 8.5

Attachment B
Daily Reporting Template for Laboratory Parameters

Date:
Time:
On-Time Result or Update:
Construction Activity:
Round of Sampling for Day (eg., 1st of 3 events):
Additional Comments:

Parameter	Units	Acute Criterion	Chronic Criterion	Highest Background*	Sample I.D.: Background Location Top	Background Location Middle	Background Location Bottom	Construction Location Top	Construction Location Middle	Construction Location Bottom
Conventional Parameters										
Total Suspended Solids (TSS)	mg/L	--	--	TBD						
Metals[6]										
Cadmium	µg/L	0.5	0.09	TBD						
Lead	µg/L	14	0.54	TBD						
Zinc	µg/L	36	36	TBD						
Polycyclic Aromatic Hydrocarbons (PAHs)										
Naphthalene	µg/L	807	194	TBD						
Acenaphthylene	µg/L	1277	307	TBD						
Acenaphthene	µg/L	233	56	TBD						
Fluorene	µg/L	162	39	TBD						
Phenanthrene	µg/L	79	19	TBD						
Anthracene	µg/L	87	21	TBD						
Fluoranthene	µg/L	30	7.1	TBD						
Pyrene	µg/L	42	10	TBD						
Benzo(a)anthracene	µg/L	9.2	2.2	TBD						
Chrysene	µg/L	8.3	2.0	TBD						
Benzo(b)fluoranthene	µg/L	2.8	0.68	TBD						
Benzo(k)fluoranthene	µg/L	2.7	0.64	TBD						
Benzo(a)pyrene	µg/L	4.0	0.96	TBD						
Indeno(1,2,3-cd)pyrene	µg/L	1.2	0.28	TBD						
Dibenzo(a,h)anthracene	µg/L	1.2	0.28	TBD						
Benzo(g,h,i)perylene	µg/L	1.8	0.44	TBD						

Notes:
N/AV - Result not yet available
ND - Non Detect
J - Not within quality control limits, estimated data
Above chronic criterion and background (and data not yet qualified)
Above acute criterion and background (and data not yet qualified)
* Value is the 90th percentile background value calculated during pre-construction, or the value of the highest background sample taken on the same day (whichever is higher).

APPENDIX F
RIVER CURRENT ANALYSIS

Technical Memorandum

WEST Consultants, Inc.

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www.westconsultants.com

To: Tom Wang, P.E.

Company: Anchor Environmental

Date: November 9, 2006

From: Henry Hu, Ph.D., P.E.

Subject: Hydrodynamic Modeling for Terminal 4

Introduction

WEST Consultants, Inc. (WEST) has taken the river-wide EFDC model, refined the grid to provide increased resolution in the vicinity of the slips, and used the hydrodynamic model to evaluate sediment capping, dredging, and berm construction. The EFDC model is being developed to simulate hydrodynamics and sediment transport in the Lower Willamette River for the Lower Willamette Group (WEST Consultants, 2006).

This technical memorandum is to provide a review of the modifications to the EFDC model and the results from simulations of the February 1996 event for the baseline conditions and the proposed actions. The February 1996 event was one of the largest floods on the Willamette River in recent history, and is considered to be close to a 100-year event. The peak flow was estimated to be 457,000 cfs.

Model Setup

Grid Extension/Refinement

The floodplain extent for the February 1996 event was determined using the results of a calibrated one-dimensional unsteady UNET model. The UNET model was developed by the Portland District, U.S. Army Corps of Engineers, and covers the Lower Columbia River System from Bonneville Dam to Astoria, Oregon, and includes major tributaries to the Columbia River, such as the Willamette River (USACE, 1996). The simulated maximum water surface elevations plus additional 0-3 feet were used to determine the lateral grid extent.

The grid was modified to increase the grid resolution in the area of the Terminal 4 slips. The

previous grid developed for the Lower Willamette Group to model the 1996 event had a nominal resolution in the vicinity of Terminal 4 of 200 m along the Willamette River and 25 m across the river. Cells resolve the lengths of Slips 1-3 but not their widths. The grid resolution in the Willamette River flow direction was increased to about 25 m from three rows of cells upstream to three rows of cells downstream of the slips. The resolution of the adjacent rows was increased to 50-100 m to provide a transition to the original grid. The result is a resolution of the order of 25 m longitudinally and laterally in the Terminal 4 study area. Figure 1 and Figure 2 show the grid in the vicinity of Terminal 4.

Due to the proposed berm placement in Slip 1, a further modification to the existing conditions EFDC grid was necessary to simulate the proposed conditions. The proposed berm completely closes Slip 1 from the flow in the Willamette River, and it was necessary to remove the cells within Slip 1 to maintain a stable model.

Bathymetry

For all model cells within the coverage of detailed existing bathymetric surveys, the bathymetry was based on the summer 2002 bathymetric survey. For all cells that are outside the bank-to-bank grid, the bathymetry was determined using two data sources. For areas between RM 0 and approximately RM 15, high-resolution LiDAR data were collected by LWG in December 2001. For areas beyond the LiDAR coverage and other detailed existing bathymetric surveys, the ground elevations were estimated using existing USGS Digital Elevation Models (DEM's).

The bathymetry in each cell in the EFDC model within the areas designated for capping, dredging, or berm placement was adjusted to capture the change in elevation due to the proposed actions. Anchor Environmental supplied WEST with plans containing elevations of the proposed conditions.

Boundary Conditions

A radiation separation condition was used along the three open boundaries. Hourly stage data at Vancouver, WA and St. Helens, OR for the February 1996 event were downloaded from the Columbia River Operational Hydromet Management System (CROHMS). CROHMS is an automated database for water management of the Columbia River system and is primarily operated by the U.S. Army Corps of Engineers.

Hourly river flows in the Willamette River were provided by the U.S. Army Corps of Engineers. The flow hydrograph was derived using the Corps' HEC-5 model based on observed inflows, outflows, and stages in CHROMS for gauged basins in all Willamette Valley Projects and estimated flows for ungauged rivers (USACE, 1996). Figure 3 shows the hydrograph for the February 1996 event.

Results

Baseline Conditions

Figure 1 shows the maximum cell shear stress in the vicinity of Terminal 4. The figure represents the maximum shear occurring during any point of the 1996 event hydrograph. The shear stress in the slip areas is relatively small with most cells ranging from 0 to 0.05 N/m^2 and only a small number of

cells in the 0.05 to 0.1 N/m^2 range. Compared to the main channel of the Willamette River, which has maximum shear stress values as large as 10 – 12 N/m^2, the slips are cut off from the main channel flow. Table 1 has the cell-by-cell values of the maximum shear stress and the maximum velocity, and Figure 2 shows the location of the cell identification number in Table 1.

Proposed Conditions

The proposed conditions, which include dredging, capping, and the berm closing Slip 1, were modeled to produce the maximum cell shear stresses and the maximum velocities similar to the existing condition results. Figure 4 shows the maximum cell shear stress for the proposed conditions. The maximum shear in Figure 4 follows similar patterns as in Figure 1. Again, the shear stress in Slip 3 and Wheeler Bay is small compared to the shear stress in the main channel of the Willamette River. Slip 1 has been removed from the domain due to the berm elevation. Table 2 has the cell-by-cell values of the maximum shear stress and the maximum velocity, and Figures 5 and 6 show the location of the cell identification number in Table 2.

To compare the results from the proposed condition simulation with the existing condition simulation, Figure 7 shows the cell-by-cell difference between the proposed maximum shear and the existing maximum shear. The differences between the shear stress of the proposed and existing conditions are within ±0.07 N/m^2 and the location of the largest difference is shown in Figure 7 at cell 4375. Figure 8 is a plot of difference in the maximum velocity at each cell. The maximum difference occurs near the same location, cell 4351, with a difference of 0.016 m/s.

Discussion

The results show that the slip areas are not significantly affected by the main channel flow except for water surface elevation. In the simulations of both the existing and proposed conditions the shear stress was minimal within the slips. The largest difference in shear stress between the existing and proposed conditions was 0.07 N/m^2. During the calibration of the EFDC model for LWG a critical shear of 0.5 N/m^2 was used. The increase in critical shear due to the proposed actions is not significant with respect to the critical shear stress. It should also be pointed out that the Willamette River flow and tidal influence are represented in the current EFDC model, however, some other local processes, such as Prop Wash, are not represented in the model.

References

U.S. Army Corps of Engineers (USACE). 1996. Lower Columbia UNET Model (Draft). Portland District.

WEST Consultants, Inc. 2006. Phase 2 Recalibration Results: Hydrodynamic Sedimentation Modeling for Lower Willamette River. Draft Report. Prepared for Lower Willamette Group, Portland, OR. WEST Consultants, Inc., Bellevue, WA.

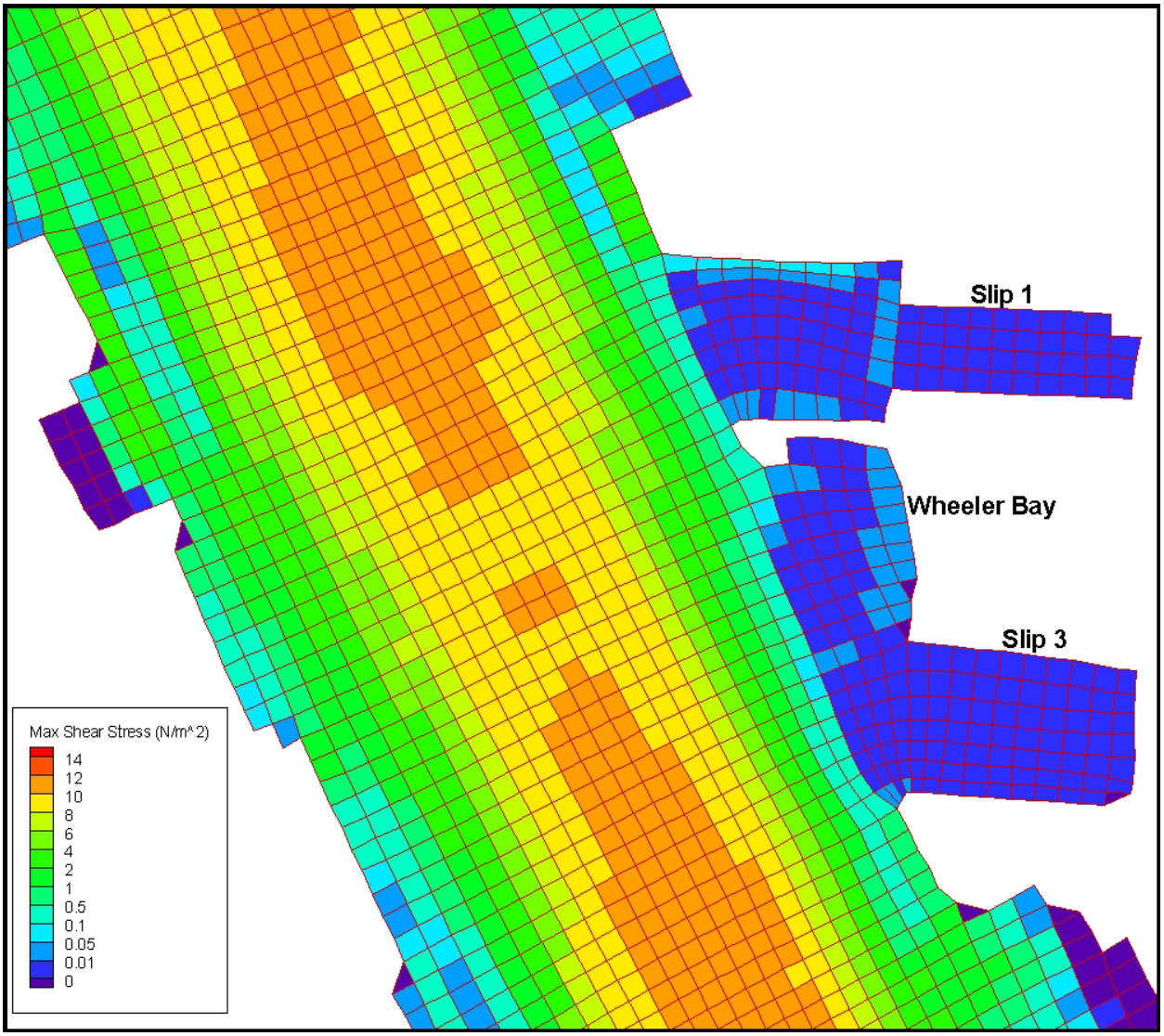

Figure 1. Existing Conditions Maximum Shear Stress

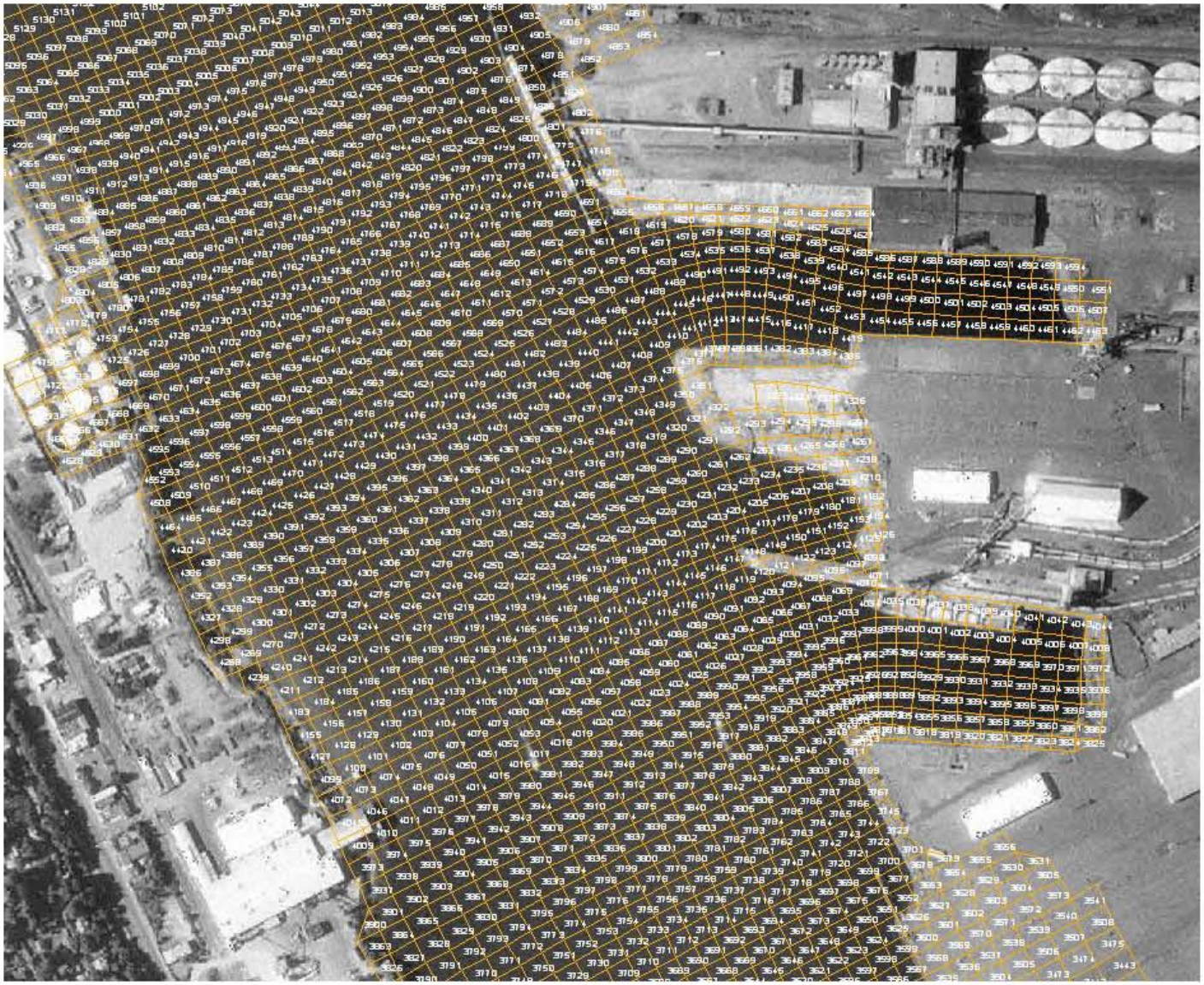

Figure 2. Existing Conditions Cell ID

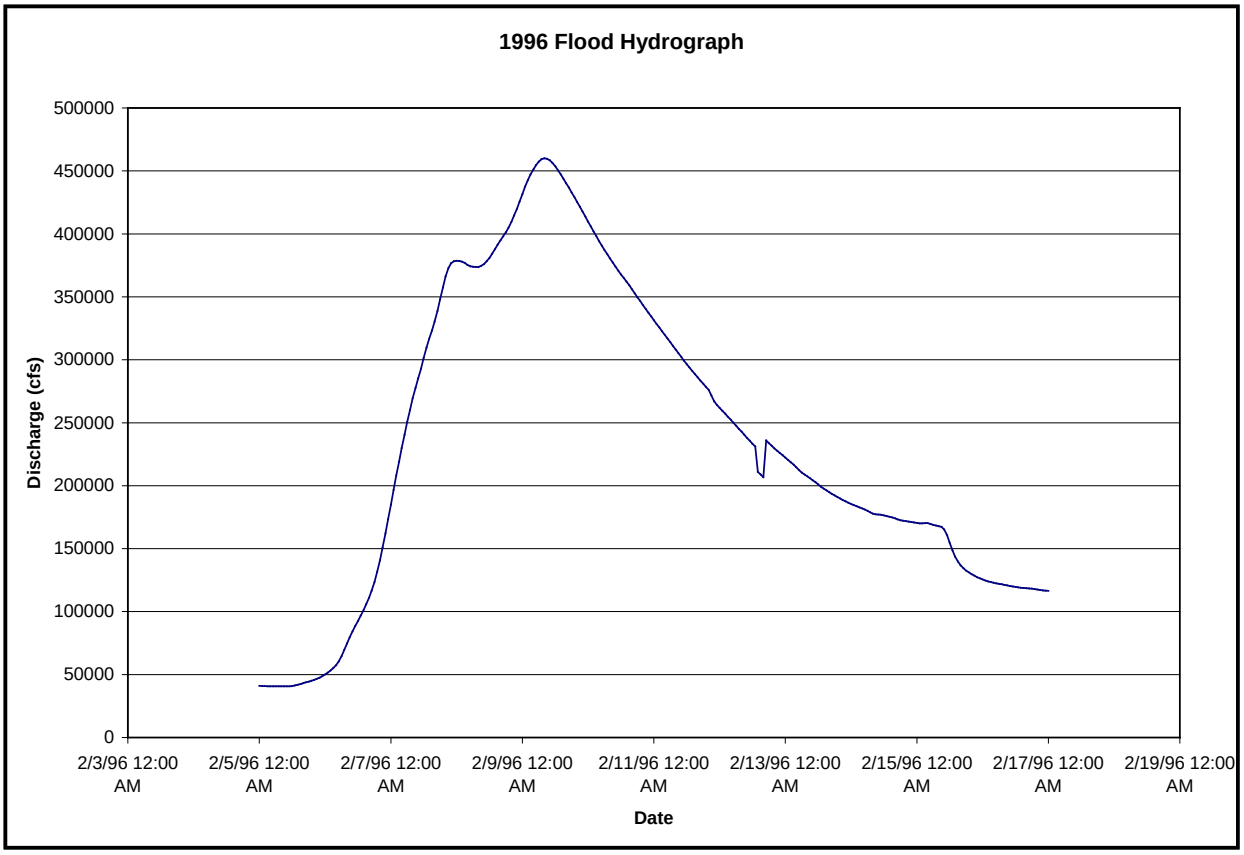

Figure 3. February 1996 Hydrograph

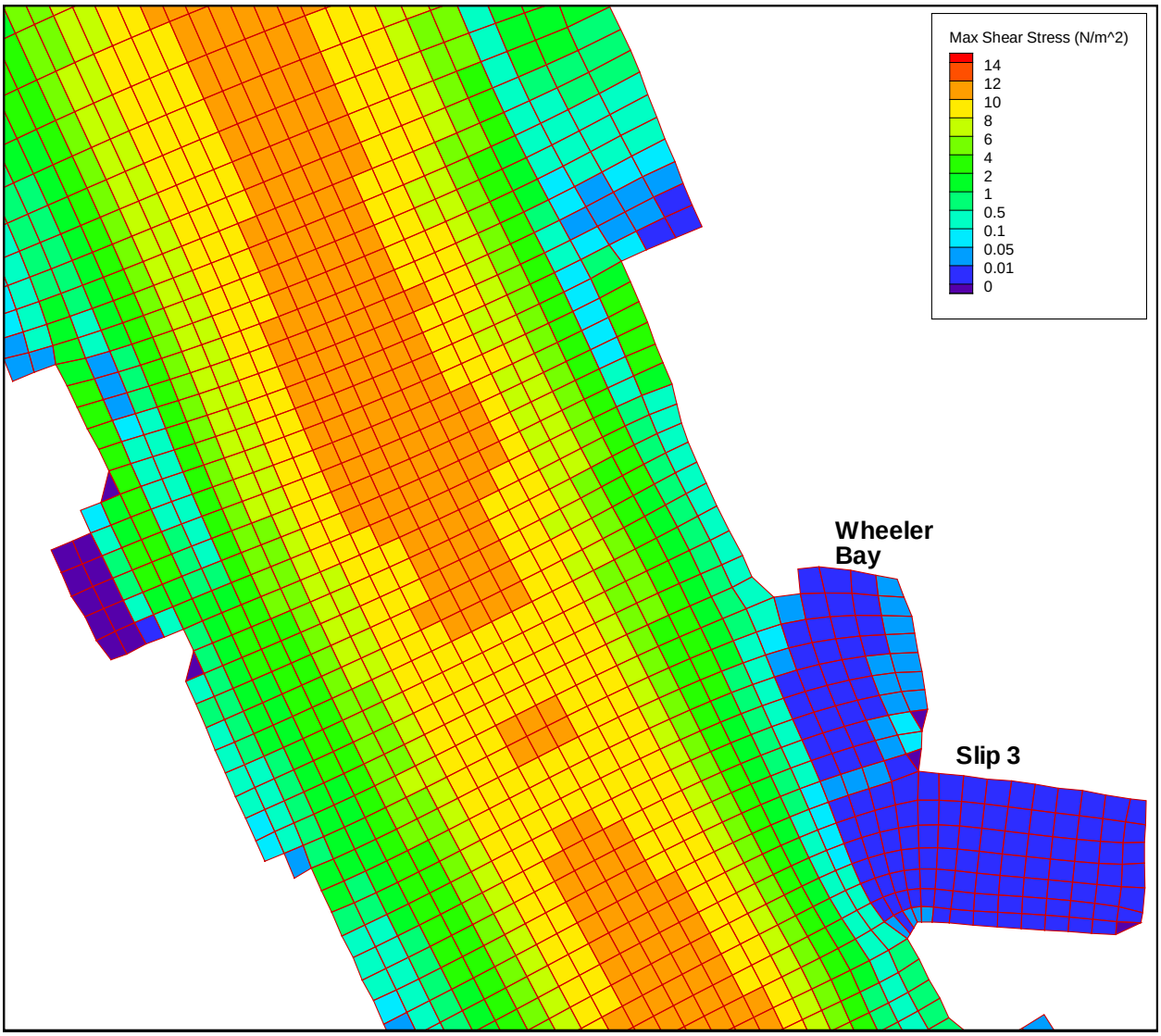

Figure 4. Proposed Condition Maximum Shear Stress

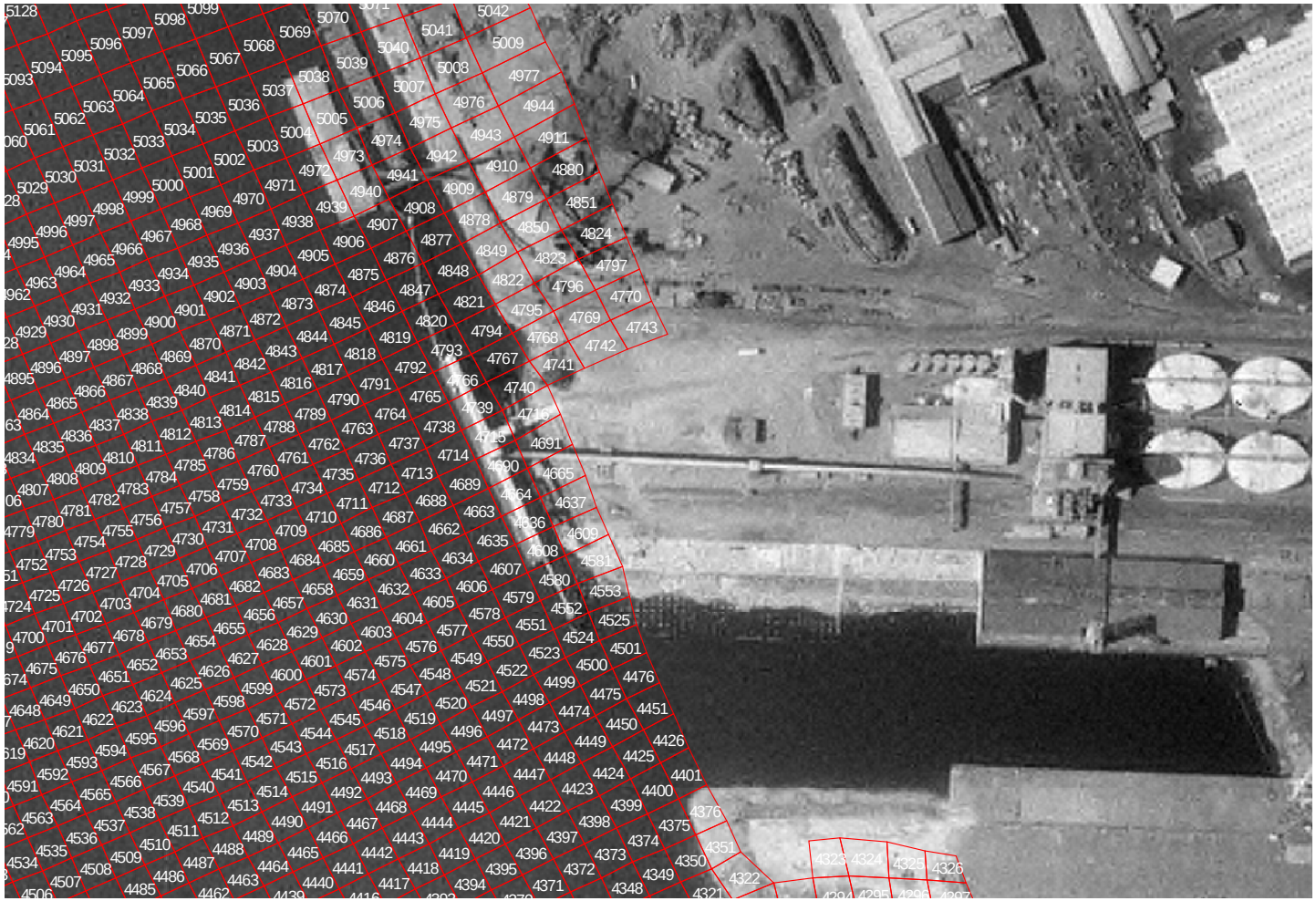

Figure 5. Proposed Conditions Cell ID near Slip 1

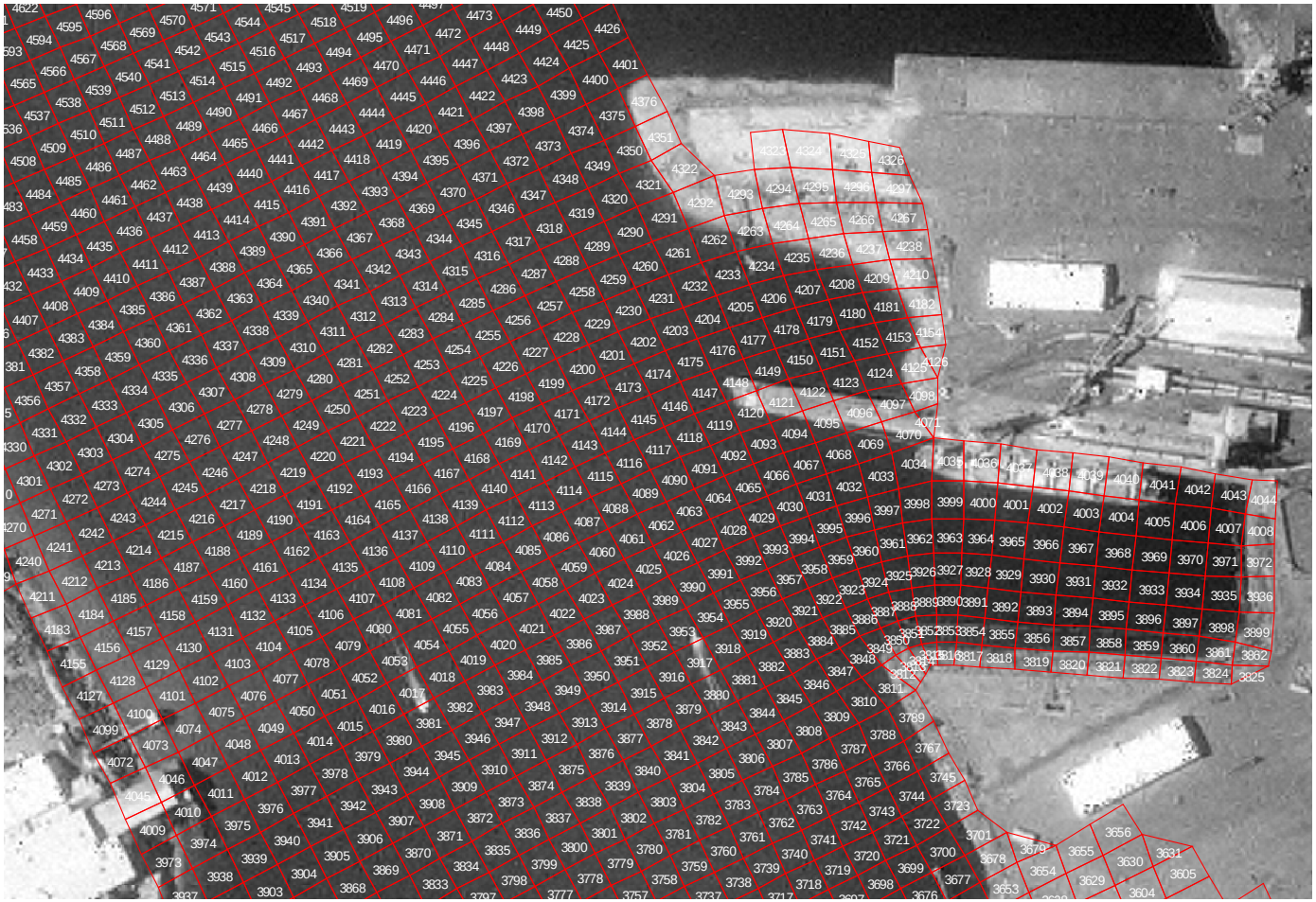

Figure 6. Proposed Conditions Cell ID near Slip 3

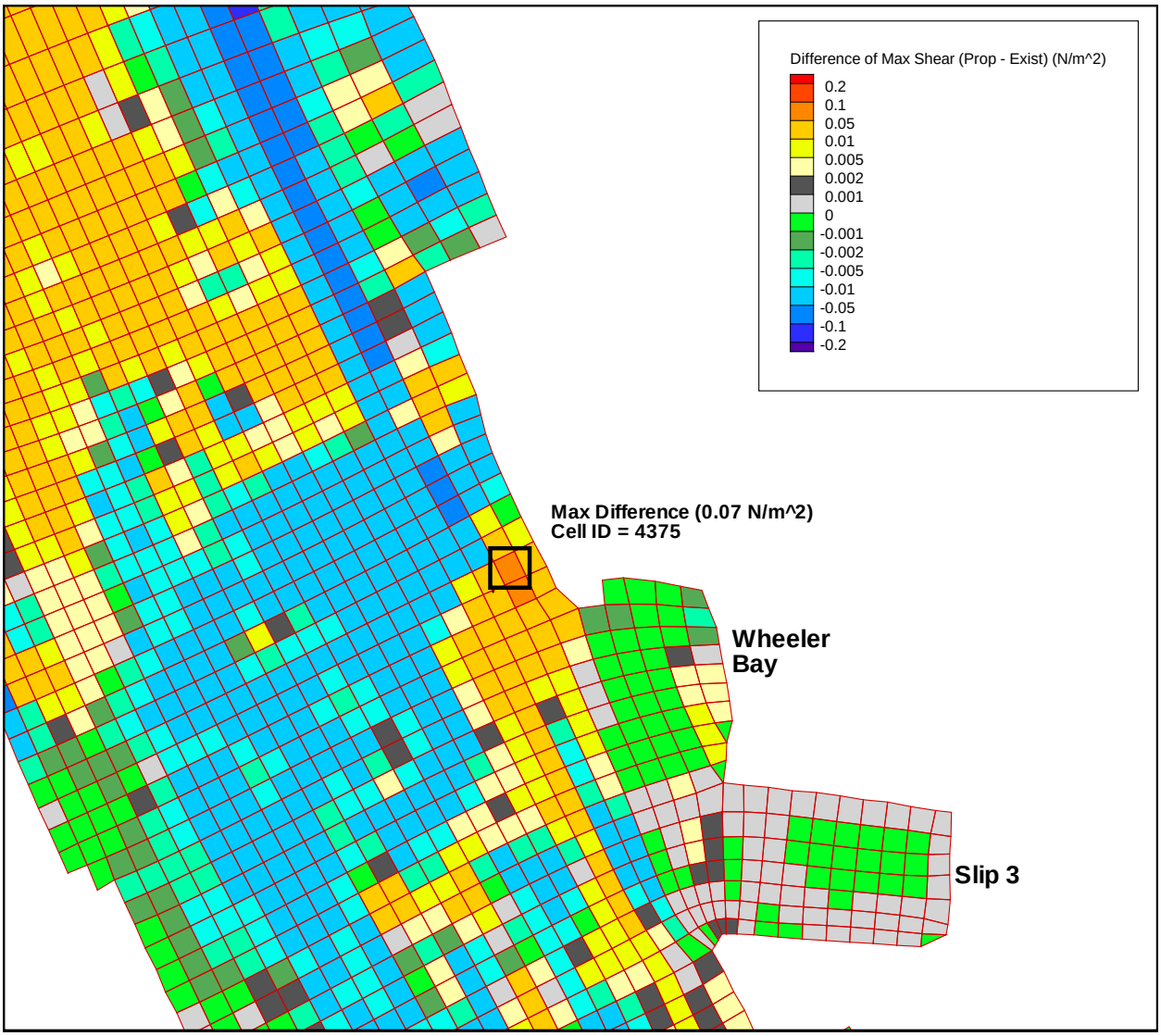

Figure 7. Difference between Proposed and Existing Conditions Maximum Shear Stress

Figure 8. Difference between Proposed and Existing Conditions Maximum Velocity

Tables 1 & 2. Existing and Proposed Condition Maximum Shear and Velocity

Existing

Cell ID	Maximum Shear Stress	Maximum Velocity (m/s)
3811	0.464	0.224
3812	0.020	0.028
3813	0.010	0.024
3814	0.010	0.026
3815	0.013	0.032
3816	0.009	0.029
3817	0.003	0.021
3818	0.003	0.023
3819	0.005	0.029
3820	0.006	0.032
3821	0.006	0.034
3822	0.007	0.034
3823	0.007	0.034
3824	0.006	0.032
3825	0.000	0.000
3846	1.209	0.466
3847	0.325	0.236
3848	0.187	0.168
3849	0.008	0.026
3850	0.004	0.026
3851	0.004	0.027
3852	0.004	0.027
3853	0.003	0.024
3854	0.002	0.018
3855	0.001	0.014
3856	0.001	0.015
3857	0.002	0.017
3858	0.002	0.017
3859	0.002	0.017
3860	0.002	0.018
3861	0.002	0.019
3862	0.003	0.023
3883	1.347	0.494
3884	0.390	0.262
3885	0.128	0.150
3886	0.004	0.024
3887	0.004	0.025
3888	0.003	0.024
3889	0.003	0.020
3890	0.001	0.014
3891	0.001	0.014
3892	0.001	0.013
3893	0.001	0.009
3894	0.000	0.006

Proposed

Cell ID	Maximum Shear Stress	Maximum Velocity (m/s)
3767	0.571	0.240
3787	1.013	0.420
3788	0.329	0.227
3789	0.636	0.253
3809	1.120	0.444
3810	0.321	0.227
3811	0.464	0.224
3812	0.021	0.029
3813	0.010	0.024
3814	0.011	0.026
3815	0.014	0.033
3816	0.011	0.030
3817	0.003	0.021
3818	0.003	0.023
3819	0.004	0.028
3820	0.006	0.032
3821	0.007	0.035
3822	0.007	0.035
3823	0.007	0.035
3824	0.006	0.033
3825	0.000	0.000
3846	1.217	0.468
3847	0.329	0.237
3848	0.185	0.167
3849	0.008	0.027
3850	0.005	0.027
3851	0.005	0.029
3852	0.005	0.029
3853	0.004	0.025
3854	0.002	0.019
3855	0.001	0.014
3856	0.002	0.016
3857	0.002	0.018
3858	0.002	0.018
3859	0.002	0.018
3860	0.002	0.019
3861	0.002	0.019
3862	0.004	0.024
3883	1.359	0.497
3884	0.392	0.263
3885	0.118	0.145
3886	0.004	0.025
3887	0.004	0.026
3888	0.004	0.025

Cell ID	Maximum Shear Stress	Maximum Velocity (m/s)
3895	0.000	0.006
3896	0.000	0.005
3897	0.000	0.004
3898	0.000	0.005
3899	0.005	0.030
3920	1.489	0.520
3921	0.459	0.284
3922	0.124	0.147
3923	0.003	0.022
3924	0.003	0.022
3925	0.003	0.023
3926	0.003	0.023
3927	0.002	0.016
3928	0.001	0.016
3929	0.001	0.014
3930	0.001	0.010
3931	0.000	0.007
3932	0.000	0.007
3933	0.000	0.008
3934	0.000	0.009
3935	0.001	0.013
3936	0.004	0.026
3956	1.572	0.534
3957	0.489	0.293
3958	0.116	0.142
3959	0.002	0.020
3960	0.002	0.018
3961	0.003	0.023
3962	0.004	0.026
3963	0.002	0.018
3964	0.001	0.014
3965	0.001	0.014
3966	0.001	0.011
3967	0.000	0.009
3968	0.000	0.009
3969	0.000	0.009
3970	0.001	0.010
3971	0.001	0.011
3972	0.002	0.016
3992	1.620	0.542
3993	0.502	0.297
3994	0.107	0.137
3995	0.002	0.017
3996	0.002	0.018
3997	0.004	0.025
3998	0.005	0.030
3999	0.002	0.018

Cell ID	Maximum Shear Stress	Maximum Velocity (m/s)
3889	0.003	0.025
3890	0.001	0.014
3891	0.002	0.019
3892	0.001	0.016
3893	0.001	0.012
3894	0.000	0.008
3895	0.000	0.006
3896	0.000	0.006
3897	0.000	0.005
3898	0.000	0.006
3899	0.006	0.031
3920	1.502	0.522
3921	0.451	0.283
3922	0.103	0.137
3923	0.003	0.023
3924	0.003	0.023
3925	0.004	0.028
3926	0.005	0.029
3927	0.001	0.015
3928	0.002	0.020
3929	0.001	0.016
3930	0.001	0.012
3931	0.000	0.007
3932	0.000	0.006
3933	0.000	0.007
3934	0.000	0.008
3935	0.001	0.012
3936	0.005	0.027
3956	1.587	0.537
3957	0.472	0.291
3958	0.089	0.128
3959	0.002	0.020
3960	0.002	0.020
3961	0.005	0.032
3962	0.006	0.033
3963	0.002	0.018
3964	0.002	0.018
3965	0.001	0.015
3966	0.001	0.011
3967	0.000	0.008
3968	0.000	0.006
3969	0.000	0.007
3970	0.000	0.008
3971	0.001	0.011
3972	0.002	0.017
3992	1.632	0.545
3993	0.476	0.293

Cell ID	Maximum Shear Stress	Maximum Velocity (m/s)
4000	0.001	0.012
4001	0.001	0.011
4002	0.001	0.010
4003	0.001	0.011
4004	0.001	0.011
4005	0.001	0.011
4006	0.001	0.010
4007	0.001	0.009
4008	0.001	0.010
4028	1.661	0.549
4029	0.513	0.301
4030	0.098	0.131
4031	0.003	0.022
4032	0.005	0.028
4033	0.006	0.030
4034	0.006	0.033
4035	0.003	0.020
4036	0.001	0.013
4037	0.000	0.009
4038	0.000	0.009
4039	0.001	0.011
4040	0.001	0.012
4041	0.001	0.012
4042	0.001	0.011
4043	0.000	0.008
4044	0.000	0.005
4064	1.715	0.558
4065	0.541	0.308
4066	0.095	0.128
4067	0.016	0.052
4068	0.014	0.047
4069	0.008	0.037
4070	0.006	0.032
4071	0.000	0.000
4091	1.769	0.565
4092	0.585	0.319
4093	0.107	0.133
4094	0.005	0.024
4095	0.002	0.012
4096	0.001	0.009
4097	0.018	0.041
4098	0.045	0.068
4118	1.797	0.569
4119	0.621	0.327
4120	0.119	0.140
4121	0.002	0.016
4122	0.001	0.010

Cell ID	Maximum Shear Stress	Maximum Velocity (m/s)
3994	0.081	0.122
3995	0.002	0.017
3996	0.002	0.019
3997	0.006	0.034
3998	0.007	0.034
3999	0.002	0.019
4000	0.001	0.014
4001	0.001	0.012
4002	0.001	0.010
4003	0.001	0.011
4004	0.001	0.011
4005	0.001	0.010
4006	0.001	0.010
4007	0.001	0.010
4008	0.001	0.011
4028	1.669	0.551
4029	0.484	0.295
4030	0.079	0.120
4031	0.004	0.023
4032	0.006	0.031
4033	0.006	0.033
4034	0.007	0.036
4035	0.003	0.023
4036	0.001	0.014
4037	0.000	0.009
4038	0.001	0.012
4039	0.001	0.014
4040	0.001	0.015
4041	0.001	0.014
4042	0.001	0.012
4043	0.000	0.009
4044	0.000	0.005
4064	1.728	0.560
4065	0.527	0.305
4066	0.091	0.126
4067	0.017	0.053
4068	0.015	0.049
4069	0.011	0.043
4070	0.006	0.032
4071	0.000	0.000
4091	1.785	0.568
4092	0.581	0.318
4093	0.110	0.135
4094	0.005	0.023
4095	0.002	0.012
4096	0.001	0.009
4097	0.018	0.040

Cell ID	Maximum Shear Stress	Maximum Velocity (m/s)
4123	0.001	0.009
4124	0.018	0.034
4125	0.048	0.076
4126	0.000	0.000
4146	1.814	0.572
4147	0.651	0.335
4148	0.129	0.145
4149	0.001	0.011
4150	0.001	0.008
4151	0.000	0.007
4152	0.001	0.009
4153	0.027	0.052
4154	0.030	0.057
4174	1.836	0.575
4175	0.691	0.345
4176	0.143	0.153
4177	0.001	0.010
4178	0.000	0.007
4179	0.000	0.006
4180	0.000	0.006
4181	0.016	0.040
4182	0.030	0.056
4202	1.857	0.578
4203	0.743	0.358
4204	0.163	0.163
4205	0.004	0.017
4206	0.000	0.007
4207	0.000	0.006
4208	0.000	0.006
4209	0.010	0.032
4210	0.028	0.055
4230	2.040	0.602
4231	0.884	0.388
4232	0.250	0.196
4233	0.016	0.040
4234	0.000	0.006
4235	0.000	0.006
4236	0.000	0.006
4237	0.008	0.025
4238	0.027	0.054
4259	2.353	0.639
4260	1.115	0.430
4261	0.423	0.247
4262	0.066	0.086
4263	0.000	0.005
4264	0.000	0.005
4265	0.000	0.006

Cell ID	Maximum Shear Stress	Maximum Velocity (m/s)
4098	0.052	0.071
4118	1.810	0.571
4119	0.615	0.326
4120	0.124	0.143
4121	0.002	0.016
4122	0.001	0.010
4123	0.001	0.009
4124	0.017	0.035
4125	0.057	0.079
4126	0.000	0.000
4146	1.827	0.574
4147	0.645	0.334
4148	0.134	0.148
4149	0.001	0.011
4150	0.000	0.008
4151	0.000	0.007
4152	0.001	0.009
4153	0.033	0.055
4154	0.034	0.058
4174	1.850	0.577
4175	0.689	0.345
4176	0.149	0.156
4177	0.002	0.011
4178	0.000	0.006
4179	0.000	0.006
4180	0.000	0.006
4181	0.021	0.043
4182	0.034	0.058
4202	1.873	0.581
4203	0.745	0.359
4204	0.170	0.166
4205	0.005	0.019
4206	0.000	0.006
4207	0.000	0.006
4208	0.000	0.006
4209	0.014	0.036
4210	0.032	0.056
4230	2.057	0.605
4231	0.891	0.389
4232	0.259	0.199
4233	0.017	0.041
4234	0.000	0.005
4235	0.000	0.005
4236	0.000	0.005
4237	0.010	0.028
4238	0.028	0.053
4259	2.376	0.642

Cell ID	Maximum Shear Stress	Maximum Velocity (m/s)
4266	0.004	0.017
4267	0.026	0.052
4289	2.471	0.651
4290	1.258	0.455
4291	0.529	0.272
4292	0.102	0.120
4293	0.021	0.048
4294	0.011	0.034
4295	0.001	0.007
4296	0.001	0.010
4297	0.026	0.053
4319	2.504	0.656
4320	1.338	0.469
4321	0.594	0.288
4322	0.144	0.138
4323	0.008	0.026
4324	0.007	0.032
4325	0.006	0.030
4326	0.014	0.031
4348	2.654	0.675
4349	1.481	0.493
4350	0.738	0.320
4351	0.230	0.179
4373	2.865	0.701
4374	1.672	0.525
4375	0.789	0.340
4376	0.215	0.176
4377	0.012	0.030
4378	0.012	0.041
4379	0.013	0.044
4380	0.010	0.040
4381	0.010	0.042
4382	0.012	0.045
4383	0.012	0.046
4384	0.010	0.040
4385	0.004	0.021
4407	3.042	0.727
4408	1.786	0.546
4409	0.728	0.342
4410	0.134	0.147
4411	0.009	0.031
4412	0.007	0.034
4413	0.008	0.036
4414	0.007	0.036
4415	0.007	0.034
4416	0.007	0.035
4417	0.007	0.035

Cell ID	Maximum Shear Stress	Maximum Velocity (m/s)
4260	1.131	0.433
4261	0.437	0.251
4262	0.070	0.089
4263	0.000	0.005
4264	0.000	0.005
4265	0.000	0.006
4266	0.004	0.018
4267	0.024	0.050
4289	2.500	0.655
4290	1.283	0.460
4291	0.554	0.278
4292	0.113	0.126
4293	0.019	0.045
4294	0.010	0.032
4295	0.000	0.006
4296	0.001	0.009
4297	0.024	0.050
4319	2.532	0.660
4320	1.367	0.474
4321	0.631	0.296
4322	0.166	0.148
4323	0.007	0.025
4324	0.006	0.030
4325	0.005	0.028
4326	0.013	0.029
4348	2.674	0.678
4349	1.511	0.498
4350	0.797	0.333
4351	0.274	0.195
4373	2.872	0.702
4374	1.691	0.528
4375	0.857	0.355
4376	0.253	0.190
4398	3.025	0.725
4399	1.773	0.544
4400	0.769	0.351
4401	0.142	0.150
4423	3.102	0.741
4424	1.793	0.555
4425	0.787	0.363
4426	0.117	0.140
4448	3.300	0.767
4449	1.937	0.580
4450	0.893	0.387
4451	0.139	0.152
4473	3.602	0.802
4474	2.131	0.609

Cell ID	Maximum Shear Stress	Maximum Velocity (m/s)
4418	0.007	0.035
4419	0.008	0.036
4441	3.139	0.745
4442	1.836	0.561
4443	0.781	0.361
4444	0.118	0.140
4445	0.005	0.025
4446	0.004	0.025
4447	0.003	0.023
4448	0.003	0.021
4449	0.002	0.019
4450	0.002	0.020
4451	0.003	0.023
4452	0.006	0.033
4453	0.014	0.049
4454	0.000	0.005
4455	0.000	0.007
4456	0.000	0.008
4457	0.000	0.007
4458	0.000	0.006
4459	0.000	0.005
4460	0.000	0.005
4461	0.000	0.005
4462	0.000	0.004
4463	0.000	0.002
4485	3.343	0.772
4486	1.994	0.589
4487	0.910	0.390
4488	0.145	0.155
4489	0.006	0.030
4490	0.002	0.019
4491	0.001	0.014
4492	0.001	0.009
4493	0.000	0.004
4494	0.000	0.004
4495	0.001	0.011
4496	0.006	0.031
4497	0.019	0.057
4498	0.001	0.012
4499	0.000	0.002
4500	0.000	0.002
4501	0.000	0.002
4502	0.000	0.002
4503	0.000	0.003
4504	0.000	0.003
4505	0.000	0.003
4506	0.000	0.002

Cell ID	Maximum Shear Stress	Maximum Velocity (m/s)
4475	0.966	0.402
4476	0.145	0.156
4498	3.898	0.834
4499	2.255	0.626
4500	0.965	0.402
4501	0.130	0.148
4522	4.233	0.869
4523	2.343	0.638
4524	0.846	0.376
4525	0.101	0.129
4550	4.449	0.895
4551	2.585	0.672
4552	0.620	0.309
4553	0.200	0.163
4578	4.483	0.905
4579	2.797	0.698
4580	0.414	0.231
4581	1.494	0.348
4606	4.650	0.924
4607	2.829	0.700
4608	0.216	0.158
4609	2.666	0.488
4634	4.959	0.955
4635	2.865	0.705
4636	0.094	0.101
4637	2.563	0.478
4662	5.238	0.981
4663	2.970	0.718
4664	0.058	0.079
4665	2.328	0.456
4688	5.532	1.008
4689	3.159	0.740
4690	0.056	0.077
4691	2.020	0.424
4713	5.468	1.008
4714	3.128	0.742
4715	0.064	0.083
4716	1.758	0.395
4737	5.072	0.984
4738	2.883	0.723
4739	0.060	0.095
4740	0.925	0.266
4741	0.085	0.056
4742	0.003	0.011
4743	0.007	0.010
4764	4.998	0.984
4765	2.855	0.727

Cell ID	Maximum Shear Stress	Maximum Velocity (m/s)
4507	0.000	0.002
4529	3.649	0.807
4530	2.193	0.618
4531	0.990	0.407
4532	0.166	0.167
4533	0.010	0.039
4534	0.001	0.014
4535	0.000	0.008
4536	0.001	0.012
4537	0.001	0.014
4538	0.001	0.013
4539	0.001	0.012
4540	0.005	0.029
4541	0.021	0.060
4542	0.001	0.013
4543	0.000	0.002
4544	0.000	0.003
4545	0.000	0.003
4546	0.000	0.003
4547	0.000	0.003
4548	0.000	0.003
4549	0.000	0.004
4550	0.000	0.003
4551	0.000	0.002
4573	3.944	0.839
4574	2.316	0.635
4575	0.982	0.406
4576	0.169	0.168
4577	0.009	0.036
4578	0.002	0.018
4579	0.004	0.023
4580	0.006	0.031
4581	0.006	0.031
4582	0.004	0.027
4583	0.003	0.023
4584	0.006	0.031
4585	0.020	0.060
4586	0.001	0.006
4587	0.000	0.007
4588	0.000	0.006
4589	0.000	0.005
4590	0.000	0.006
4591	0.000	0.006
4592	0.000	0.005
4593	0.000	0.004
4594	0.000	0.002
4615	4.271	0.873

Cell ID	Maximum Shear Stress	Maximum Velocity (m/s)
4766	0.184	0.153
4767	0.098	0.092
4768	0.030	0.053
4769	0.019	0.037
4770	0.009	0.013
4791	5.142	0.998
4792	2.993	0.745
4793	0.439	0.261
4794	0.017	0.039
4795	0.030	0.058
4796	0.030	0.050
4797	0.015	0.023
4818	5.208	1.005
4819	3.135	0.762
4820	0.757	0.354
4821	0.056	0.065
4822	0.044	0.076
4823	0.062	0.077
4824	0.072	0.050
4845	5.232	1.007
4846	3.280	0.779
4847	1.088	0.428
4848	0.085	0.081
4849	0.112	0.110
4850	0.157	0.122
4851	0.187	0.085
4874	5.225	1.006
4875	3.439	0.798
4876	1.452	0.496
4877	0.111	0.100
4878	0.206	0.150
4879	0.280	0.163
4880	0.315	0.111
4905	5.162	1.000
4906	3.613	0.818
4907	1.885	0.566
4908	0.136	0.117
4909	0.294	0.179
4910	0.410	0.198
4911	0.424	0.129
4938	5.634	1.033
4939	4.184	0.872
4940	2.554	0.657
4941	0.187	0.146
4942	0.411	0.199
4943	0.596	0.230
4944	0.526	0.142

Cell ID	Maximum Shear Stress	Maximum Velocity (m/s)
4616	2.391	0.645
4617	0.842	0.375
4618	0.150	0.158
4619	0.006	0.025
4620	0.012	0.043
4621	0.022	0.061
4622	0.026	0.067
4623	0.025	0.065
4624	0.020	0.058
4625	0.015	0.049
4626	0.010	0.039
4627	0.014	0.048
4652	4.479	0.898
4653	2.596	0.673
4654	0.584	0.299
4655	0.234	0.186
4656	0.063	0.093
4657	0.077	0.114
4658	0.082	0.117
4659	0.083	0.118
4660	0.077	0.114
4661	0.067	0.106
4662	0.051	0.092
4663	0.027	0.066
4664	0.008	0.030
4689	4.509	0.907
4690	2.795	0.697
4691	0.383	0.223
4692	1.485	0.346
4717	4.681	0.928
4718	2.844	0.702
4719	0.206	0.155
4720	2.656	0.487
4745	4.995	0.958
4746	2.902	0.709
4747	0.091	0.101
4748	2.572	0.479

Cell ID	Maximum Shear Stress	Maximum Velocity (m/s)
4971	6.830	1.114
4972	5.171	0.955
4973	3.311	0.747
4974	0.316	0.200
4975	0.677	0.229
4976	0.901	0.263
4977	0.653	0.156
5003	7.403	1.149
5004	5.688	0.995
5005	3.767	0.794
5006	0.362	0.225
5007	1.027	0.283
5008	1.181	0.299
5009	0.823	0.174
5036	7.299	1.141
5037	5.757	1.001
5038	4.017	0.820
5039	0.318	0.213
5040	1.304	0.320
5041	1.257	0.332
5042	1.168	0.205

APPENDIX G
BERM ARMOR DESIGN

ANCHOR QEA

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MEMORANDUM

To:	Port of Portland	**Date:**	November 17, 2006 *(Updated August 8, 2011)*
From:	Anchor QEA, LLC	**Project:**	050332-01
Cc:			
Re:	Flood Flow Current Erosion Analysis, Terminal 4 Early Action		

This memorandum presents the engineering analysis used to determine the material gradations necessary at the Terminal 4 cap areas and along the confined disposal facility (CDF) containment berm face for flood flow protection. Maximum river flow velocities were obtained from the hydrodynamic analysis of the 100-year flood event performed by WEST Consultants (WEST Consultants 2006; Appendix F to the DAR). This analysis is part of the armor layer design for the Early Action caps and containment berm; other analyses being performed include propeller wash and wave resistance.

METHODOLOGY

The U.S. Army Corps of Engineers (USACE) provides guidance for determining the material gradations for maximum flood flow or storm velocities near capped sediments. Appendix A, Armor Layer Design, of the *Guidance for In-Situ Subaqueous Capping of Contaminated Sediments* (Palermo et al. 1998) and Chapter 3 of the Engineering Manual (EM) 1110-2-1601 entitled, "Hydraulic Design of Flood Control Channels" (USACE 1994) provided procedures for evaluating the design. The method of determining stone size in the EM is based on a depth-averaged local velocity. However, the following equation, as presented in Appendix A of the Capping Guidance document, relates velocity to stone size for any location in the channel:

$$D_{50} = S_f C_S C_V C_T C_G d \left[\left(\frac{\delta_W}{\delta_S - \delta_W} \right)^{1/2} \frac{V}{\sqrt{K_1 g d}} \right]^{2.5}$$

Where,

S_f = Safety Factor – 1.3

C_S = Stability Coefficient for Incipient Failure - 0.3 for angular rock

C_V = Velocity Distribution Coefficient – 1 for straight channels, inside of bends

C_T = Blanket Thickness Coefficient – 1 for minimum thickness of material

C_G = Gradation Coefficient – 0.3 for angular rock

δ_W δ_S = Unit weight of water and sediment, respectively

d = local depth

V = Local depth averaged velocity

K_1 = Side Slope Correction Factor

K_1 is the relationship between the angle of the slope (θ) and the angle of repose for the cap material (ϕ) and is defined as:

$$K_1 = \sqrt{1 - \frac{\sin^2 \theta}{\sin^2 \phi}}$$

For this analysis, the angle of the slope was varied from 10H:1V to 2H:1V for the different cap areas. However, a final slope of 2H:1V was selected as a conservative approach, which results in a larger grain size. The angle of repose for the cap material used was 30 degrees for wet sand.

RESULTS OF THE RIVER FLOOD FLOW VELOCITY ANALYSIS

Table 1 summarizes the input parameters used and resultant grain size required to resist the 100-year flood flow conditions. As noted above, the local depth averaged velocity used in the analysis was determined from the EFDC model being developed for the hydrodynamic and sediment transport modeling of the Lower Willamette River for the Lower Willamette Group by WEST Consultants (2006). Grid locations referenced in the following summaries are provided on Figures 5 and 6 from the WEST Consultants report (Appendix F to the DAR).

Berth 401. The Berth 401 cap is located in water elevations of approximately -15 to above 20 feet National Geodetic Vertical Datum (NGVD). Velocities in the vicinity of the cap range from 0.13 to 0.87 feet per second (fps). The average depth velocity directly over the cap (No. 4767) is 0.30 feet per second, which requires a median grain size diameter (D_{50}) of 0.002 inches, or silt-sized material to resist erosion. The grid immediately to the south (No. 4740) has a velocity of 0.87 fps, which results in a D_{50} of 0.028 inches, or medium sand.

Wheeler Bay. The Wheeler Bay aquatic cap is located in water elevations of -10 to 0 feet NGVD. The majority of the grid areas covering the aquatic portion of the Wheeler Bay cap have velocities less than 0.05 fps, which results in a silt. The largest velocity determined for the cap area is 0.18 fps at grid No. 4153, which is also a silt.

Along the shoreline, the velocities are somewhat higher ranging from 0.12 fps along the northeastern slope to 0.26 fps on the eastern slope. For this velocity range, the D_{50} required to resist erosion for all the cap areas in Wheeler Bay is 0.0013 inches or less, which is a silt.

Berth 411. The Berth 411 cap is located in water elevations of -25 to +16 feet NGVD. A velocity of 0.07 fps for grid No. 4035 is representative of the grids along the pier (No. 4035 to No. 4042), which results in a D_{50} of 0.0001 inches, or silt. In addition, these velocities do not include the effects of underpier piling, which will dissipate the local water currents. Therefore, the flood current for the underpier area is assumed to be negligible.

Head of Slip 3. There are two distinct areas of the cap located at the head of Slip 3. The first is located in front of the bulkhead in water elevations of -35 to -18 feet NGVD. The second is located behind the bulkhead, which extends to elevation +6.7 feet, in water elevations of -18 to 20 feet NGVD. The majority of the grids along the head of the slip have velocities less than 0.1 fps, which results in a silt. The largest velocity determined for the area is 0.10 fps at grid No. 3899 in the southeast corner of the slip. This results in a maximum D_{50} of 0.0001 inches or silt required to resist erosion.

Pier 5. The Pier 5 cap is located in water elevations of -35 to +0 feet NGVD. Velocities along the major portion of the pier (from the head to the mouth of Slip 3) range from 0.05 to 0.12 FPS, which results in a maximum D_{50} of 0.0002, or silt. And similar to the analysis for Berth

411, these velocities would be further decreased due the effects of underpier piling, which dissipate the water currents. Therefore, the flood current for the Pier 5 underpier area is assumed to be negligible.

For the corner cap area at the mouth of Slip 3, higher velocities up to 0.55 and 0.74 fps were determined for the offshore (toe) portion of the slope cap (grid No. 3811 and No. 3848, respectively), which extends from the pier into the river. In this area, resulting D_{50} of 0.088 inches (fine sand) to 0.018 inches (medium sand) provide a stable stone size. At the upper portion of the slope the velocities decrease to less than 0.1 fps (e.g., 0.09 fps for grid No. 3849 adjacent and upslope from No. 3848).

Berth 414. The Berth 414 cap is submerged in a minimum water depth of 15 feet, and completely exposed to the river currents. Velocities were up to 0.74 fps at grid No. 3788 (located over the deeper portion of the cap) and up to 0.83 fps at grid No. 3789 further up the slope. This results in a maximum D_{50} of approximately 0.01 to 0.0125 inches, or fine sand, for the submerged cap area required to resist erosion.

CDF Berm. Table 2 summarizes the input parameters used and resultant grain size required to resist the 100-year flood flow conditions along the face of the Slip 1 CDF containment. At the lower section of the CDF (-35 to approximately -15 feet NGVD), the velocities range from 1.01 to 1.32 fps resulting in a medium sand, or a D_{50} of 0.02 to 0.04 inches. Along the face of the berm, elevation -15 to +25 feet NGVD, the velocities decrease to 0.42 to 1.14 fps, resulting in a maximum D_{50} of approximately 0.005 to 0.055 inches, or fine to medium sand required to resist erosion.

REFERENCES

Palermo, M., Maynord, S., Miller, J., and Reible, D. 1998. "Guidance for In-Situ Subaqueous Capping of Contaminated Sediments," EPA 905-B96-004, Great Lakes National Program Office, Chicago, IL.

U.S. Army Corps of Engineers (USACE). 1994. Hydraulic Design of Flood Control Channels. EM 1110-2-1601, US Government Printing Office, Washington, DC.

WEST Consultants, Inc. 2006. Hydrodynamic Modeling for Terminal 4 Memo. Prepared for Anchor Environmental, October 31, 2006.

TABLES

Table 1
Sediment Cap Size Results for Flood Flows in Cap Areas

Cap Area	Representative Grid Number	Minimum Water Depth (Feet)	Shear Stress (Dynes/Cm^2)	Local Depth Averaged Velocity (Feet/Second)	D_{50} in Inches	Sediment Type
Berth 401	4767	1	0.98	0.30	0.0020	SILT
	4794	1	0.17	0.13	0.0002	SILT
	4740	1	9.25	0.87	0.0281	MEDIUM SAND
	4768	1	0.30	0.17	0.0005	SILT
Wheeler Bay Aquatic Cap	4124	10	0.17	0.11	0.0001	SILT
	4153	10	0.33	0.18	0.0003	SILT
	4181	10	0.21	0.14	0.0002	SILT
Wheeler Bay Shoreline Cap	4098	1	0.52	0.23	0.0010	SILT
	4125	1	0.57	0.26	0.0013	SILT
	4209	1	0.14	0.12	0.0002	SILT
Berth 411	4035	1	0.03	0.07	0.0001	SILT
Head of Slip 3	3899	1	0.06	0.10	0.0001	SILT
Pier 5	3822	1	0.07	0.12	0.0002	SILT
	3851	1	0.05	0.10	0.0001	SILT
Pier 5 Corner at Mouth of Slip 3	3811	1	4.64	0.74	0.0182	MEDIUM SAND
	3849	1	0.08	0.09	0.0001	SILT
	3848	1	1.85	0.55	0.0088	FINE SAND
Berth 414	3788	15	3.29	0.74	0.0096	FINE SAND
	3789	15	6.36	0.83	0.0125	FINE SAND

Notes:

The majority of the Wheeler Bay Aquatic grid areas (4123,4151, 4152,4179, 4180, 4207, and 4208) have velocities less than 0.05 fps.

The slope cap areas along the northern shoreline of Wheeler Bay (Grid numbers 4236, 4235, 4264, and 4263) have velocities less than 0.05 fps.

The cap grid areas at the Head of Slip 3 (3898, 3899, 3935, 3936, 3971, 3972, 4007, 4008, 4043, and 4044) have velocities less than 0.1 fps.

Table 2
Sediment Size Results for Flood Flows along the Slip 1 CDF

Cell Number	Minimum Water Depth (Feet)	Shear Stress (Dynes/Cm^2)	Local Depth Averaged Velocity (Feet/Second)	D_{50} in Inches	Sediment Type
4475	15	9.66	1.32	0.040	MEDIUM SAND
4500	15	9.65	1.32	0.040	MEDIUM SAND
4450	15	8.93	1.27	0.036	MEDIUM SAND
4524	15	8.46	1.23	0.034	MEDIUM SAND
4425	15	7.87	1.19	0.031	MEDIUM SAND
4400	15	7.69	1.15	0.029	MEDIUM SAND
4552	15	6.20	1.01	0.021	MEDIUM SAND
4581	1	14.94	1.14	0.055	MEDIUM SAND
4553	1	2.00	0.53	0.008	FINE SAND
4476	1	1.45	0.51	0.007	FINE SAND
4451	1	1.39	0.50	0.007	FINE SAND
4401	1	1.42	0.49	0.007	FINE SAND
4501	1	1.30	0.48	0.006	FINE SAND
4426	1	1.17	0.46	0.006	FINE SAND
4525	1	1.01	0.42	0.005	FINE SAND

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MEMORANDUM

To:	Port of Portland	**Date:**	November 9, 2006 *(Updated August 8, 2011)*
From:	Anchor QEA, LLC	**Project:**	050332-01
Cc:			
Re:	Propeller Wash Analysis for Terminal 4		

This memorandum presents the engineering analysis used to determine the material gradations necessary at the Terminal 4 cap areas for protection from propeller wash. This analysis is part of the armor layer design for the Early Action caps; other analyses being performed include flood flow and wave resistance.

The propeller jet of a maneuvering vessel has the potential to impact the cap surface and may cause erosion of capping materials if they are not sized appropriately. Propeller wash in prospective capping areas include commercial vessels and tugs. Propeller wash velocities from vessels will likely be localized and of short duration. The propeller wash from passing tugs and commercial vessels along the Willamette River will not likely affect the cap surface. However, the propeller from these vessels during a maneuvering operation (e.g., berthing with bow thruster or tug assist) can cause significant erosion of bottom sediments if an appropriate armor stone is not in place to resist the propeller-induced bottom velocities.

Commercial vessels that call on Berth 411 in Slip 3 are "Panamax" size, deep-draft Bulk Carrier (primarily grain) ships. While Berth 401 is not currently in operation, future operations at the berth are likely to include similar vessels. This same assumption was used in sizing the armor protection required on the confined disposal facility (CDF) containment berm—vessels calling on the new replacement berth will induce propeller wash on the berm face. These vessels are assisted in and out of port by large privately-owned tractor tugs. In addition to maneuvering within Slip 3 and around Berth 401, the tugs may also operate in Wheeler Bay and Berth 414 while on stand-by.

1 PROPWASH MODELING THEORY

The currently available predictive models for propeller-induced bottom velocities are based on jet flow for a stationary jet, and were developed more than 30 years ago without significant revisions since. The rotation of a vessel's propeller produces an underwater jet, commonly called propeller wash. The bottom water velocities caused by propellers were predicted using a spreadsheet model PROPWASH, based on the equations developed by Blaauw and van de Kaa (1978) and Verhey (1983). This approach is also recommended in Appendix A of the U.S. Environmental Protection Agency and U.S. Army Corps of Engineers (USEPA/USACE) guidance document *Guidance for In-Situ Capping of Contaminated Sediments* (Palermo et al. 1998b). This model requires specific input regarding vessel characteristics (e.g., propeller diameter, depth of shaft, and shaft horsepower) and has been used for several cap designs approved by state and federal agencies.

The jet velocity exiting the propeller is calculated using Equation 4 from the USACE guidance document:

$$U_o = C_2 \left(\frac{P_d}{D_p^2} \right)^{1/3}$$

Where,

P_d = the applied engine/propeller power in HP

C_2 = 9.72 for non-ducted propellers or 7.68 for ducted propellers

The maximum bottom velocity in the propeller wash of a maneuvering vessel is calculated using Equation 3 from the USACE guidance document:

$$V_{b(\max)} = \frac{C_1 U_o D_o}{H_p}$$

Where,

$V_{b(max)}$ = the maximum bottom velocity in feet per second (fps)

C_1 = 0.22 for non-ducted propeller or 0.30 for ducted propeller
U_0 = the jet velocity exiting propeller in fps (calculated from Equation 4, above)
D_p = the diameter of the propeller in feet
D_0 = the initial slipstream diameter which is 0.71 D_p for a non-ducted propeller or D_p for a ducted propeller
H_p = the distance from propeller shaft to channel bottom in feet

For a defined water depth, bottom velocities at various distances behind the propeller are computed using the jet velocity exiting the propeller (Blaauw and van de Kaa 1978):

$$\frac{V_X}{U_0} = 2.78\,\frac{D_0}{x}\,\exp\left[-15.43\frac{z^2}{x^2}\right]$$

Where,
V_x = the velocity at x and z in fps
D_0 = 0.71 D_p for a non-ducted propeller or D_p for a ducted propeller
X = the axial distance (behind) from the propeller plane in feet
Z = the vertical distance from the propeller axis

The model predicts the bottom velocity and associated grain size required to resist the long-term, steady-state propeller wash from vessels for a given depth and distance behind the propeller. It is important to note that these analyses are conservative for the case of a moving vessel as they are solely based on slowly maneuvering vessels (i.e., vessel speed of zero). However, in reality, the propeller wash force is transient in nature since the vessels typically are operating at some speed, which acts to significantly reduce the duration and magnitude of the propeller wash.

In addition, the stable stone size equation for propeller wash developed by Blaauw et al. (1984) incorporates a coefficient, C_3, to describe the degree of sediment transport allowed, which is a site-specific parameter based on the acceptability of particle rearrangement. Data from Maynord (1984) and (Palermo et al. 1998b) suggests that C_3 equal to 0.55 is appropriate in harbor areas where repeated (or consistent directional) attack is expected and no transport/movement can be tolerated. In contrast, C_3 equal to 0.70 is reported as sufficient

for general channel protection where infrequent attack (or random directional attack) is expected and thus, small transport is allowed such that normal river flow conditions or other random attacks will serve to reposition a localized perturbation of bottom sediment. Values of 0.55 to 0.70 were assumed for C_3 based on the vessel operating conditions for each cap area, with 0.70 selected for general cap protection where less frequent attack from vessel operation (i.e., non-localized scour effects) is expected.

Effects of the jet produced by propeller wash can also be described in terms of depth of scour caused by slowly maneuvering ships. Maximum scour depths were computed for a defined grain size as a function of water depth and duration of scour, based on the following empirical relationship developed by Hamill (1988):

$$\varepsilon_{\max} = 45.04\Gamma^{-6.98}\left[\ln(t)\right]^{\Gamma}$$

Where,

ε_{max} = the maximum depth of scour in mm

Γ = experimental coefficient $= 4.1135\left[\frac{C}{D_{50}}\right]^{0.742}\left[\frac{D_P}{D_{50}}\right]^{-0.522} F_o$

C = tip clearance in mm = $d_{water} - \left(d_{shaft} + \frac{D_p}{2}\right)$

F_0 = Froude Number $= \frac{V_o}{\sqrt{D_{50}\left(\gamma_s - \gamma_w\right)/\gamma_w}}$

t = the duration of scour in seconds

A spreadsheet was used to determine these empirical relationships among initial velocity, tip clearance, propeller diameter, sediment size, and time in order to compute scour depth at different locations for a given grain size.

2 DESIGN VESSELS

Discussions with tug operators and the Columbia River Pilots indicate that the bulk carrier vessels and large tractor-tugs normally navigate in the deeper portions of Slip 3 as they enter from the river. Tugs that typically operate at the Port of Portland's (Port's) facilities and

were selected for analysis include the *Daniel Foss* (owned and operated by Foss Maritime) and the *Portland* (owned and operated by Shaver Transportation Company). The *Portland* is the most powerful tug that operates at the Port, with a maximum horsepower (HP) of 3,600 and a draft of 12.6 feet. The *Daniel Foss* has a larger draft, 16 feet, and a maximum HP of 3,200. Communications with the tug captains revealed that the tugs use an average of approximately 25 percent of their maximum HP for typical maneuvering and repositioning, and between 50 and 75 percent for escort operations when thrust is applied during initial movement of the larger vessels. In addition, the higher HP is typically applied in short, 30 second to 1 minute, bursts for initial movement of the vessels, then decreased to lower levels (50 percent or less) for continual movement.

The large, deep-draft, foreign-flagged bulk carrier ships typical at Terminal 4 are single propeller with engine power from 5,000 to 12,000 HP and lengths of 500 to 700 feet. The *Duncan Bay*, 555 feet long with a 32-foot draft and a maximum HP of 7,800 is typical of vessels that call at Berth 411 in Slip 3. The *Monte Pelmo* is a larger vessel, nearly 740 feet long with a roughly 40-foot draft and maximum HP of 12,000, which could call at Berth 401 along the river where there is more room. Vessels calling at Berth 410/411 are also often in the range of 700 feet length, with drafts of about 40 feet. The 32-foot draft vessel is used in calculations because such draft may be more relevant for under pier slopes due to the sheetpile wall.

Characteristics of the different vessels considered in this analysis are presented in Table 1. In addition to the propellers on the vessels, it was assumed that a typical bow thruster propeller on a 35-foot draft vessel would be 5 to 6 feet in diameter with a maximum HP of 2,000. Although the local tug operators were not aware of any vessels with bow thrusters operating in Slip 3, potential bow thruster propeller wash impacts to the Underpier Capping Area at Berth 411 were addressed in this analysis.

3 CAP AREA CHARACTERISTICS

The cap areas at Terminal 4 were divided into segments to analyze the propwash associated with a specific vessel and its operation for the given site conditions. Table 2 shows the cap area, specific vessel to be analyzed, the range of water depths within the cap area, and the

approximate lateral distance from the vessel operation (propeller) to the cap area. In Wheeler Bay, which has limited access, and Berth 414 cap areas, only tugs were analyzed.

4 PROPELLER WASH ANALYSIS RESULTS

The maximum predicted bottom velocity and stable sediment size results of the analysis are presented in Table 3. The following subsections provide a summary of the results for each of the capping areas.

4.1 Berth 401

The PROPWASH model was run for the *Portland* and the *Monte Pelmo* for the cap area ranging from elevation -15 to 0 feet National Geodetic Vertical Datum (NGVD). The model was run for the tug *Portland* assuming the operator applies up to 25 percent of the total horsepower for maneuvering in shallow water (minimum water depth of 15.5 feet), and for the bulk carrier vessel *Monte Pelmo* assuming that the operator uses up to 50 percent of the total horsepower when departing the pier.

For the tug, a propwash velocity of 1.3 to 1.9 fps was calculated, which results in a median grain size diameter (D_{50}) of 2 inches (coarse gravel) required to limit scour. The calculated maximum scour depth is for the shallowest water the tug would maneuver in and assumes the tug is stationary for 30 seconds to 2 minutes. Conversation with the tug operators indicate the initial power applied when getting underway is typically less than 30 seconds, and less than 2 minutes when initially assisting the commercial vessels. For Berth 401, the maximum scour depth for the 2-inch coarse gravel ranged from 3.7 to 4.5 inches.

For the *Monte Pelmo*, propwash velocities of 2.3 to 4.8 fps were calculated for operations at 50 percent power for a distance of 300 feet to 150 feet from the cap area, respectively, as the vessel is initially pulled from the berth by tugs, then begins to operate under its own power as it moves north. The results of the analysis neglect the impact of the pile field between the vessels and the cap area, which is difficult to quantify. The piles in the area would decrease the propwash velocity, resulting in a smaller required capping material. Therefore, for the Berth 401 cap area, a propwash velocity of 2.3 fps is still considered to be a conservative value, and results in a D_{50} of 2.5 inches, or coarse gravel.

4.2 Wheeler Bay

The PROPWASH model was run for the tug *Daniel Foss* for the aquatic cap and shoreline cap in Wheeler Bay where water depths range from -10 to +20 feet NGVD. Similar to the previous analysis, the model was run assuming the operator applies up to 25 percent of the total horsepower for maneuvering in shallow water (minimum water depth of 19 feet). The propwash velocities for the aquatic and shoreline cap areas range from 1.2 to 4.2 and 1.6 to 3.6 fps, respectively. The resulting D_{50} ranged from 8 to 11 inches (cobbles) for the areas. The estimated maximum scour depth for when the vessel is operating in shallowest water over the cap area is 1.7 to 2.6 inches.

4.3 Berth 411 – Underpier

The PROPWASH model was run for a typical bow thruster on a bulk carrier vessel, such as the *Duncan Bay*. The bow thruster modeled has a propeller diameter of 6 feet and a maximum HP of 2,000. The bow thruster is ducted and located approximately 7 feet above the keel of the vessel.

The location of the submerged sheetpile wall along Berth 411 will impact the propwash velocities generated by the bow thrusters along the slope under the pier. The top elevation of the sheetpile wall is -18.3 feet NGVD. In addition, the water depth behind the sheetpile wall will have a greater impact on the results than for the other capping areas due to the limited distance between the propeller and the slope cap material.

For this analysis, two scenarios were modeled to determine the impact on the lower portion of the slope behind the sheetpile wall and the impact on the upper section of the slope. The first scenario assumes the worst-case condition, where the bottom tip of the propeller is just above the submerged sheetpile wall, or the centerline of the propeller shaft is at elevation -15.3 feet (assuming the propeller has a 6-foot diameter), and the horizontal distance from the propeller to the slope is minimal. The second scenario assumes a maximum water column depth, which occurs during ordinary high water (OHW; i.e., when the waterline is at elevation 16.6 feet NGVD). This will estimate the propwash impact on the upper portion of the slope, as the propeller shaft is at its highest elevation in the water column.

For the first scenario, with the waterline at elevation +10 feet NGVD, the bow thruster was assumed to operate between 25 and 50 percent of the total horsepower when leaving the pier. Given these conditions, propwash velocities of 7.85 to 2.8 fps were calculated 15 to 65 feet from the pier line toward shore at the underpier slope between elevation -20 and 0 feet NGVD (30- to 10-foot water depths), respectively. Cap areas on the slope lower than elevation -20 feet NGVD would have significantly less shear stress due to a shadowing effect caused by the sheetpile wall, and would be on the lower end of the propwash velocities, or approximately 3 fps or less.

Similar to the previous analysis, the bow thruster was assumed to operate between 25 and 50 percent of the total horsepower for the second scenario in which the waterline is at elevation +16.6 feet NGVD. Smaller propwash velocities of 6.5 to 2.6 fps for the slope between elevation -13 and +6 feet NGVD resulted due to the increased horizontal distance from the propeller to the slope area (30 to 70 feet from the pier line).

In both cases, the results of the bow thruster analysis are overly conservative given the presence of the large number of timber piling supporting the pier structure. The piling would dissipate the energy of the propeller jet generated by the bow thruster, resulting in a lower shear stress on the slope cap material. Therefore, the 25 percent operational condition is determined to be appropriate for the site, and still conservative. The resulting D_{50} for the cap material for the different slope elevations are presented below for both the low water and high water cases.

Resulting required D_{50}:

Elevation in Feet NGVD	-25 to -20	-20 to -14	-14 to -10	-10 to -5	-5 to OHW
D_{50} for Case 1 (Waterline at +10)	6 inch	1.5 ft	1 ft	6 inch	4 inch
D_{50} for Case 2 (Waterline at +16.6)	2 inch	1 ft	1 ft	9 inch	4 inch

Subsequent analysis of the bottom velocity at various distances along the slope was performed using the equation developed by Blaauw and van de Kaa (1978) to plot a

relationship for varying water depths for the uncapped slope. As shown on Figure 1, the maximum bottom velocity for each distance to the slope occurs at an elevation equal to the position of the propeller shaft (25 feet in this case). In addition, the fully-developed jet velocity distribution is similar to a horizontal bell-shaped curve, equal vertical distances (above and below the propeller shaft) result in the same velocity-distance curve. Specifically, the velocity-distance curve for a position of 30 feet is the same as that for 20 feet (both 5 feet from the propeller shaft with a water depth of 25 feet).

4.4 Head of Slip 3 – Behind the Bulkhead

The PROPWASH model was run for the tug *Portland* for repetitive attacks on the shoreline cap behind the bulkhead when assisting commercial vessels at Berth 411. The top elevation of the bulkhead is +6.7 feet NGVD, so when the upper tip of the propeller is at that elevation or below, the propwash from the tug will impact the wall and not the slope (e.g., water elevations of +10 feet NGVD or lower). Similar to the analysis for the underpier area of Berth 411, the worst-case condition occurs when the bottom tip of the propeller is just above the submerged sheetpile wall. However, because the propeller shaft is 8 feet below the waterline and the maximum water elevation during which normal shipping operations are assumed to occur (OHW) is +16.6 feet NGVD, the shaft would be at elevation +8.6 feet, with the bottom tip of the propeller at elevation +4.1 feet, or 2.6 feet below the top of the sheetpile wall. The sheetpile wall would create some shadowing effect for any water elevation, and the jet velocity would be further limited as the waterline drops. As a result, propwash effects for the area are considered negligible for the selection of cap material for the area.

4.5 Head of Slip 3 – In Front of the Bulkhead

The PROPWASH model was run for the bulk carrier vessel *Duncan Bay* and for repetitive attacks by the tug, *Daniel Foss*, in water depths ranging from -25 to -10 feet NGVD. The model was run for the tug assuming the operator applies up to 75 percent of the total horsepower for assisting commercial vessels during berthing and sailing. In addition, tug operators typically maintain a minimum distance of one ship length from slopes and in-water structures when performing berthing operations. For this analysis, the tug would maintain a distance of 100 feet from the bulkhead. The model was run for the *Duncan Bay*, assuming

that the operator uses up to 75 percent of the total horsepower when departing the pier with tug assistance. The vessel would have a minimum distance of 200 feet from the bulkhead to allow access for the tug.

For the tug, propwash velocities of 2.3 to 3.0 fps were calculated, which results in a D_{50} of 6 inches (cobbles). The calculated maximum scour depth for the shallowest water the tug would maneuver in (19 feet) was 1.7 to 2.6 inches for a D_{50} of 6 inches (cobbles). For the *Duncan Bay*, propwash velocities of 2.9 to 3.9 fps were calculated, resulting in a D_{50} of 7 inches (cobbles) and scour depths between 1 and 1.6 inches.

4.6 Pier 5

The PROPWASH model was run for the tug *Daniel Foss* for the shoreline cap at Pier 5 from elevation -40 to 0 feet NGVD. Similar to previous analyses, the model was run assuming the operator applies 25 to 75 percent of the total horsepower for maneuvering near the pier and comes no closer than 100 feet while assisting commercial vessels into Berth 411. The propwash velocities ranged from 2.0 to 3.2 fps for these operating conditions. The resulting D_{50} ranged from 4 to 7 inches (cobbles), with estimated scour depths of 2 to 3 inches for the smaller, 4-inch cobbles and less than 1 inch for the larger, 7-inch cobbles.

4.7 Berth 414

The PROPWASH model was run for the tug *Daniel Foss* and the tug *Portland* at Berth 414 where water depths ranged from -30 to 0 feet NGVD. Similar to the previous analyses, the model was run assuming the operator applies up to 25 percent of the total horsepower for maneuvering in shallow water (minimum water depth of 19 feet for the *Daniel Foss* and 15.5 feet for the *Portland*). The propwash velocities for both tugs ranged from 1.4 to 4.1 fps, and the resulting D_{50} was 8 inches (cobbles) for both tugs in the cap area. The estimated maximum scour depth was 1 to 1.6 inches when the *Daniel Foss* operates in 19 feet of water and 1.2 to 1.9 inches when the *Portland* operates in 15.5 feet of water. The scour depth becomes less than half an inch when the water depth is increased by 2 feet.

4.8 CDF Berm Face

The PROPWASH model was run for the *Portland* and the *Monte Pelmo* at Berth 401 adjacent to the CDF berm face. As described in Sections 2, Design Vessels, and 4.1, Berth 401, above, the model was run for the tug *Portland* at 25 percent HP for maneuvering, and at 50 percent HP for the *Monte Pelmo* when departing the pier. The vessel *Monte Pelmo* resulted in higher propwash velocities than the tug at Berth 401 and, therefore, additional modeling specific to the CDF berm face was performed using this vessel. The propwash velocities were calculated at a distance of 125 feet to 400 feet behind the vessel, which is the approximate distance from the vessel at berth and the face of the CDF at the lowest elevations of -35 feet NGVD to the upper elevations approaching OHW. The following presents the resulting velocities and D_{50} for the cap material at the different locations on the berm face for two situations, when the waterline is at 0 feet NGVD and when the waterline is at OHW.

Elevation in Feet NGVD	-35 to -25	-25 to -10	-10 to 0	0 to OHW
Case 1 (Waterline at 0)				
D_{50}	15 inch	7 inch	4 inch	NA
Velocity	5.7 fps	3.9 fps	2.9 fps	
Case 2 (Waterline at +16.6)				
D_{50}	7 inch	6.5 inch	5 inch	3 inch
Velocity	3.75 fps	3.7 fps	3.2 fps	2.4 fps

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TABLES

Table 1
Vessel Type

Vessel Type	Length Overall in Feet	Beam in Feet	Draft in Feet	Maximum HP	Operational HP	Propeller Diameter in Feet	Depth of Propeller Axle in Feet
Tugs							
"Daniel Foss"	96	32	16.0	3,200	800-2,400	8	12
"Portland"	108	34	12.6	3,600	900-2,700	9	8
Bulk Carrier Ships - Propeller							
"Duncan Bay"	555	89	32	7,800	1,950-5,850	16	23
"Monte Pelmo"	738	106	39.5	12,000	3,000-9,000	18	30
Bulk Carrier Ship - Bow Thruster							
"Duncan Bay"	555	89	32	2,000	500-1,500	6	25

The typical range of Maximum HP for bulk carrier ships is 5,000 to 12,000. The Operational HP for tractor tugs varies from 25 percent for maneuvering and repositioning, to between 50 and 75 percent for escort operations—50 percent for typical escort and 75 percent for initial movement of the vessels. The Operational HP input value for propwash modeling depends on the anticipated activity of the vessel relative to the particular cap location. For example, the large vessels may not directly impact the Wheeler Bay aquatic and slope caps, but tugs may as they reposition in the area.

Table 2
Cap Area Characteristics

Cap Area		Design Vessel Type	Water Depths in Feet NGVD	Approximate Lateral Distance from Vessel to Cap in Feet	Additional Factors	Comments on Existing Conditions
Berth 401		Tug - Portland	-15 to +15	105 to 250	Piling between vessels and cap area.	The existing area is predominantly fine to medium sand. Currently, there is no vessel activity.
		Vessel - Monte Pelmo		150 to 300		
Wheeler Bay	Shoreline	Tug - Daniel Foss	0 to +20	75 to 400+	Propwash from vessels at Berth 410 have to go through dense pile field supporting the berth. Vessel propwash will also be from the new replacement pier.	The existing area is predominantly fine to medium sand.
	Aquatic	Tug - Daniel Foss	-10 to 0	75 to 300		
Berth 411 Underpier		Tug - Portland	-40 to -5	20 to 50	Piling and sheetpile wall between vessels and cap area. Sheetpile wall top at elev -20 feet NGVD.	
		Vessel - Duncan Bay		25 to 55		
Head of Slip 3	Behind Bulkhead	Tug - Daniel Foss	-10 to +15	60 to 135	Area behind sheetpile built to a top elevation of 10 feet NGVD.	
	In Front of Bulkhead	Tug - Daniel Foss	-25 to -10	30 to 120+		
		Vessel - Duncan Bay		100 to 190		
Pier 5 Area		Tug - Daniel Foss	-35 to 0	50 to 100		
Berth 414		Tug - Daniel Foss	-30 to 0	30	Tugs may maneuver near cap during repositioning/stand-by. Ships will not sail from the cap area. The impacts caused by passing ships will be considered in the surface wave analysis.	
		Tug - Portland		30		

Table 3
Propeller Wash Results for Port of Portland Terminal 4 Cap Areas

Cap Area and Vessel Type	Waterline Elevation in Feet	Vb(max) Range in Feet per Second	D_{50} in Inches	Cap Material Description	Estimated Scour Depth in Inches	Primary Design Assumptions
Berth 401 - Aquatic						
Tug - "Portland"		1.3 to 1.9	2.0	COARSE GRAVEL	3.0 to 4.5	Tug operational at 25% max for maneuvering in shallow water (minimum water depth of 15.5 feet). The results do not include additional factors such as the pile field between the vessels and the cap area.
Vessel - "Monte Pelmo"		2.3 to 4.8	11.0	COBBLES	0.4 to 0.7	Vessel at 50% maximum HP when departing (minimum water depth of 45 feet). The results do not include additional factors such as the pile field between the vessels and the cap area.
Wheeler Bay - Aquatic						
Tug - "Daniel Foss"	+3.0	1.2 to 4.2	11.0	COBBLES	1.7 to 2.6	Cap Area 2 (Detail refs from Dwg. Sheet 14). Tug operational at 25% max for maneuvering in shallow water (minimum water depth of 19 feet).
Wheeler Bay - Shoreline						
Tug - "Daniel Foss"	+3.0	1.6 to 3.6	8.0	COBBLES	N/A - For Slope Areas	Cap Area 1 (Detail refs from Dwg. Sheet 14). Tug operational HP at 25% max for maneuvering in shallow water (minimum water depth of 19 feet).
Berth 411 - Underpier						
Vessel - "Duncan Bay" Bow Thruster						Distances from pierline to mudline along the slope for varying water depths are based on POP T4 Sheet C-10.dwg dated August 2006. The results do not include additional factors such as the pile field of the pier between the vessel and the cap area.
Mudline Elev. -25	0	2.1 to 3.0	4.0	COBBLES	N/A	Vessel's bow thrusters operational at 25% max for operating at the pierhead line. Propeller at top of sheetpile wall.
Mudline Elev. -20	0	6.1 to 6.2	18.0	RIP RAP ARMOR	N/A	Vessel's bow thrusters operational at 25% max for operating at the pierhead line. Propeller at top of sheetpile wall.
Mudline Elev. -14	0	4.7 to 5.6	12.0	RIP RAP ARMOR	N/A	Vessel's bow thrusters operational at 25% max for operating at the pierhead line. Propeller at top of sheetpile wall.

Table 3
Propeller Wash Results for Port of Portland Terminal 4 Cap Areas

Cap Area and Vessel Type	Waterline Elevation in Feet	Vb(max) Range in Feet per Second	D_{50} in Inches	Cap Material Description	Estimated Scour Depth in Inches	Primary Design Assumptions
Mudline Elev. -10	+16.6	3.8 to 4.8	9.0	COBBLES	N/A	Vessel's bow thrusters operational at 25% max for operating at the pierhead line. Propeller approximately 10 feet above tip of sheetpile wall.
Mudline Elev. -5	+16.6	3.0 to 3.2	4.0	COBBLES	N/A	Vessel's bow thrusters operational at 25% max for operating at the pierhead line. Propeller approximately 10 feet above tip of sheetpile wall.
Head of Slip 3 - Behind Bulkhead						
Tug - "Portland"	+16.6	3.2 to 3.7	9.0	COBBLES	0.1 to 0.3	Tug operational at 75% max for assisting vessels. Distances from stern of tug to the mudline along the slope for varying water depths were based on Figure 12 of the 30% DAR dated August 2006 and Table 2 - Cap Area Characteristics. Propeller tip elevation at top of sheetpile wall.
Head of Slip 3 - In Front of Bulkhead						
Tug - "Daniel Foss"		2.3 to 3.0	6.0	COBBLES	1.7 to 2.6	Tug operational at 75% max for assisting vessels. Distances from stern of tug to the mudline along the slope for varying water depths was based on Figure 12 of the 30% DAR dated August 2006.
Vessel - "Duncan Bay"		2.9 to 3.9	7.0	COBBLES	1.0 to 1.6	Vessel operational at 75% max for departing the pierhead line with tug assistance. Distances from stern of the vessel to mudline elevations along the slope were based on Figure 12 of the 30% DAR dated August 2006.
Pier 5 Area						
Tug - "Daniel Foss"		2.0 to 2.3	4.0	COBBLES	1.9 to 2.9	Tug operational HP at 75% max for assisting vessel into Berth 411. Distances from stern of the vessel to mudline elevations along the slope were based on Figure 12 of the 30% DAR dated August 2006.
Tug - "Daniel Foss"		2.4 to 3.2	7.0	COBBLES	0.5 to 0.9	Tug operational HP at 25% max for maneuvering near Pier 5. Distances from stern of the vessel to mudline elevations along the slope were based on Figure 12 of the 30% DAR dated August 2006.

Table 3
Propeller Wash Results for Port of Portland Terminal 4 Cap Areas

Cap Area and Vessel Type	Waterline Elevation in Feet	Vb(max) Range in Feet per Second	D_{50} in Inches	Cap Material Description	Estimated Scour Depth in Inches	Primary Design Assumptions
Berth 414 - Aquatic						
Tug - "Daniel Foss"	+3.0	1.6 to 4.0	8.0	COBBLES	1.0 to 1.6	Tug operational at 25% max for maneuvering in shallow water (minimum water depth of 19 feet).
Tug - "Portland"		1.4 to 4.1	8.0	COBBLES	1.2 to 1.9	Tug operational at 25% max for maneuvering in shallow water (minimum water depth of 15.5 feet).
CDF Berm Face						
Tug - "Portland"		1.3 to 1.9	2.0	COARSE GRAVEL	3.0 to 4.5	Tug operational at 25% max for maneuvering in shallow water (minimum water depth of 15.5 feet).
Vessel - "Monte Pelmo"						Vessel at 50% maximum HP when departing (minimum water depth of 45 feet).
Mudline Elev. -35	0	3.8 to 5.7	15.0	RIP RAP ARMOR	N/A	
Mudline Elev. -25	0	3.7 to 3.9	7.0	COBBLES	N/A	
Mudline Elev. -10	+16.6	3.2 to 2.9	5.0	COBBLES	N/A	
Mudline Elev. 0	+16.6	0.0 to 2.4	3.0	VERY COARSE GRAVEL	N/A	

The Estimated Scour Depth is for the most shallow water the vessel would operate in and assumes the vessel is operating at the assumed parameters, and stationary for 30 seconds to 2 minutes.

FIGURES

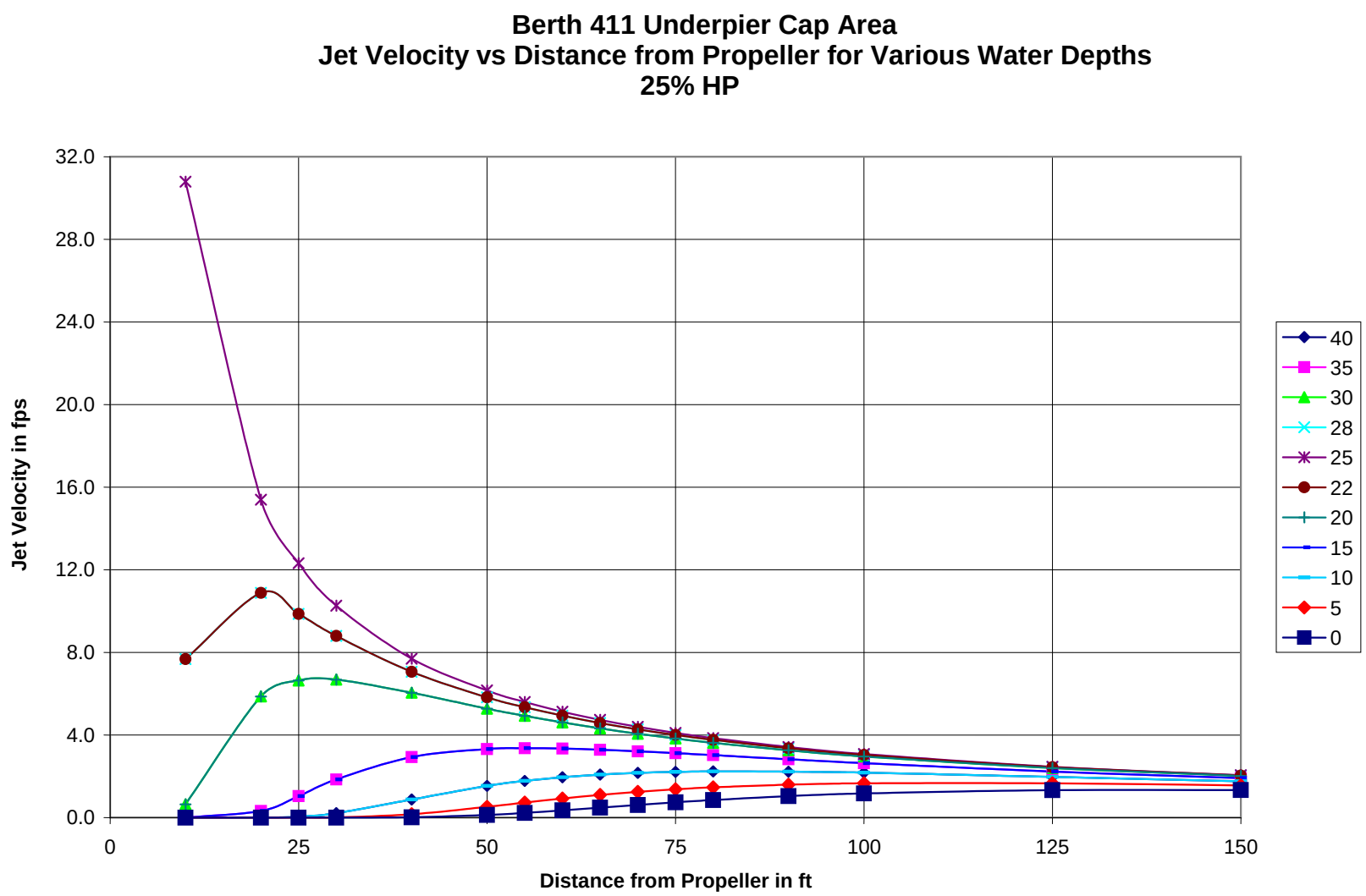

Figure 1
Jet Velocity vs. Distance from Propeller for Various Water Depths
Propeller Wash Analysis – Terminal 4 Early Action
Portland, Oregon

ANCHOR QEA

ANCHOR QEA

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MEMORANDUM

To:	Port of Portland	**Date:**	November 9, 2006 *(Updated August 8, 2011)*
From:	Anchor QEA, LLC	**Project:**	050332-01
Cc:			
Re:	Wind- and Vessel-Induced Wave Analysis for Terminal 4		

This memorandum provides an analysis of the impacts of surface waves on the Terminal 4 cap areas. Surface waves generated by wind conditions and vessel activity within the Terminal 4 project area and adjacent Willamette River are analyzed. For each of the wave-generating elements, the methodology of the analysis and results for the Terminal 4 aquatic cap areas, including Berth 401, Wheeler Bay, Berth 411, the Head of Slip 3, Pier 5, and Berth 414, and the Slip 1 containment berm, are presented herein. Finally, the memorandum presents stable sediment sizes for each of the aquatic cap areas due to wave shear forces and discusses the effects of wave breaking forces on the shoreline areas. This analysis is part of the armor layer design for the Early Action caps and containment berm; other analyses being performed include propeller wash and flood flow current resistance.

1 WIND WAVE ANALYSIS

1.1 Methodology

The methodology used for wind-induced wave analysis was comparable to that used for the McCormick & Baxter Superfund Site, located approximately 3 miles upstream of Terminal 4, (PB Ports & Marine 2002). Wind data was obtained for the Portland International Airport from the National Climatic Data Center (1976 to 2004) and the Meteorological Resource Center (Webmet.com) (1961 to 1975). The wind speed datasets were adjusted to a consistent anemometer height of 20 feet. Wind speed and wind direction (the direction the wind is coming from in degrees clockwise from true North) values represent the average over a

2-minute period of the measurements. The Coastal Engineering Manual (USACE 2003, pg. II-2-4) presents the calculation for adjusting the wind speed duration, as follows:

For t ≤ 3,600 sec

$$\frac{U_t}{U_{3,600}} = 1.277 + 0.296 \tanh\left(0.9 \log_{10}\left(\frac{45}{t}\right)\right)$$

Where,

t = time in seconds

U_t = wind speed in mph at time t

$U_{3,600}$ = 1-hour average wind speed in mph

1.1.1 Directions of Interest

Based on the wind information, a wind rose was developed for the site using WRPLOT View (Lakes Environmental 2006) to determine the dominant wind directions. Figure 1 shows the predominant winds blow from the SE, NW, and S. Wind-fetches, the distance over which wind blows to create a wave, were determined based on the site conditions at the Mouth of Slip 3 (Figure 2) and at Berth 401 (Figure 3). The longest fetch that can affect the site is from the NW and the SSE. The strongest winds that can affect the site come from the ESE, NW, and NNW directions.

1.1.2 Determination of Extreme Wind Speeds

For each year, from 1961 to 2004, the maximum wind speed for each direction of interested (based on fetch length and wind speed) was modeled with a Type I Extreme Value (Gumbel) Distribution. The Gumbel probability distribution for wind speeds corresponding to S (180 degrees) and W (270 degrees) are shown on Figures 4 and 5, respectively. The probability distribution was then used to estimate the extreme wind speed corresponding to a storm with a recurrence interval of 100 years, 50 years, 10 years, and 2 years as shown in Table 1.

1.1.3 Predicted Wave Growth and Transformation Analysis

The U.S. Army Corps of Engineers' (USACE's) Coastal Engineering System (ACES) program was used to model wave growth and propagation due to winds (Veri-Tech 2006). This analysis was conducted using the 44 years of wind data gathered from 1961 to 2004 for the project site. Figures 2 and 3 illustrate the fetch radials and distances that were used in the ACES model. The model computes deep-water wave heights and associated periods for a given wind direction and fetch configuration (length and orientation).

Wave parameters were hindcast using the Wind Speed Adjustment and Wave Growth module of ACES. Since the site is surrounded by land, the restricted fetch approach was applied. The restricted fetch methodology allows for wave growth and development in off-wind directions while considering the shape of the basin (CERC 1992). Because the site is exposed to winds coming from the NW and S, winds blowing from between 160 and 320 degrees (zero degree represents N and degrees are counted clockwise) were introduced in the model. Table 2 presents the input parameters used to calculate the significant wave heights and periods for the 100-, 50-, and 10-year extreme wind speeds for each direction of concern. As described previously, the wind data was adjusted to a constant anemometer height of 20 feet and duration of 2 minutes to represent the observed wind speed in the model. An iterative approach was used to determine the duration of the final wind speed, such that the maximum wave height for the given fetch distance and wind speed would be realized. Table 3 presents the significant wave height and wave period for the 100-, 50-, and 10-year extreme wind speeds for the directions of concern.

The significant wave height will change as a result of wave transformations as a wave propagates from deep water (depth of 30 to 50 feet) into the nearshore area. The Wave Transformation module of ACES (based on Snell's linear wave theory) was used to compute the nearshore wave height and wave length based on the input parameters shown in Table 4.

The bottom orbital velocity was calculated using linear wave theory, as follows:

$$V_{b(\max)} = \frac{H_s g k T_s}{4\pi \cosh(hk)}$$

Where,

H_s = Significant wave height in feet

T_s = Significant wave period in seconds

k = Wave number, $2\pi / L$

h = water depth in feet

L = Wave length in feet, $\frac{gT^2}{2\pi}\tanh\frac{2\pi h}{L}$ (iterative calculation)

The bottom orbital velocity corresponds to the velocity of a water particle at the surface of the sediment, and is conservatively referred to in this document as the bottom current velocity.

1.1.4 Sediment Size Determination

The stable sediment size was linked to the bottom orbital velocity generated by the wave using the stable stone size equation developed by Blaauw et al. (1984) as recommended by the USACE "Guidance for In-Situ Subaqueous Capping of Contaminated Sediments, Appendix A: Armor Layer Design" (Palermo et al. 1998)

$$D_{50} = \frac{\left(\frac{V_{b(\max)}}{C_3}\right)^2}{g * \left(\frac{\partial_S - \partial_W}{\partial_W}\right)}$$

Where,

$V_{b(max)}$ = the maximum orbital bottom velocity in fps

C_3 = coefficient (defined below)

∂_S = the unit weight of stone (165 pcf)

∂_W = the unit weight of water (62.4 pcf)

This equation incorporates a coefficient, C_3, to describe the degree of sediment transport allowed. A C_3 equal to 1.7 for orbital velocities beneath waves is recommended in the USACE guidance document.

1.2 Wind Wave Analysis Results

Table 5 presents the iterative results (as the water moves from deep water into shallow water) for wind-waves generated by a 100-year wind blowing from the direction of concern to the various cap areas at Terminal 4. Analyses to determine the grain size required to resist erosion due to the passing wave were preformed for each of the cap areas and various directions of interest. Results for the individual capping areas are described below and presented in Table 6.

1.2.1 Berth 401

Initially, the ACES model was run for 100-year winds of 50.3 mph blowing from 180 degrees (S), and 32.6 mph blowing from 270 degrees (W). The resulting significant wave height and period were 1.65 feet and 2.42 seconds for the 180 degree wind, and 1.1 feet and 2.05 seconds for the 270 degree wind. Using the larger of the two waves, the Wave Transformation module of ACES was run for the 180 degree wind with a bottom slope of 10:1. Model and subsequent calculations result in bottom orbital velocities of 0.5 to 2.7 fps as the water depth decreases from 10 to 2 feet. The median grain size, D_{50}, for 10 feet of water would be 0.02 inches (medium sand) to resist the bottom shear stress due to the passing wave prior to breaking. As the water depth over the cap area decreases to 2 feet, a D_{50} of 0.56 inches (fine gravel) is required.

However, waves coming from either of these prominent directions would pass under the berth and would be dissipated. Therefore, an additional model run was performed for a northwest blowing wind which may not be as impeded by structures adjacent to the cap area (e.g., the berth itself) as winds from other directions. For the 300 degree wind, a significant wave height of 1.18 feet and period 2.13 seconds was modeled. Bottom orbital velocities of 0.22 to 2.32 fps for water depths of 10 to 1.5 feet require a D_{50} up to 0.42 inches (fine gravel) to resist the bottom shear stress due to the passing wave prior to breaking. As the water depth over the cap area increases to greater than 10 feet, the bottom velocity decreases to less than 0.22 fps and a D_{50} of 0.004 inches (fine sand) is required.

1.2.2 Wheeler Bay

Wind waves for three directions of concern were calculated for Wheeler Bay based on the wind strength, fetch distance, and presence of the Berth 410 pier. The model was run for 200 degrees (SSW) for the northern shoreline of the bay, and 270 (W) and 300 (WNW) degrees for the eastern shoreline near the berth. The resulting significant wave height and period were 1.81 feet and 2.52 seconds for the 200 degree wind, 1.1 feet and 2.05 seconds for the 270 degree wind, and 1.18 feet and 2.13 seconds for the 300 degree wind. Using the 1.81-foot wave for the northern shoreline, the ACES model, and calculations resulted in bottom orbital velocities of 0.6 to 2.8 fps as the water depth decreases from 10 to 2.3 feet (approximate elevation +5 to +14 feet NGVD at high river stage). The corresponding maximum D_{50} of 0.62 inches indicates fine gravel would be required at the shallow water depths on the upper portion of the slope.

For the aquatic cap and eastern shoreline cap areas, a wave height of 1.18 feet and wave period of 2.13 seconds (from the 300 degree wind) were used to calculate the bottom orbital velocity for the aquatic cap and for the shoreline cap areas. For the aquatic cap area, the mud line varies from elevation -14 feet to -8 feet NGVD with a typical slope of 10:1, so the water depths will range from 30 to 8 feet during low and high tides. Bottom orbital velocities up to 0.37 fps were calculated for these water depths, resulting in a maximum D_{50} of 0.011 inches (fine sand). For the eastern shoreline cap, the mud line has an approximate slope of 10:1 slope up to ordinary low water (OLW), then a slope of 6:1 from OLW to ordinary high water (OHW). The elevation in the cap area varies from -10 or -8 feet to OHW (+16.6 feet NGVD), with water depths ranging from roughly 25 to 0 feet during low and high tides. The bottom orbital velocity for the water depth of 1.5 feet (before the wave breaks) is 2.32 fps, corresponding to a D_{50} of 0.42 inches (fine gravel).

1.2.3 Head of Slip 3

Based on the geometry of the slip and the limited fetch distances, wind-generated waves from 270 degrees (winds coming from the west) would have the largest impact on the head of the slip where the fetch distance is the maximum (approximately 0.55 miles). For the 100-year wind speed of 32.6 mph, the model calculated a significant wave height of 0.85 feet with a wave period of 1.78 seconds. The model and calculations resulted in bottom orbital

velocities of 0.06 to 1.9 fps as the water depth decreases from 10 feet to nearly a 1 foot, and a maximum D_{50} of 0.3 inches (fine gravel).

1.2.4 Pier 5

Along the Pier 5 slope cap, wind-generated wave are most likely to impact the west corner of the cap area near the mouth of Slip 3. The analysis was performed for three directions of concern: 180 degrees (S), 200 degrees (SSW), and 310 degrees (roughly NW). The maximum wave height of 1.34 feet and period of 2.12 seconds for the 200 degree wind were calculated from the ACES model and used to determine the maximum bottom orbital velocities for the site. For the cap area with a slope of 2:1, bottom orbital velocities of 0.0043 to 2.7 fps were calculated for water depths of 25 to 2 feet. As presented in Table 5, the cap material for the slope would range from a silt at the lowest point of the cap (water depth of 35 feet) to 0.4 inches (fine gravel) at the upper end of the cap where the water depth is close to 2 feet.

1.2.5 Berth 414

The cap at Berth 414 is completely submerged and located in a minimum water depth of 15 feet. Similar to the previous analyses at Pier 5, the largest wave for the area (1.34 feet and 2.12 seconds) was generated from the 200 degree wind blowing from the SSW. For the cap area with a bottom slope of 10:1 and at a depth of 15 feet, the bottom orbital velocity generated by the 1.34-foot high wave is negligible. At a water depth of 10 feet, the bottom velocity is 0.25 fps with a D_{50} of 0.005 inches, or fine sand.

1.2.6 Slip 1 Containment Berm

For the Slip 1 containment berm, the ACES model was run for 100-year winds of 54.7 mph blowing from 200 degrees (SSW), and 33.2 mph blowing from 300 degrees (WNW). The resulting significant wave height and period were 1.81 feet and 2.52 seconds for the 200 degree wind, and 1.18 feet and 2.13 seconds for the 300 degree wind. Using the larger of the two waves, the Wave Transformation module of ACES was run for the 200 degree wind with a typical bottom slope of 2:1 (from elevation -35 feet to OHW). Model and subsequent calculations result in a maximum bottom orbital velocity 2.87 fps as the water depth decreases from 35 feet to a little over 2 feet. The median grain size, D_{50}, for 10 feet of water would be 0.03 inches (medium sand) to resist the bottom shear stress due to the passing wave

prior to breaking. As the water depth over the cap area decreases to roughly 2.5 feet, a D_{50} of 0.61 inches (fine gravel) is required.

2 VESSEL-INDUCED WAVE ANALYSIS

Waterway traffic in the vicinity of Terminal 4 ranges from large Panamax vessels (which call at nearby Berth 415) to smaller recreational vessels such as ski boats and cabin cruisers. The analysis performed for the McCormick & Baxter Superfund Site, located approximately 3 miles upstream of Terminal 4 concluded the following, "Ship, tug, and barge tow-generated wave heights were found to be smaller than those generated by fireboats during a response." (PB Ports & Marine 2002). Therefore, for this analysis, a fireboat (converted tug) was selected as the most conservative vessel for wave generation.

2.1 Methodology

Analysis of the vessel-generated waves was performed using the SHIPWAVE computer model. This model is based on the empirical model developed by Weggel and Sorensen (1986). Model inputs include water depth, vessel displacement, distance from the sailing line, vessel speed, and bow geometry (or hull form) coefficients. The model inputs for the Terminal 4 cap areas are presented in Table 7. Model results include the wave height and period for the selected distance from the sailing line as presented on Table 8.

The vessel-generated wave is then propagated into shallow water and the slopes of the cap areas using the Wave Transformation module of ACES, as detailed in Section 1.1.3 Predicted Wave Growth and Transformation Analysis. The maximum orbital velocity of the wave prior to breaking is then calculated and used to determine the stable sediment size for the cap area, as detailed in Section 1.1.4 Sediment Size Determination.

2.2 Vessel-Induced Wave Analysis Results

The following presents the result of the analysis for each of the Terminal 4 aquatic cap areas. For cap areas within Slip 3 (e.g., those at Berth 411, the Head of Slip 3, and at Pier 5), vessel-generated waves were determined to be less than 1 foot in height due to the low operating speeds of less than 5 knots within the slip. Results are summarized on Table 8.

2.2.1 Berth 401

For the Berth 401 cap area, the distance from the moving vessel to the cap area ranges from a minimum of 150 feet, which generates the more conservative, or higher, wave height, to 250 feet or more. The vessel speed has a moderate affect on the wave height as a vessel traveling 150 feet from the cap area at a speed of 12 knots generates a 2.38 foot wave, whereas a vessel traveling at 14 to 15 knots results in nearly a foot increase to 3.13 and 3.65 feet, respectively. Wave periods are calculated from the vessel speed and water depth, and are independent of other input parameters. For a vessel speed of 15 knots, a wave period of 4.08 seconds was calculated. Wave heights for a vessel traveling 15 knots were determined to be between 2.98 and 3.5 for distances of 150 to 250 feet from the cap area. The cap area at Berth 401 is relatively protected from waves generated in the river by winds or vessel movement from the south by the pile field supporting the pier structure. As a result, wave heights would be significantly dissipated as they moved through the pile field. However, the cap area is exposed to waves from the west, or perpendicular to the shoreline.

As waves generated by passing vessels propagate towards shore, the slope of the shoreline affects the height at which the wave breaks, based on when the wave "feels" the seabed. During low water (elevation 0 feet NGVD), the slope of the shoreline at Berth 401 between -10 and 0 feet is 10H:1V. During high water (elevation +16.6 feet NGVD), the slope from elevation -5 feet to OHW is 6H:1V. Using the Wave Transformation module of ACES, the 3.5-foot wave generated by the vessel 150 feet from the sailing line is propagated at low water into a 4.5-foot wave at a water depth of 4.2 feet. The maximum orbital velocity of the wave occurs when the wave height reaches 3.8 feet at a water depth of 4.9 feet, or just prior to breaking. For high water conditions, the maximum orbital velocity occurs when the wave reaches a height of 3.79 feet in 4.8 feet of water. Therefore, considering low and high water conditions, the maximum bottom orbital velocities from the 3.8-foot and 3.79-foot waves were approximately 4.3 fps, which resulted in a D_{50} of 1.4 to 1.5 inches (coarse gravel).

2.2.2 Wheeler Bay

For the Wheeler Bay cap area, the distance from the moving vessel to the aquatic edge of the cap area (about elevation -9 feet NGVD) is approximately 325 feet. For analysis of the high water level condition, a distance of 425 feet from the sailing line to approximate elevation

0 feet was assumed. For a vessel traveling 15 knots in 30 feet of water, wave heights of 2.06 and 2.33 feet, with a wave period of 4.38 seconds were calculated for the high and low water conditions, respectively.

In Wheeler Bay, the slope in the cap area between approximate elevation -10 and 0 feet NGVD is 10H:1V. From 0 to 16.6 feet, the slope is roughly 6H:1V. The wave transformation analysis for Wheeler Bay results in breaking heights of 3.2 to 3.4 feet at water depths of 2.5 to 3 feet for the high and low water conditions, respectively. The maximum orbital velocity occurs when the wave height reaches 2.7 feet at a water depth of 3.4 feet. The bottom orbital velocity of 3.9 fps results in a D_{50} of 1.2 inches, which is coarse gravel, at the low water condition.

2.2.3 Pier 5 Corner at the Mouth of Slip 3

For the cap area at the western edge of the Pier 5 cap area, the distance from the moving vessel to the cap area is approximately 175 feet. Using the SHIPWAVE model, a wave height of 3.02 feet and a wave period of 4.19 seconds was calculated. Based on the wave's angle of approach, the slope from the base of the cap at elevation -35 feet to 0 feet NGVD ranges from 2H:1V to 6H:1V. Analysis of these slopes results in waves with a breaking height between 4.2 and 4.7 feet at water depths of 3.4 to 4.1 feet, respectively. The maximum orbital velocity and resulting D_{50} for this cap area are 4.42 fps and 1.5 inches, which is coarse gravel.

2.2.4 Slip 1 Containment Berm

The Slip 1 containment berm was assumed to have similar impacts as the Berth 401 cap area, described previously. The minimum distance from the moving vessel to the containment berm was estimated to be 150 feet. For a vessel speed of 15 knots, a wave height of 3.5 feet and wave period of 4.08 seconds was calculated. Using the Wave Transformation module of ACES, the 3.5-foot wave is propagated from elevation -35 to 0 feet (low water) over a 2H:1V slope into a 4.6-foot wave at a water depth of 4 feet. The maximum orbital velocity of the wave occurs when the wave height reaches 3.7 feet at a water depth of 4.8 feet, or just prior to breaking. The maximum orbital velocity and resulting D_{50} for the face of the containment berm are 4.3 fps and 1.4 inches, which is coarse gravel.

3 BREAKING WAVE ANALYSIS

The shoreline portions of the aquatic cap areas (i.e., cap areas that extend from OLW to OHW) adjacent to Berth 401, Wheeler Bay, and the river-ward corner of Pier 5, as well as the face of the Slip 1 containment berm are subject to breaking waves. From the previous sections of this memorandum, it is evident that vessel-generated waves would result in more erosive forces than those developed from wind waves. Accordingly, only vessel-generated breaking waves were considered in the remainder of the analysis.

3.1 Methodology

The previous analysis of the vessel-generated waves considered the effects of the highest magnitude wave on the aquatic caps and characterized maximum bottom shear velocities. For the shoreline areas a more statistical approach was selected and based on vessel traffic in Portland Harbor and along the lower Willamette River. Using a cumulative frequency distribution, the top 5 percent wave height and associated wave period were selected and carried through the analysis. The slopes were modeled as permeable revetments and ACES was used to determine the required armoring for each shoreline cap location.

3.1.1 Vessel Traffic

A database of vessel trips within Portland Harbor and along the lower Willamette River was developed using information obtained using the USACE Waterborne Commerce Statistics website (http://www.iwr.usace.army.mil/ndc/wcsc/wcsc.htm) and other similar resources. Approximately 63,000 vessel trips per year occur nearby the Terminal 4 facility; 84 percent of these trips can be attributed to cargo vessel and tug operations. The remainder of the trips are associated with recreational boating, commuter/tourist ferries, commercial fishing vessels, cruise ships, and fire boats.

3.1.2 Vessel Wave Generation

Berth 401, the Slip 1 containment berm, and the Pier 5 corner are all located within similar proximity to the harbor line and, therefore, were modeled using the same wave generation conditions. Wheeler Bay is setback approximately 200 additional feet and is slightly more protected. The SHIPWAVE model was used to generate wave heights and periods for each of the vessels in the two areas of interest. Two frequency distribution plots were developed

to determine the top 5 percent wave height and period. These parameters were then input into the ACES Rubble Mound Revetment Design module to determine the W_{50} and D_{50} for each location of interest. Table 9 presents the input parameters required of the model.

3.2 Breaking Wave Analysis Results

The model indicates that armor grain sizes between 7 and 10 inches will be necessary to protect caps within the surf zone areas. For the Slip 1 containment berm, these grain sizes represent the median size required to resist movement of during wave attack. The remaining cap areas were designed to experience less than 5 percent movement of individual armor rocks. These results are also included in Table 9.

4 CONCLUSIONS

Table 10 presents a summary of grain sizes for the different areas for wind-induced and vessel-induced waves. As can be seen in the table, vessel-induced waves produce the dominant erosional forces at all of the cap areas. The required armor grain sizes determined from the breaking wave analysis were also included to illustrate which areas would require additional armoring within the surf zone.

5 REFERENCES

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Weggel, J. R., and Sorensen, R.M. 1986. "A Ship wave prediction for port and channel design." Proceedings of the Ports '86 Conference, Oakland, CA, 19-21 May 1986. Paul H. Sorensen, ed., American Society of Civil Engineers, New York, 797-814.

TABLES

Table 1
Recurrence Wind Speeds and Fetch Distances for Terminal 4

Average Recurrence Interval (Year)	100	50	10	2	Fetch Distance (miles)	
Wind Direction (degrees blowing from)	Wind Speed (mph)				Slip 3 (Figure 2)	Berth 401 (Figure 3)
160	33.0	30.8	25.4	19.3	NA	1.3
170	42.6	39.3	31.6	22.7	NA	0.92
180	50.3	46.7	38.1	28.4	0.60	0.67
200	54.7	50.9	41.7	31.3	0.44	0.42
270	32.6	30.6	25.8	20.4	0.40	0.35
300	33.2	31.2	26.6	21.3	0.64	0.50
310	29.8	28.4	24.8	20.8	0.85	0.70
320	33.8	31.9	27.5	22.4	NA	1.33
330	30.3	28.8	25.5	21.7	NA	1.45

Table 2
Input Parameters for ACES Wind Speed Adjustment
and Wave Growth Deep Water (Fetch Limited Wave Growth)

z_{obs}	Elevation of observed wind	20	[ft]
U_{obs}	Observed wind speed	(See Table 3)	[mph]
ΔT	Air-sea temperature difference	+4	[°C]
DurO	Duration of observed wind speed	2	[min]
DurF	Duration of final wind	Variable	[min]
LAT	Latitude of wind observation	45.59	[°]
α	Observed wind direction	(See Table 3)	[°N]

The duration of the wind speed was adjusted to achieve the maximum wave growth.

Table 3
ACES Wind Speed Adjustment and Wave Growth Results for Terminal 4 Points of Interest

Input Conditions		Model Output for Slip 3 POI		Model Output for Berth 401 POI	
Direction [°N]	Speed [mph]	Hs [ft]	Tp [s]	Hs [ft]	Tp [s]
160	33.0	NA-Wind does not affect this point of interest		1.02	1.93
160	30.8			0.97	1.93
160	25.4			0.76	1.73
170	42.6			1.37	2.2
170	39.3			1.25	2.11
170	31.6			0.98	1.93
180	50.3	1.20	1.99	1.65	2.42
180	46.7	1.11	1.96	1.53	2.34
180	38.1	0.87	1.73	1.23	2.14
200	54.7	1.34	2.12	1.81	2.52
200	50.9	1.22	2.00	1.68	2.44
200	41.7	0.99	1.86	1.33	2.2
270	32.6	0.85	1.78	1.10	2.05
270	30.6	0.78	1.70	1.02	1.99
270	25.8	0.64	1.54	0.85	1.83
300	33.2	0.86	1.75	1.18	2.13
300	31.2	0.80	1.72	1.09	2.06
300	26.6	0.67	1.60	0.92	1.91
310	29.8	0.77	1.70	1.04	2.02
310	28.4	0.72	1.65	0.97	1.96
310	24.8	0.62	1.55	0.84	1.84
320	33.8	NA-Wind does not affect this point of interest		1.18	2.13
320	31.9			1.11	2.07
320	27.5			0.95	1.93
330	30.3			1.05	2.02
330	28.8			0.99	1.97
330	25.5			0.86	1.86

Input wind speed per direction from Gumbel Extreme Value Analysis and includes 100-, 50-, and 10-year recurrence interval, respectively. (See Table 1)

Table 4
Input Parameters for ACES Wave Transformation

H1	Known (deep water) wave height	(See Table 5)	[ft]
T	Wave period	(See Table 3)	[sec]
d1	Water depth for H1	50	[ft]
d2	Water depth (nearshore) for which to determine H2	(See Table 5)	[ft]
$\alpha 1$	Wave crest angle (bathymetry roughly parallel to shoreline)	0	[°]
	Nearshore slope (maximum value at site to be conservative)	Varies - Aquatic slopes of 20:1 to 6:1. Shoreline slopes up to 3:1.	

Table 5
Wind-Wave Analysis Results

Cap Area, Wind Direction, and Primary Shoreline Slope	H1 [ft]	Ts [sec]	d2 [ft]	H2 [ft]	H*b* [ft]	d*b* [ft]	L [ft]	V*b(max)* [fps]	D_{50} [in]	Sediment Type
Berth 401	1.65	2.42	20	1.65	1.84	1.84	30.00	0.06	0.000	SILT
180 Degrees			10	1.58	1.84	1.84	29.20	0.48	0.018	MEDIUM SAND
10:1			5	1.51	1.84	1.84	25.35	1.24	0.120	COARSE SAND
			2.1	1.6	1.84	1.84	18.43	2.67	0.558	FINE GRAVEL
Berth 401	1.10	2.05	20	1.1	1.27	1.15	21.50	0.01	0.000	SILT
270 Degrees			10	1.08	1.27	1.15	21.40	0.18	0.002	SILT
6:1			5	1.02	1.27	1.15	19.80	0.67	0.035	MEDIUM SAND
			1.4	1.08	1.27	1.15	12.82	2.23	0.391	FINE GRAVEL
Berth 401	1.18	2.13	30	1.18	1.31	1.35	23.20	0.00	0.000	SILT
300 Degrees			10	1.16	1.31	1.35	23.00	0.22	0.004	FINE SAND
10:1			5	1.09	1.31	1.35	21.00	0.76	0.045	MEDIUM SAND
			1.5	1.16	1.31	1.35	13.80	2.32	0.421	FINE GRAVEL
Wheeler Bay	1.81	2.52	25	1.81	1.98	2.26	32.5	0.04	0.000	SILT
200 Degrees			10	1.72	1.98	2.26	31.4	0.59	0.027	MEDIUM SAND
20:1			5	1.65	1.98	2.26	26.8	1.41	0.156	COARSE SAND
			2.3	1.76	1.98	2.26	20.1	2.80	0.613	FINE GRAVEL
Wheeler Bay	1.10	2.05	25	1.1	1.25	1.23	21.5	0.00	0.000	SILT
270 Degrees			10	1.09	1.25	1.23	21.4	0.18	0.002	SILT
10:1			5	1.02	1.25	1.23	19.8	0.67	0.035	MEDIUM SAND
			2	1.03	1.25	1.23	14.8	1.66	0.216	FINE GRAVEL
			1.4	1.08	1.25	1.23	12.8	2.23	0.391	FINE GRAVEL
Wheeler Bay	1.18	2.13	30	1.18	1.31	1.35	23.20	0.00	0.000	SILT
300 Degrees			10	1.16	1.31	1.35	23.00	0.22	0.004	FINE SAND
10:1			8	1.14	1.31	1.35	22.68	0.37	0.011	FINE SAND
			5	1.09	1.31	1.35	21.00	0.76	0.045	MEDIUM SAND
			2	1.12	1.31	1.35	15.50	1.84	0.265	FINE GRAVEL
			1.5	1.16	1.31	1.35	13.80	2.32	0.421	FINE GRAVEL

Table 5
Wind-Wave Analysis Results

Cap Area, Wind Direction, and Primary Shoreline Slope	H1 [ft]	Ts [sec]	d2 [ft]	H2 [ft]	H*b* [ft]	d*b* [ft]	L [ft]	V*b(max)* [fps]	D_{50} [in]	Sediment Type
Corner at Head of Slip 3	0.85	1.78	25	0.85	0.94	1.06	16.2	0.00	0.000	SILT
270 Degrees			10	0.85	0.81485	0.92	16.2	0.06	0.000	SILT
20:1			5	0.8	0.81485	0.92	15.6	0.39	0.012	FINE SAND
			2	0.78	0.81485	0.92	12.5	1.15	0.104	COARSE SAND
			1.1	0.83	0.81485	0.92	9.8	1.93	0.291	FINE GRAVEL
Corner at Head of Slip 3	1.34	2.12	25	1.34	1.55	1.42	23.0	0.00	0.000	SILT
200 Degrees			10	1.32	1.55	1.42	22.8	0.25	0.005	FINE SAND
20:1			5	1.24	1.55	1.42	20.9	0.86	0.058	MEDIUM SAND
			2	1.27	1.55	1.42	15.5	2.07	0.337	FINE GRAVEL
			1.8	1.28	1.55	1.42	14.8	2.26	0.400	FINE GRAVEL
Berth 414	1.34	2.12	25	1.34	1.48	1.50	23.0	0.00	0.000	SILT
200 Degrees			10	1.32	1.48	1.50	22.8	0.25	0.005	FINE SAND
10:1			5	1.24	1.48	1.50	20.8	0.86	0.057	MEDIUM SAND
			2	1.27	1.48	1.50	15.5	2.07	0.337	FINE GRAVEL
			1.8	1.28	1.48	1.50	14.8	2.26	0.400	FINE GRAVEL
Slip 1 Containment Berm	1.81	2.52	25	1.81	2.12	1.91	32.5	0.04	0.000	SILT
200 Degrees			10	1.72	2.12	1.91	31.4	0.59	0.027	MEDIUM SAND
2:1			5	1.62	2.12	1.91	26.8	1.38	0.150	COARSE SAND
			2.3	1.76	2.12	1.91	20.1	2.80	0.614	FINE GRAVEL

Table 6
Summary of Wind-Wave Analysis for Terminal 4 Cap Area Design

Cap Area Name	Applicable Direction and 100-year Wind Speed in mph		Significant Wave Height in feet and Period in seconds		Maximum Bottom Orbital Velocity in fps	D_{50} (in inches) and Corresponding Cap Material	
Berth 401	180 degrees (S)	50.3	1.65	2.42	2.67	0.56	FINE GRAVEL
	270 degrees (W)	32.6	1.10	2.05	2.23	0.39	FINE GRAVEL
	300 degrees (WNW)	33.2	1.18	2.13	2.32	0.42	FINE GRAVEL
Wheeler Bay	200 degrees (SSW)	54.7	1.81	2.52	2.80	0.61	FINE GRAVEL
	270 degrees (W)	32.6	1.10	2.05	2.23	0.39	FINE GRAVEL
	300 degrees (WNW)	33.2	1.18	2.13	2.32	0.42	FINE GRAVEL
Head of Slip 3	270 degrees (W)	32.6	0.85	1.78	1.93	0.29	FINE GRAVEL
Pier 5 at Mouth of Slip 3	200 degrees (SSW)	54.7	1.34	2.12	2.26	0.40	FINE GRAVEL
Berth 414	200 degrees (SSW)	54.7	1.34	2.12	2.26	0.40	FINE GRAVEL
Slip 1 Containment Berm	200 degrees (SSW)	54.7	1.81	2.52	2.80	0.61	FINE GRAVEL

Wind direction is degrees from North.
Berth 411 and Pier 5 were not analyzed due to the extremely limited fetch distance.

Table 7
Input Parameters for Vessel-Induced Wave Analysis for Aquatic Cap Areas

Cap Area	Distance from Sailing Line in Feet	Water Depth at Sailing Line in Feet	Shoreline Slope for Wave Transformation xH:1V	Water Depth at Point of Wave Transformation in Feet
Berth 401 (OHW)	150	45	6	20
Berth 401 (OLW)	150	45	10	10
Wheeler Bay (OHW)	475	30	6	15
Wheeler Bay (OLW)	325	30	10	10
Pier 5	175	35	6	20
Pier 5	175	35	2	25

Notes:

Vessel Displacement is 500 tons for all model cases.

Vessel Speed is 15 knots for all model cases.

Table 8
Results for Ship-Generated Wave Analysis for Aquatic Cap Areas

	SHIPWAVE Model Results		ACES Wave Transformation Results				Calculated Values		
Cap Area	Wave Height in Feet	Wave Period in Seconds	Water Depth at Maximum Orbital Velocity in Feet	Wave Height at Maximum Orbital Velocity in Feet	Wave Height at Breaking Hb in Feet	Water Depth at Breaking db in Feet	Vb(max) in fps	D_{50} in Inches	Sediment Type
Berth 401 (OLW)	3.50	4.08	4.9	3.80	4.48	4.2	4.28	1.4	COARSE GRAVEL
Berth 401 (OHW)	3.50	4.08	4.8	3.79	4.53	3.9	4.32	1.5	COARSE GRAVEL
WB - E Bay(OHW)	2.06	4.38	3.1	2.51	3.20	2.5	3.77	1.1	COARSE GRAVEL
WB - E Bay (OLW)	2.33	4.38	3.4	2.74	3.40	2.9	3.91	1.2	COARSE GRAVEL
Pier 5	3.02	4.19	4.2	3.32	4.21	3.4	4.14	1.3	COARSE GRAVEL
Pier 5	3.63	4.19	5.0	3.95	4.73	4.1	4.42	1.5	COARSE GRAVEL

Table 9
Input Parameters for ACES Rubble Mound Revetment Design

Parameter	Wheeler Bay	Berth 401/Pier 5	Slip 1 Berm Face	
Significant wave height in feet (Hs)	2.25	2.94	2.94	Top 5% Wave Height
Significant wave period in seconds (Ts)	3.78	3.93	3.93	Period associated with Wave Height
Cotan of nearshore slope (cot phi)	10	10	10	Below OLW
Water depth at toe of revetment in feet (ds)	3.5	4	4	At low water
Cotan of structure slope (cot theta)	6	6	6	Between OLW and OHW
Unit weight of rock in pcf (wr)	165	165	165	Specified
Permeability coefficient (P)	0.1	0.1	0.1	Default
Damage level (S)	3	3	1	Movement of few armor units
Breaking criteria	0.78	0.78	0.78	Default
W_{50} in pounds	19	36	70	Model Results
D_{50} in inches	7	8	10	Model Results

Table 10
Sediment Cap Size Results for Wind- and Vessel-Generated Waves

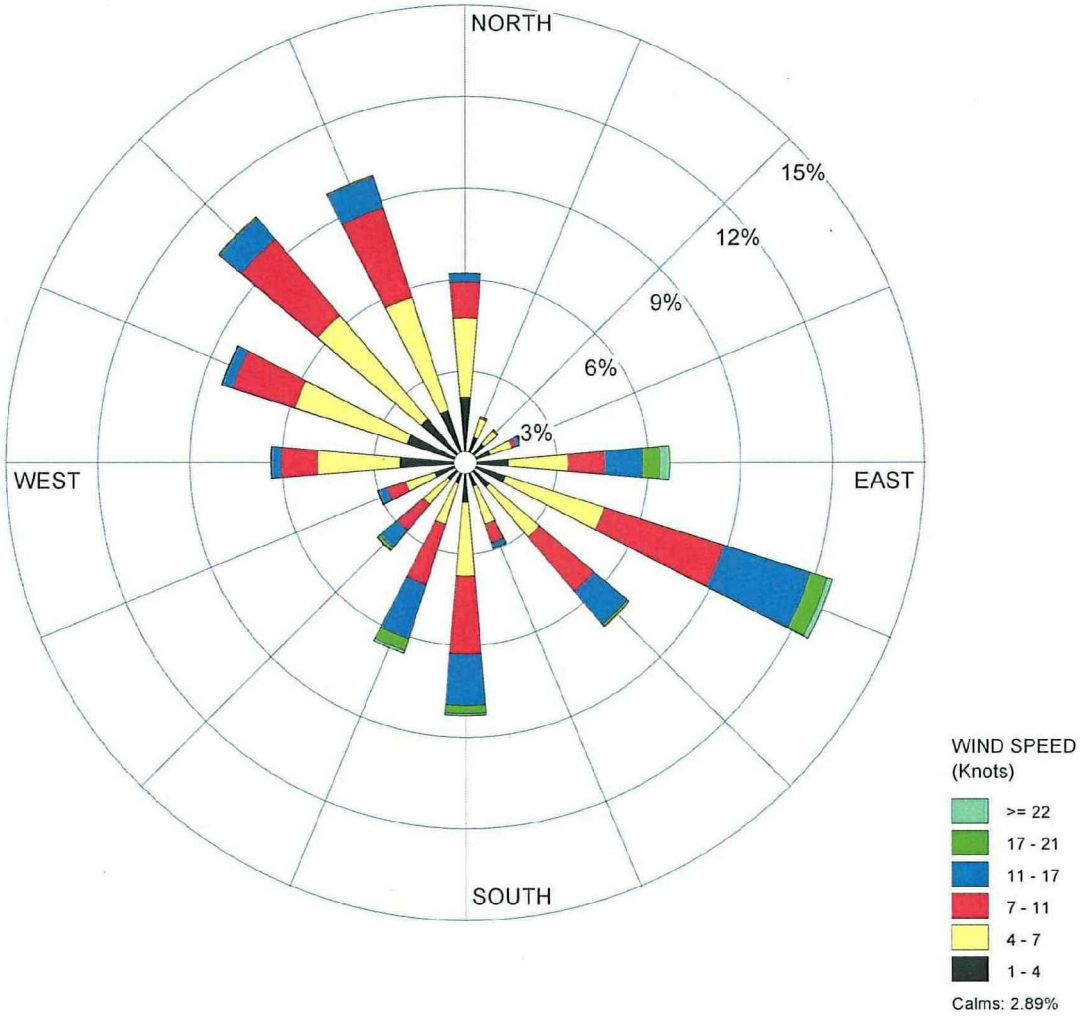
	D_{50} in inches		
	Wind Wave	**Vessel Wave**	**Surf Zone**
Berth 401	0.4	1.5	8
Wheeler Bay	0.6	1.2	7
Berth 411	(a)	(a)	(b)
Head of Slip 3	0.3	(a)	(a)
Pier 5	0.4	1.5	8
Berth 414	0.4	(a)	(b)
Slip 1 Containment Berm	0.6	1.4	9

Notes:
(a) Analysis was not performed because negligible surface waves are anticipated in relation to velocities produced from propeller wash
(b) Cap does not extend into the surf zone

FIGURES

WIND ROSE PLOT:
Station #24229 - PORTLAND/INT'L ARPT, OR

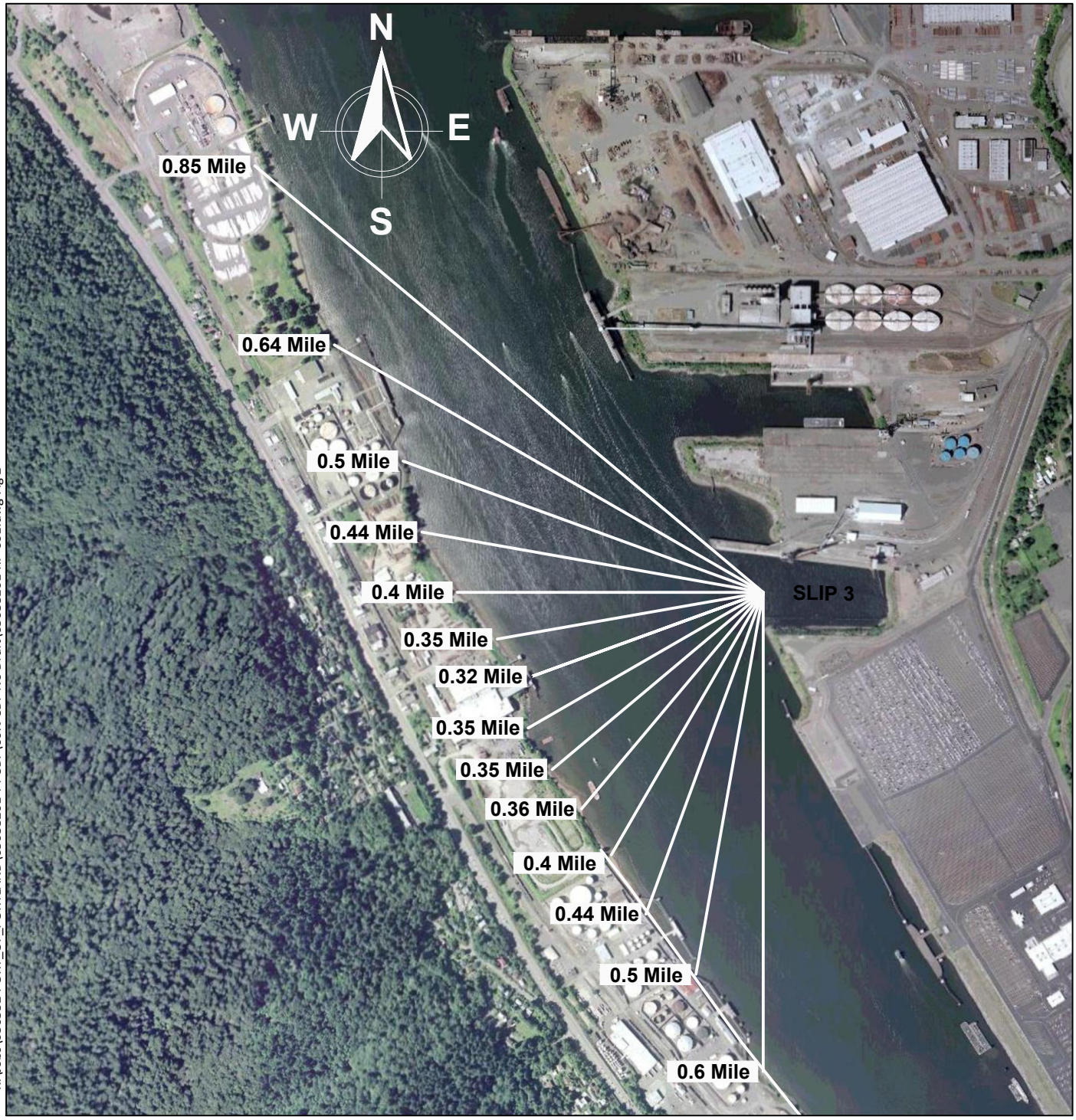
DISPLAY:
Wind Speed
Direction (blowing from)



COMMENTS:	DATA PERIOD: 1961-2004 **2002-2004 1976-1980 1981-1985 1986-1989 1995-1993 1997-1999 1996-1997 1961 1962 1963 1964 1965 1966 1967 1968**	COMPANY NAME: **Anchor Environmental**	
		MODELER: **Sara Carroll**	
	CALM WINDS: **2.89%**	TOTAL COUNT: **333338 hrs.**	
	AVG. WIND SPEED: **7.54 Knots**	DATE: **10/21/2006**	PROJECT NO.: 050332-01

Aug 08, 2011 4:07pm tgriga K:\jobs\050332-PORT_OF_PORTLAND\05033201 T4 CDF\60% CDF No Draft\05033201-RP-001.dwg Fig 1

Figure 1
Wind Rose Plot
Wind- and Vessel-Induced Wave Analysis - Terminal 4 Early Action
Portland, Oregon



K:\jobs\050332-PORT_OF_PORTLAND\05033201 T4 CDF\60% CDF No Draft\05033201-RP-001.dwg Fig 2

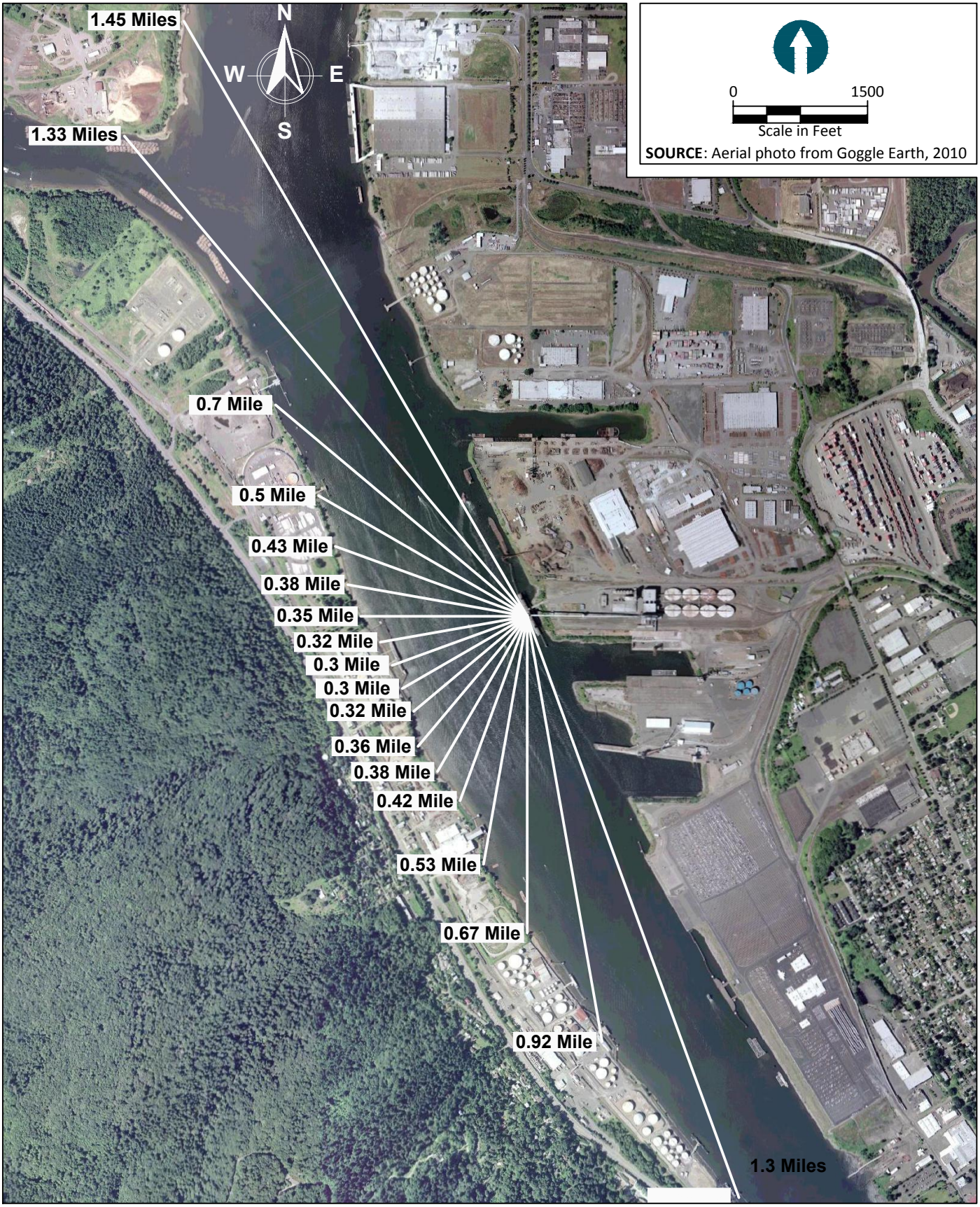
Aug 08, 2011 4:07pm tgriga

SOURCE: Aerial photo from Goggle Earth, 2010

0 1000
Scale in Feet

Figure 2
Fetch Direction and Distance for Terminal 4 - Slip 3
Wind- and Vessel-Induced Wave Analysis - Terminal 4 Early Action
Portland, Oregon

ANCHOR QEA



K:\Jobs\050332-PORT_OF_PORTLAND\05033201 T4 CDF\60% CDF No Draft\05033201-RP-001.dwg Fig 3

Aug 08, 2011 3:49pm tgriga

Figure 3
Fetch Direction and Distance for Berth 401
Wind- and Vessel-Induced Wave Analysis - Terminal 4 Early Action
Portland, Oregon

ANCHOR QEA

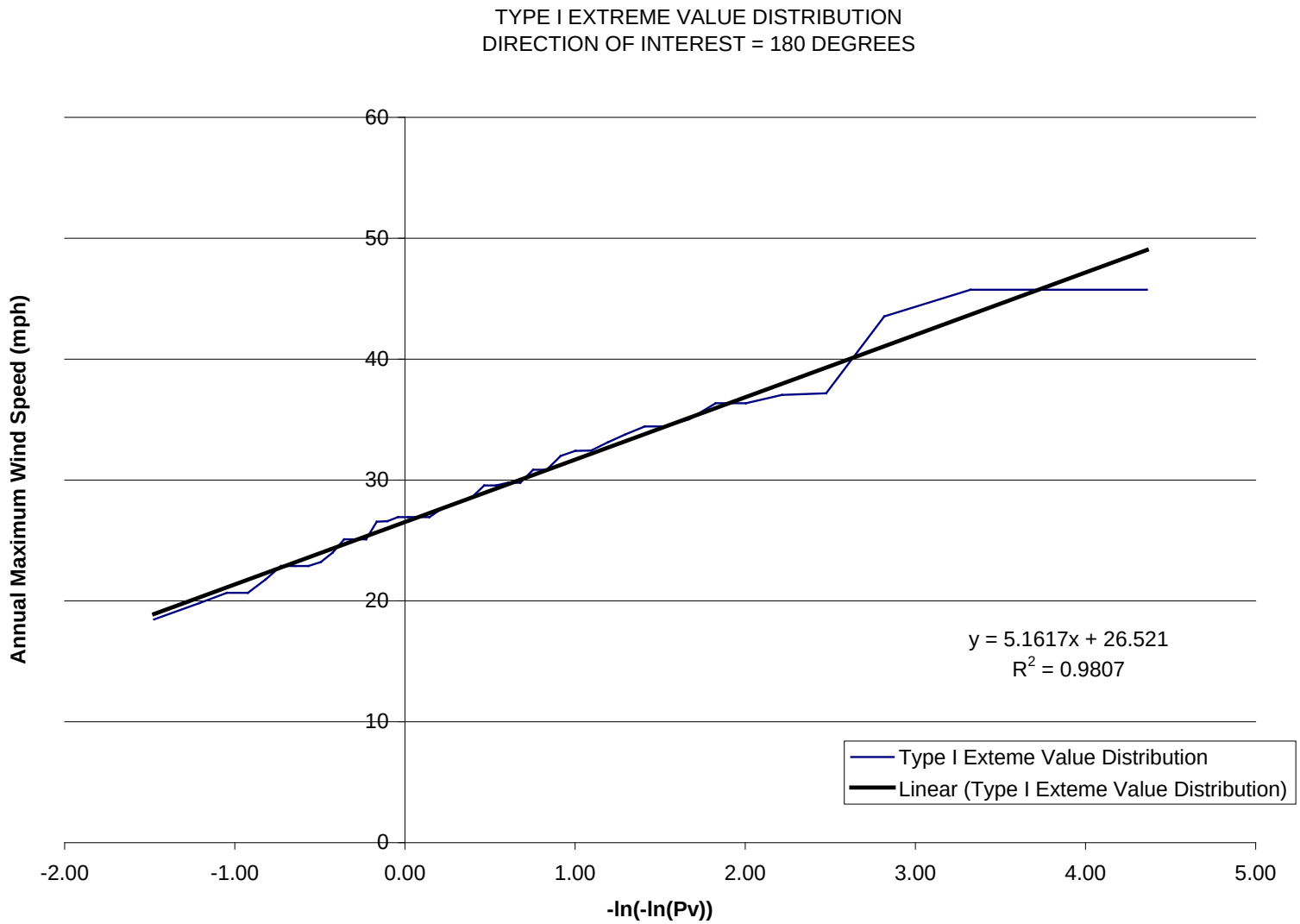


Figure 4
Type 1 Extreme Value Distribution – 180° Direction of Interest
Wind- and Vessel-Induced Wave Analysis – Terminal 4 Early Action
Portland, Oregon

ANCHOR QEA

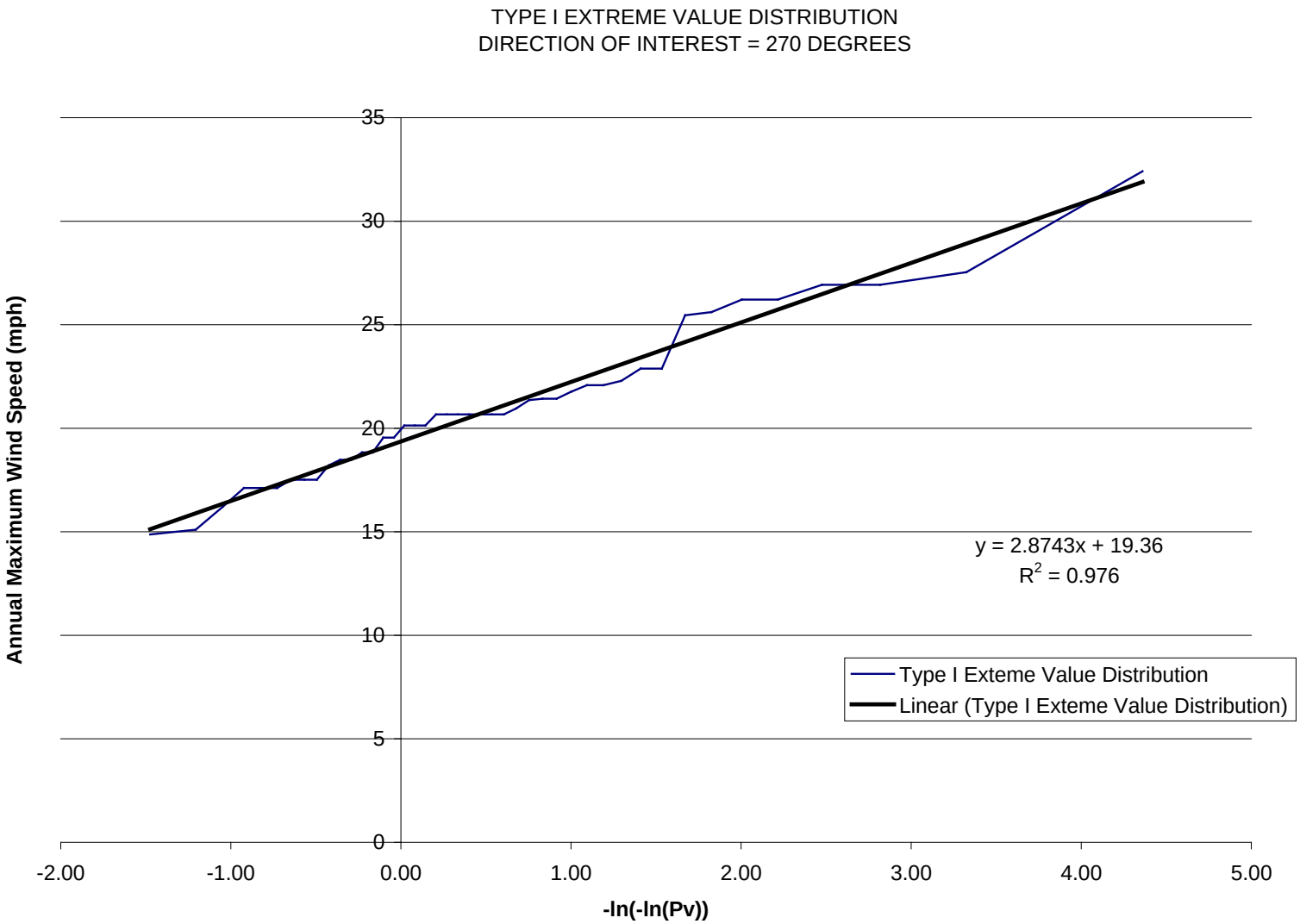


Figure 5
Type 1 Extreme Value Distribution – 270° Direction of Interest
Wind- and Vessel-Induced Wave Analysis – Terminal 4 Early Action
Portland, Oregon

ANCHOR QEA

APPENDIX H
GEOTECHNICAL ASSESSMENT OF THE CONTAINMENT BERM

Ash Creek Associates, Inc.
Environmental and Geotechnical Consultants

Memorandum

Date: August 3, 2011

To: Mr. John Verduin, Anchor Environmental, LLC

From: Stuart Albright, P.E., Ash Creek Associates
Stephen Dickenson, PhD. P.E., New Albion Geotechnical, Inc.

Re: Updated Preliminary Seismic and Geotechnical Evaluations
Terminal 4, Slip 1 CDF
Portland, Oregon
1165-00

REGISTERED PROFESSIONAL ENGINEER
14431PE
OREGON
JULY 26, 1989
STUART ALBRIGHT

EXPIRES: 12/31/11

We have completed the seismic and geotechnical analysis for the Confined Disposal Facility (CDF), proposed for Terminal 4, Slip 1, on the Willamette River in Portland, Oregon. This study incorporates over 90 years of geotechnical data available for Terminal 4 as well as the most recently available data for seismic risk. The approaches taken for the analyses of seismic hazard and dynamic soil response, as well as the static and seismic design, are consistent with recent CDF designs completed in the EPA Region 10 (City of Tacoma, 2003) and Port of Tacoma Slip 1 CDFs (Occidental Chemical and Port of Tacoma, 2003).

The purpose of our work was to provide seismic and geotechnical engineering assessments of the site, as well as to provide recommendations for the proposed CDF. Our scope of work for this project included:

- A review of general geologic literature and previous geotechnical reports in the project vicinity;
- Review of past subsurface explorations;
- Geotechnical engineering analyses;
- Review and synthesis of regional probabilistic seismic hazard analysis prepared by the U.S. Geological Survey (USGS); and
- Preparation of this report.

This report includes the following:

- A description of the CDF configuration including a discussion of the materials proposed for constructing the berm;
- A probabilistic seismic hazard analysis including a discussion of general regional seismicity and site-specific hazards;

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- A discussion of site geotechnical conditions developed from extensive past subsurface explorations;
- An evaluation of liquefaction potential associated with design earthquakes; and
- A berm stability analysis with cases for:
  - Short Term Static Stability (conditions representative of the CDF during the filling operations);
  - Long Term Static Stability (conditions representative of the CDF after full filling);
  - Seismic Stability (Pseudostatic and Deformation Based Procedures); and
  - Post Earthquake Stability (using residual strength models).

EXECUTIVE SUMMARY

The results of this study indicate that the CDF structure as proposed is protective of the contaminated dredged sediment placed in the CDF. The structure will adequately contain the dredged material during static conditions representative of normal operations and prevent the release of the dredged material into the Willamette River during design earthquake scenarios.

Static factors of safety in excess of 1.5 and seismic factors of safety in excess of 1.1 are broadly considered acceptable for earth structures in cases where nominal permanent deformations are tolerable. For all cases, the factors of safety against a deep slope movement were far in excess of these values. Supplementary deformation analyses of the berm indicate that tolerable deformations would result during the design earthquake scenarios.

Our analysis did indicate the potential for permanent deformations of the berm face during a design earthquake scenario. The slope movement is considered to be within tolerable ranges, although such deformations would require rebuilding the outer face of the berm.

We have summarized the result of our evaluation. Detailed descriptions of our work follow.

Seismicity. For a 10 percent probability of exceedance in 50 years (i.e., 475-year return period) event, we selected the following scenarios for subsequent analysis of dynamic soil response, soil liquefaction, and design for the CDF berm:

1. M_w 9.0 CSZ event resulting in bedrock ground motions of 0.14g beneath the site.
2. M_w 6.2 crustal source resulting in bedrock ground motions of 0.20g.
3. The intraslab (or intraplate) source has been shown to contribute the least to bedrock peak acceleration and spectral accelerations (0.2 and 1.0 second), and therefore omitted from further consideration in our analyses.

Soil Profile. In general, the upland areas adjacent to the CDF were constructed of loose to medium dense sand fills. The majority of Slip 1 (both upland and in the slip) is underlain by a dark grey, medium dense to dense, medium to coarse sand. The upper 5 to 10 feet of this formation can range to loose, likely owing to ongoing alluvial processes (i.e., scour and redeposition). The soils immediately beneath the mudline within Slip 1 are predominantly soft clay, silt, and sand sediments. At depth, the site is underlain by dense, partially cemented deposits of gravel and sand which likely constitutes the Troutdale Formation.

Liquefaction Analysis. The results of our liquefaction analyses indicate factors of safety of less than 1 (indicative of liquefaction) for much of the upper 35 feet of soil under the toe of the containment berm. For the analysis of the midpoint of the berm, factors of safety of less than 1 were indicated for the upper 17 feet of native sand. The majority of this material is anticipated to be removed prior to constructing the CDF. No indication of liquefaction was predicted

for native sand deposits under the crest of the berm. The results of our liquefaction analyses were incorporated into the stability analyses.

Short Term Static Stability. The factor of safety relative to a shallow slope movement was 1.52. The factor of safety for slope stability for a deep slope movement that would intersect the decant water was 1.72. These values indicate that the berm would be stable during hydraulic placement of the dredged sediments.

Long Term Static Stability. The long-term static stability case reflects a finished condition for the CDF. The factor of safety for our long-term static stability analysis was 1.62. The factor of safety for deep slope movements was 2.00. These values indicate that the berm will be stable under normal operating conditions.

Seismic Stability. The factor of safety relative to shallow surface movement representing sloughing of shallow soil from the slope face was 1.00. Stability analyses for a slip plane through the toe of the slope and adjacent native river bed soils provided a factor of safety of 1.10, indicating that the toe of the berm is vulnerable to lateral deformation during the design level ground motions. The pattern of deformations suggests that the slope displacement would be confined to the outer, lower portion of the berm and that the majority of the berm would be unaffected by this localized slip. The remaining berm possesses sufficient residual strength to contain the contaminated dredged materials. It is assumed that limited, localized deformations of the berm will be tolerable for the extreme event, and it is recommended that a provision for maintenance of the CDF will be in place for post-earthquake repairs.

We evaluated the impact of a progressive failure of the toe of the berm resulting from the design earthquake. In order to evaluate this potential, we assumed that the deepest failure surface with a pseudostatic factor of safety of 1 or lower has *occurred*. Further, we took the conservative assumption that all of the material within the slide block was removed by river currents. The reduced shear strengths described in Section 6.5, Post Earthquake Stability, were applied. This includes strength reductions for excess pore pressures and liquefaction. In spite of the conservative assumptions, the results of this analysis indicate that the factor of safety against a further shallow failure is in excess of 1.3. Our analysis indicates that the design is stable relative to a progressive failure.

The primary concern for the seismic performance of the CDF is the factor of safety for deep shear surfaces that intersect the dredged sediments. The pseudostatic analyses provided a factor of safety of 1.10 for this scenario. This indicates that the potential for "global," deep seated failure of the berm during a design earthquake is very low.

Post Earthquake Stability. For the post-earthquake scenario, the factor of safety for shallow, surface movement was 1.04 and for deep shear surfaces that intersect the dredged sediments was 1.35. These values indicate that the berm will be susceptible to surface distress after the CLE event but that the contained sediments are not susceptible to release.

Deformation Modelling. Application of the chart solution developed for the ODOT indicates that permanent slope displacements of up to 5 feet may be realized for shallow slide planes near the toe of the berm during the M_w 9.0 CSZ scenario earthquake. This deformation is considered tolerable as it is localized, does not include the majority of the CDF berm, and it is highly unlikely that this would lead to the release of contaminated sediments into the river. The Newmark solution for this same scenario indicates a much smaller range of potential slide deformations (roughly 2 to 3 feet). The potential for large-scale, deep-seated sliding is a much more critical situation for the containment of the contaminated sediments. The chart solution and Newmark procedures were applied for the deep slide plane. The range of estimated displacements was less than 1 to 2 feet for all scenarios, demonstrating tolerable deformations in all cases.

1.0 CDF CONFIGURATION AND GENERAL ASSUMPTIONS

1.1 CDF Configuration

Per the design an at-grade CDF berm will be constructed at the mouth of Slip 1. The CDF will consist of three main components: (1) a CDF containment berm, (2) dredged fill, and (3) a surface capping layer over the dredged fill. The berm configuration for our analysis incorporates a 2H:1V slope for the inward faces. This design configuration is consistent with containment berms constructed for the St. Paul and Port of Tacoma Slip 1 CDFs. The majority of the outward face is also constructed at a 2H:1V slope, although the toe of the berm will be buttressed with a rock blanket 20 feet thick horizontally at the toe, tapering to 5 feet thick at the midpoint of the berm (elevation 0 feet). The crest of the structure will be constructed to elevation 33 feet NGVD and is assumed to be 20 feet wide. The cross section is shown on the generalized stability cross section, Figure 1. The base of the structure will be placed at depths ranging up to 10 feet below existing grades depending on depths of softer alluvium that will require removal. For the majority of the berm structure, the removal of loose material will likely be less than 5 feet. We have assumed that 10 feet will be removed below the outer toe of the berm and replaced with structural fill.

The main CDF berm will be constructed in stages that involve the placement of successive training terraces built of imported quarry spalls (large crushed rock). This material will be placed in triangular berms approximately 20 feet high. The main berm fill will then be placed in between the edge training terraces. After the initial 20 feet of berm infill is placed, two additional training terraces will be constructed. These will then be infilled as with the first set. The remainder of the cell will be constructed above river level using berm fill without edge berms.

A new structure will be built along the pierhead line just upstream of the berm to replace the current Berth 405 structure in Slip 1. The berth for the new structure could be dredged to elevation -46 feet NGVD in the future. Therefore, the berm is designed with this elevation at the toe. This elevation was selected to correspond with the deepest dredging requirements that are likely under current and potential uses for Terminal 4.

Behind the berm, contaminated dredged sediments will be placed to elevation 9.5 feet NGVD or below. Between elevation 9.5 and 28 feet NGVD, non-contaminated dredge sediment will be placed. The upper 4.5 feet of the CDF will be filled with imported granular materials.

1.1.1 CDF Materials

The berm material will consist of a well-graded mix of sand and gravel. The berm will be constructed using training terraces consisting of quarry spalls. The outer face of the berm will have a surficial armor layer placed to resist potential erosive forces. An approximate gradation for the proposed berm fill material is given in the table below. This gradation has been used successfully at other CDF containment berms in Region 10.

Table 1.1a: Preliminary Berm Fill Gradation

Screen Size	Percent Passing
4-inch	90 to 100
3/4-inch	50 to 75
U.S. No. 4	35 to 55
U.S. No. 10	25 to 45
U.S. No. 40	10 to 25
U.S. No. 200	0 to 4

The intent of the gradation shown in Table 1.1a is to achieve the optimal balance of soil properties, specifically to maximize the frictional strength of the soil while keeping the permeability as low as practicable. This gradation provides minimized permeability while possessing sufficient shear strength to stand at slopes that are practical for a waterfront slope. The slopes proposed are consistent with existing slopes in the river, and are necessary to limit fill in

the river channel and impacts on navigation. As such, it is necessary to utilize a berm fill that has sufficient stability under seismic and static conditions at the slopes developed. Based on our stability analysis of the currently proposed berm geometry and adjacent bathymetry, this requires a friction angle of at least 35 degrees. Such friction angles are difficult to achieve without specifying a soil with a significant quantity of angular gravel and low content of fine-grained material (i.e., material passing the No. 200 sieve).

In order to limit permeability while maintaining the needed friction angle, it is necessary to use a gradation that is "well graded". This allows for a general filling of the voids in the gravel with sand and small quantities of silt. A good distribution of grain sizes (such as proposed for use per table above) results in an enhanced friction angle, while also reducing overall permeability.

The dredged sediments that will be placed in the CDF will likely consist of a mixture of silts and sands. This material may be placed through a variety of methods including hydraulic placement. We have assumed that the resulting placed sediments will consist of relatively soft silts with low shear strength.

The fill to be placed over the contaminated dredged sediments will consist of granular soils. For the purposes of our analysis, we have assumed that these soils will consist of moderately silty sands.

2.0 SEISMICITY

In accordance with the USEPA approved EE/CA (BBL, 2005) and the Action Memorandum (USEPA, 2006), the CDF and the containment berm were evaluated for stability against a contingency level seismic event. The contingency level event (CLE) represents an earthquake with a 10 percent probability of exceedance in 50 years (i.e., 475-year return period). The seismic performance requirements for the extreme event (i.e., CLE) allow that waterfront facilities may suffer significant damage that would impair operations and major repair work would likely be required; however, catastrophic failure of the berm that would release confined contaminated sediment into the river must be precluded. Although design components, such as a CDF containment berm, may exhibit earthquake-induced deformation, containment of the contaminated sediments shall not be jeopardized.

The Action Memorandum (USEPA 2006A) requires the following geotechnical seismic analysis for the Terminal 4 RAA and the CDF containment berm stability:

- Detailed characterization of seismic sources (known regional faults) in the vicinity of the Terminal 4 RAA for development of a site-specific seismic hazard analysis;
- Development of bedrock ground motions considering the seismic sources that significantly contribute to the evaluation of the dynamic response of the native soils and CDF berm during the design earthquake scenarios. These analyses integrate the geotechnical site characterization with the dynamic behavior of the local soils.
- Evaluation of liquefaction potential for CDF containment berm, foundations soils, dredge sediment, and surrounding site soils potentially contributing to instability of the CDF during the design-level earthquake, including evaluation of liquefaction-induced deformations and lateral spreading;
- Evaluation of slope stability and deformation for both pseudo-static and post-earthquake conditions; and
- Development of contingency plan for post-earthquake inspection and repair (see Appendix E, long-term monitoring and reporting plan)

2.1 Regional Seismic Setting

The regional sources of seismicity affecting the Portland Metropolitan area, and hence the potential for ground shaking, are associated with three separate fault mechanisms. These include "mega-thrust" subduction earthquakes

(moment magnitude [M_w] 8 to 9) and relatively deeper, Benioff-zone, intraplate events (M_w 6.5 to 7.3) both associated with the Cascadia Subduction Zone (CSZ), as well as the relatively shallow crustal zone earthquakes (M_w 5.0 to 7.0). Geotechnical analyses for seismic hazards associated with liquefaction and earthquake-induced slope deformation require that the specific earthquake sources be recognized so that effects of ground motion attenuation, duration, and frequency content on these hazards can be assessed. Descriptions of these potential earthquake sources are presented as follows.

The CSZ extends from Northern California to British Columbia and the seismogenic portion of the CSZ is largely located offshore at the latitude of Portland. Within this zone, the oceanic Juan De Fuca Plate is being subducted beneath the continental North American Plate to the east. The interface between the two plates is dipping to the east, and, therefore, becomes deeper toward Portland. At the easternmost portion of the interface zone that is thought to be capable of generating strong ground motions, the interface between these two plates is located at a depth of approximately 20 to 25 kilometers (km). Quantifying the seismicity and hazard posed by the CSZ is subject to several uncertainties, including the size of the maximum credible earthquake as described by the moment magnitude of the event, the rate of seismicity associated with the CSZ, and the nature of the ground motions associated with CSZ earthquakes. Geologic evidence of previous CSZ earthquakes has been observed within coastal marshes along the Oregon coast and in off-shore landslide deposits (turbidites). This paleoseismic data has been used to infer the size of pre-historic earthquakes as well as their rate of recurrence. These geologic investigations indicate that large ($M_w > 8$) subduction zone earthquakes along Cascadia occur at intervals on the order of 300 to 500 years, well within the period of interest for this project. The most recent mega-thrust earthquake is estimated to have occurred approximately 300 years ago.

Based on the most current Probabilistic Seismic Hazard Analyses (PSHA) performed by the USGS National Seismic Hazard Mapping Program (Peterson et al. 2008, USGS 2008), the closest distance from the site to the portion of the CSZ that is thought to be capable of generating significant ground motions is approximately 95 to 100 km. This fault location is consistent with that specified by agencies such as the Oregon Department of Transportation (ODOT), U.S. Army Corps of Engineers (USACE), and U.S. Bureau of Reclamation, and accepted by regulatory agencies such as the Federal Energy Regulatory Commission (FERC).

The Benioff zone encompasses the portion of the subducting Juan De Fuca Plate located at a depth of approximately 30 to 50 km below western Oregon. Very low levels of seismicity have been observed within the intraplate zone in Oregon. However, much higher levels of seismicity within this zone have been recorded in Washington and California. Several reasons for this seismic quiescence were suggested by Geomatrix (1995) and these include changes in the direction of subduction between Oregon and British Columbia as well as the effects of volcanic activity along the Cascade Range. Historical activity associated with the intraplate zone includes the 1949 Olympia M_w 7.1, 1965 Puget Sound M_w 6.5, and 2001 Nisqually M_w 6.8 earthquakes. The regional PSHA prepared by the USGS (2008) indicates that the Benioff zone earthquakes significantly contribute to the seismic hazard at the return period associated with the CLE (i.e., 475 years).

The third source of seismicity that can result in significant ground shaking within the greater Portland area is near-surface, crustal earthquakes occurring within the North American Plate. The historical seismicity of moderate-sized crustal earthquakes in western Oregon is higher than the seismicity associated with the CSZ and the intraplate zone. The 1993 Scotts Mills (M_w 5.6) and Klamath Falls (M_w 6.0) earthquakes are examples of relatively shallow (approximately 15 km) crustal earthquakes. The characterization of the local crustal earthquake sources includes known faults thought to be active in the Portland region, and consideration of possible seismicity that may occur in the region along unmapped sources. The crustal earthquakes that occur along currently unmapped faults in the region have been referred to in seismic hazard investigations as “randomly occurring” earthquakes, “aerial sources,” or “gridded seismicity”.

2.2 Site Specific Seismic Hazard

We completed a thorough review of the regional PSHA prepared by the USGS, and supplemented their regional investigation with the most up to date information from agencies such as the Department of Geology and Mineral Industries (DOGAMI) and ODOT. This information has been supplemented with seismic hazard data from numerous other technical resources. The primary seismic sources affecting the site have been evaluated in terms of the magnitude of the earthquakes, their distance from the site, and the corresponding ground motions that are estimated for each of the respective sources. The ground motion parameter of interest for the specified return period (i.e., Peak Ground Acceleration [PGA] and 475 years for this project) is routinely provided as the mean value resulting from all of the regional seismic sources, thus it reflects the cumulative seismic hazard in the region. Once the PGA representing the cumulative hazard has been established, the relative contribution of the individual seismic sources can be determined by way of a deaggregation of the cumulative seismic hazard. The results of the deaggregation provided by the USGS PSHA (2008) were adopted in this investigation. The PGA on bedrock (Site Class B-C boundary) having an average return period of 475 years is 0.20g. The relative contributions of the primary seismic sources to the peak ground acceleration on bedrock at the site are provided in Table 2.2a.

Table 2.2a: Results of PSHA Deaggregation for Seismic Sources Affecting the Portland Region (USGS 2008)

Principal Sources (faults, subduction, random seismicity having more than 3 percent contribution to PGA				
Source Category	**Percent Contribution**	**R (km)**	**M_w**	**Epsilon0**
Cascadia M8.3-M8.7 floating	13.97	99.0	8.51	0.58
Cascadia Megathrust	23.36	95.6	9.01	0.16
WA-OR Cascades-West faults	8.87	8.4	6.63	-0.86
WUS Compressional Crustal gridded	27.13	14.2	5.88	0.32
50-km Deep Intraplate (Benioff zone)	23.61	71.8	6.89	0.79
Individual fault hazard details if its contribution to mean hazard is > 2%				
Portland Hills fault	4.02	3.1	6.72	-1.62

The seismic hazard data provided in Table 2.2a demonstrates the relative contribution of the various sources to the regional hazard for the short-period ground shaking corresponding to the PGA. The CSZ thrust events were conservatively lumped together and the M 9.0 scenario has been applied on this project. This accounts for roughly 37 percent of the seismic hazard related to PGA. The deep, Benioff zone earthquakes contribute roughly 24 percent of the hazard, and roughly 36 percent of the hazard is associated with shallow, crustal events located relatively close to the Portland metropolitan region. The epsilon values listed in Table 2.2a relate the PGA values for the specific source (M-R pair) to the mean PGA determined for the overall, cumulative hazard (i.e., 0.20g). Positive values of epsilon indicate that the PGA associated with this source and source-to-site distance is less than 0.20g, conversely negative values indicate that the PGA values are greater than the mean PGA for the region. This deaggregation procedure demonstrates that the deep Benioff zone earthquakes yield a PGA that is much smaller than 0.20g for the 475-year exposure interval.

On the basis of the PSHA analyses previously described, we have defined two scenario earthquakes for design purposes: (1) a M_w 9.0 mega-thrust earthquake along the CSZ having a source-to-site distance of 96 km; and (2) a

M_w 6.2 shallow, crustal event with a source-to-site distance of 12 km. The latter scenario yields a PGA on rock/firm soil of roughly 0.20g using the "Next Generation Attenuation" relationships (EERI 2008), consistent with the cumulative, uniform hazard at the site. The use of M_w 9.0 and 6.2 earthquakes are considered representative for the respective sources.

The relatively minor contributions from other faults were evaluated on a source by source basis. The relative contributions of the two closest faults, the Portland Hills Fault and the East Bank Fault, to the cumulative seismic hazard are small for the return period of interest, approximately 4 percent and nil, respectively. The ground motions due to these two potential seismic sources have not been incorporated into the current analyses because of the low slip rates and corresponding long return periods for damaging earthquakes estimated for these faults. Support for this decision was provided with additional input from DOGAMI personnel who are actively studying these faults (Madin, 2006). The design team has selected the following scenarios for subsequent analysis of dynamic soil response, soil liquefaction, and design for the CDF berm:

4. M_w 9.0 CSZ event resulting in bedrock ground motions of 0.14g beneath the site.
5. M_w 6.2 crustal source resulting in bedrock ground motions of 0.20g.
6. The intraslab (or intraplate) source has been shown to contribute the least to bedrock peak acceleration and spectral accelerations (0.2 and 1.0 second), and therefore omitted from further consideration in our analyses.

3.0 GEOTECHNICAL CONDITIONS

We reviewed the contents of 24 geotechnical reports prepared for past projects within Terminal 4. These data were screened for applicability to the project relative to proximity and exploration methodology. Over 80 borings and 10 cone penetrometer tests (CPTs) were included in this review. Of the borings reviewed, 11 were found to have been within the general CDF area and completed with modern drilling equipment. The most significant data available from the borings consisted of standard penetration test (SPT) blowcounts. The SPT test results were summarized and corrected for rod length, overburden pressure, and hammer efficiency. For all corrections, mid range values as recommended by the Federal Highway Administration (FHWA) were utilized (Sabatini et.al. 2002).

The following soil units were encountered in the explorations reviewed:

Loose to Medium Dense Sand Fill. In general, the upland areas adjacent to the CDF were constructed of loose to medium dense sand fills. The thickness of the fill layer ranges from approximately 17 to 35 feet. Gradation testing of the sand fills indicates fines contents ranging from approximately 5 to 15 percent.

Soft Surface Sediments. The soils immediately beneath the mudline along Slip 1 are predominantly soft clay, silt, and sand sediments. Based on the sediment cores completed for the EE/CA, the soft sediment layer generally ranges from about 0 to 3 feet in thickness.

Medium Dense Sand. The majority of Slip 1 is underlain by a dark grey, medium dense to dense, medium to coarse sand. This sand is consistent with Willamette River alluvium. Based on past laboratory testing, the fines content of this sand ranges from 3 to 8 percent. The upper 5 to 10 feet of this formation can range to loose, likely owing to ongoing alluvial processes (i.e., scour and redeposition). Below this disturbed material, the density of the sand is relatively uniform. Based on a review of 138 corrected SPT values, the average blowcount value obtained in this formation was 21 blows per foot (bpf) with a standard deviation of 9.3 bpf. The distribution of blowcounts indicates little to no variation with depth. Only one SPT sample had a measured blowcount of less than 10 (indicative of loose sand), and seven samples had blowcounts of more than 30 (indicative of dense sand). With very little variation, this formation can be modeled as a medium dense, relatively clean sand.

Troutdale Gravel. Dense, partially cemented deposits of gravel and sand were encountered below the alluvial sands. This deposit likely consists of the Troutdale Formation.

4.0 DYNAMIC SOIL RESPONSE AND SURFACE GROUND MOTIONS

The results of the probabilistic seismic hazard evaluation outlined in Section 2.2 and subsequent application of the NGA procedures for estimating the characteristics of strong shaking during the design scenario earthquakes are applicable for bedrock conditions. The potentially significant influence of soil deposits on the characteristics of the ground motions must be evaluated for the use in the analysis of geotechnical hazards associated with soil liquefaction and slope stability. Dynamic soil response analyses have been performed for three critical sections along the CDF berm: (1) centerline, (2) mid-slope at the location of the bench, and (3) at the toe of the berm. The geotechnical profile of soils and underlying rock materials was constructed after review of pertinent reports at Terminal 4, local sites along the Willamette River, and regional geologic mapping. Dynamic soil properties were obtained from *in situ* data at the Terminal 4 site, regional seismic hazard mapping projects performed by or for DOGAMI, or estimated from correlations with other geotechnical parameters such as SPT or CPT penetration resistances.

The three soil profiles selected for analysis were modeled using Pro-Shake, a commercially available software package based on the widely used program SHAKE (Schnabel et al., 1972). The soil and rock profiles included the soil layers outlined in Section 2.2 as well as the underlying deposits of Troutdale gravel, Sandy River mudstone, a weathered section of Columbia River basalt, and a base layer of relatively intact and fresh Columbia River basalt. A suite of bedrock ground motion time histories was selected on the basis of the source mechanism and magnitude of the event, source-to-site distance, as well as the intensity, duration, and frequency content of the individual motions. All motions are considered representative for the design earthquake scenarios (M_w 6.2 with source to site distance of 12 km, and M_w 9.0 at roughly 100 km distance). Three acceleration time histories were selected for the M_w 6.2 crustal event, and five time histories were employed for the M_w 9.0 event (three actual recordings and two synthetic motions generated for subduction zone earthquakes).

The 1D model Pro-Shake has been used to evaluate the dynamic response of the native soils as well as vertical "slices" of the CDF berm at three locations. This approach accounts for the varying thickness of the berm at the toe, mid-slope, and crest, but it does not capture 2D wave passage effects that may occur adjacent to the crest and upper reaches of the slope face. The dynamic soil response analyses demonstrate that all three of the soil profiles lead to an amplification of bedrock ground motions. The computed peak ground surface accelerations for three sections of the CDF berm are listed in Table 4.0a. These PGA values reflect the average of three analyses for the design crustal event and five analyses for the CSZ event. The influence of sloping ground conditions on the site response has not been directly accounted for using the 1D model.

Table 4.0a: Computed Peak Horizontal Ground Accelerations

Seismic Source	Peak Horizontal Ground Acceleration (g)			
	Bedrock	Toe of Berm	Midpoint	Centerline of Berm Crest
Shallow, crustal faulting	0.20	0.33	0.30	0.31
CSZ mega-thrust event	0.14	0.20	0.18	0.17

Field recordings obtained near slopes and 2D numerical modeling studies have demonstrated that ground motions can be modified in close proximity to the slope face, particularly adjacent to the crest of the slope. This phenomenon is referred to as Topographic Amplification. Primary factors influencing the effects of slopes on ground motions include: slope geometry (angle and height), soil profile beneath the slope, and the characteristics of the bedrock

ground motions. The former has been found to have the most influence on the motions. A synthesis of the technical literature has been performed in order to quantify the possible influence of Topographic Amplification on the CDF response and to evaluate the necessity of performing 2D dynamic analyses of the berm.

Recent investigations of the seismic performance of slopes (Bray and Travasarou 2007, Anderson et al. 2008) indicate that for the slope angles of interest for this project 1D site response modeling provides reasonably conservative estimates of the dynamic loading at the base of embankment, but that the 1D analysis can underestimate the seismic demand for shallow sliding near the crest of the embankment. These observations are supported by the results of 2D numerical modeling of slopes and guidelines for the modification of 1D analysis can be found in pertinent seismic design provisions.

The European Seismic Code (EC8) and French Seismic Code provision (outlined by Assimaki et al., 2005) provide guidelines and amplification factors for peak ground acceleration adjacent to slopes. In both codes, the topographic amplification factors are determined as functions of slope angle and ground surface location on and adjacent to the slope. The amplification factors prescribed in these codes for slopes of 2H:1V and slope height less than 100 feet are 1.0 and 1.08, indicating the peak ground accelerations along the ground surface near the crest of the slope should be increased by as much as 10 percent over estimates provided from 1D analyses. The topographic amplification factor decreases with depth to a value of 1.0 at the base of the slope. These simplified code-based procedures have been supplemented with numerous 2D numerical modeling investigations of slopes and topographic amplification (e.g., Assimaki et al., 2005; Ashford and Sitar, 1997; Stewart et al., 2001, 2004). A synthesis of the findings of these studies for slopes of 2H:1V and H ≈ 70 feet provides the following pertinent considerations: (1) topographic amplification is most pronounced immediately behind the slope crest and can lead to PGA amplification of 10 to 25 percent over estimates from 1D analyses; (2) the topographic effects decay rapidly with distance behind the slope crest, with distance down the slope face, and with depth directly beneath the crest; (3) shear strains computed using 2D methods of dynamic analysis for slopes have shown an increase in maximum shear strain of up to 25 to 50 percent in soils located at the crest and within 15 feet of the ground surface over 1D estimates in clay-rich soils (slope angle of 35°, H = 100 feet); and (4) the same study demonstrated that the 2D influence decayed rapidly with depth and was negligible at the elevation of the toe of the slope.

Based on the review of current seismic code provisions as well as empirical and numerical investigations of topographic amplification the design team felt that rigorous 2D analyses were not warranted for the slope configuration represented by the CDF. The results of the 1D SHAKE analyses have been adjusted using the semi-empirical and numerical amplification factors previously outlined to approximately, yet conservatively account for the 2D nature of the CDF berm. The PGA values provided in Table 4.0a have been increased by the following Topographic Amplification Factors (TAF): (1) TAF = 1.0 at the toe of the berm, (2) TAF = 1.1 at the midpoint decreasing with depth vertically beneath the bench to a value of 1.0 at the elevation of the toe, and (3) TAF= 1.25 at the crest of the berm, also decreasing with depth vertically beneath the midpoint to a value of 1.0 at the elevation of the toe. The amplification factors have been applied for subsequent hazard evaluations involving soil liquefaction and slope stability.

5.0 LIQUEFACTION POTENTIAL

The potential for soil liquefaction during seismic ground shaking is generally associated with loose to medium dense, saturated sands and very soft, recently deposited, non-plastic silt soils.

Loose sandy soils are present at the mudline in several locations, and it is our recommendation that these liquefiable soils be dredged from the site prior to the placement of the CDF berm. Localized lenses of liquefiable soil are probable; however, based on currently available *in situ* geotechnical data, it does not appear that these lenses are vertically and laterally continuous.

Preliminary liquefaction analyses were performed based on SPT values available from past geotechnical explorations completed in the vicinity of the CDF. These data were supplanted by CPT data available from the EECA. Ground motions and seismically induced stresses were based on the results of our dynamic site analysis detailed in the preceding section.

Liquefaction modeling was completed using the "simplified procedure" presented in Youd et al. (2001). We calculated factors of safety against liquefaction for all materials above the Troutdale Formation. The analysis was completed for three locations: under the crest of the CDF berm; midway between the crest of the berm and the toe of the berm; and beneath the toe of the berm.

The results of our liquefaction analyses indicate factors of safety of less than 1 (indicative of liquefaction) for much of the upper 35 feet of soil under the toe of the containment berm. For the midpoint analysis, factors of safety of less than 1 were indicated for the upper 17 feet of native sand. The majority of this material is anticipated to be removed prior to constructing the CDF. No indication of liquefaction was predicted for native sand deposits under the crest of the berm.

The *Simplified Liquefaction Procedures* routinely used in practice have been applied using the seismic demand (Cyclic Stress Ratio, CSR) obtained from the 1D site response analyses adjusted for sloping conditions, and the cyclic resistance of the soils (Cyclic Resistance Ratio, CRR) based on in situ data. These analyses indicate the existence of zones of soil that are potentially liquefiable under the seismic loading associated with the CLE event. The existence of liquefiable soils considered in the overall stability analyses of the CDF berm. The results of our liquefaction analyses were incorporated into the stability analyses outlined in Section 6.0.

6.0 CONTAINMENT BERM STABILITY

6.1 Methods of Stability Analysis

A number of typical cross sections through the berm were developed and analyzed for deep-seated, global stability. Stability modeling was conducted with GeoSlope's software package SLOPE/W. The software employs a limit equilibrium methodology for calculating a factor of safety against sliding or sloughing. The analysis was completed using Spencer's method which satisfies both moment and force equilibrium.

The cross section was evaluated for four cases: (1) short term static; (2) long term (post-filling) static; (3) long term (post-filling) seismic: and (4) post earthquake static. For each case, we evaluated the slope stability based on a search of circular, block, and segmental slip planes. We also searched through the calculated slip planes that pass through the contaminated dredged sediment to determine which of these have the lowest factor of safety. These are referred to as the shallow slip plane and the deep slip plane, respectively. The deep slip plane represents deep-seated embankment deformations that might result in release of contaminated sediment. A graphical representation of the results of each of these analyses is shown on Figures 2 through 6.

Soil parameters used in the analyses were developed based on the results of the geotechnical site characterization and review of available in situ and laboratory data. The penetration resistance of the soils (SPT N and CPT q values), laboratory strength testing, and gradation data were used in concert with published references to develop strengths and unit weights.

For the static and pseudostatic analyses, drained strength parameters were used. These values are appropriate for cases where the density and/or permeability of the soils precludes the generation of significant excess pore pressure (generally excess pore pressure ratios, R_u, less than 0.3). The strength of the native soils was developed based on correlations with corrected SPT blow counts and CPT tip resistance (Sabatini 2002 and Mayne 2007). The strengths of other soils such as the berm and dredged materials were estimated based on anticipated gradation and densities of these soils. Under the toe of the embankment, the upper 10 feet was assumed to have been removed and

replaced with training dike material. The values assumed for non-native soils are comparable to assumed values used in designing previous CDF facilities in EPA Region 10 (City of Tacoma, 2003; Occidental Chemical and Port of Tacoma, 2003). A summary of drained soil parameters employed in our analyses is presented Table 6.1.

The post-earthquake static analyses were performed to evaluate the margin of safety that may exist during and immediately after seismic loading during the design level events. The shear resistance of the soils was modified to account for the generation of excess pore pressure and possible degradation of strength during cyclic loading. The results of these analyses have been used in deformation analyses of the CDF and foundation soils.

Table 6.1: Drained Soil Properties, Global Stability Assessment

Soil Unit	Moist Unit Weight (pcf)	Cohesion c' (psf)	Internal Friction Angle (phi')
Berm Fill	135	0	35
Contaminated Dredged Material	120	0	24
CDF Fill	120	0	32
CDF Surface Layer	125	0	35
Native Sands	120	0	35
Quarry Spalls	135	9	43

6.2 Short Term Static Stability

The critical section for the short term static stability reflects the conditions present during filling of the CDF when the entire CDF may be used to decant hydraulically dredged sediments. Our analysis was based on the most critical case for this condition, with the contaminated sediment placed, the water in the CDF to within 2 feet of the crest of the CDF, and with the river at a low water stage. On the basis of the construction and dredging methods proposed and the schedule for filling of the CDF it is considered unlikely that the water in the CDF would reach this elevation. This case is shown on Figure 2.

The factor of safety relative to a shallow slope movement was 1.52. The factor of safety for slope stability for a deep slope movement that would intersect the decant water was 1.72. These values indicate that the berm would be stable during hydraulic placement of the dredged sediments.

6.3 Long Term Static Stability

The long term static stability case reflects a finished condition for the CDF. For this case, we assumed that the groundwater table within the CDF would approach current levels observed inland of Slip 1. This case is shown on Figure 3.

The factor of safety for our long term static stability analysis was 1.62. The factor of safety for deep slope movements was 2.00. These values indicate that the berm will be stable under normal operating conditions.

6.4 Seismic Stability (Pseudostatic)

The seismic stability was evaluated using pseudostatic limit equilibrium analyses for the CLE (i.e., 475-year return interval ground motions). The lateral force coefficient used in the analysis was equal to one-half of the peak horizontal acceleration developed from the seismic analysis, consistent with recommendations for situations where minor slope deformations are considered tolerable (Anderson et al. 2008). We used the maximum value for peak horizontal acceleration computed during our dynamic study. In order to account for the 2D slope response previously described, we increased the PGA values computed using the 1D site response model by 15 percent and applied this

value uniformly throughout the entire model. This approximation appears to be conservative for the CDF berm based on our review of the technical literature. This case is shown on Figure 4.

The factor of safety relative to shallow surface movement representing sloughing of shallow soil from the slope face was 1.00. Stability analyses for a slip plane through the toe of the slope and adjacent native river bed soils provided a factor of safety of 1.10, indicating that the toe of the berm is vulnerable to lateral deformation during the design level ground motions. The pattern of deformations suggests that the slope displacement would be confined to the outer, lower portion of the berm and that the majority of the berm would be unaffected by this localized slip. The remaining berm possesses sufficient residual strength to contain the contaminated dredged materials. It is assumed that limited, localized deformations of the berm will be tolerable for the extreme event, and it is recommended that a provision for maintenance of the CDF will be in-place for post-earthquake repairs.

We evaluated the impact of a progressive failure of the toe of the berm resulting from the design earthquake. In order to evaluate this potential, we assumed that the deepest failure surface with a pseudostatic factor of safety of 1 or lower has *occurred*. Further, we took the conservative assumption that all of the material within the slide block was removed by river currents. The reduced shear strengths described in Section 6.5, Post Earthquake Stability were applied. This includes strength reductions for excess pore pressures and liquefaction. In spite of the conservative assumptions, the results of this analysis indicate that the factor of safety against a further shallow failure is in excess of 1.3. Our analysis indicates that the design is stable relative to a progressive failure.

The primary concern for the seismic performance of the CDF is the factor of safety for deep shear surfaces that intersect the dredged sediments. The pseudostatic analyses provided a factor of safety of 1.10 for this scenario. This indicates that the potential for "global," deep seated failure of the berm during a design earthquake is very low.

6.5 Post-Earthquake Stability

For the post-earthquake scenario, we modified the strength parameters used in the static case. This approach is consistent with the design approach used at other Region 10 CDFs (City of Tacoma, 2003; Occidental Chemical and Port of Tacoma, 2003). This included inserting a zone of liquefied sand under the toe of the embankment. This case is shown on Figure 5.

Stress-dependent undrained residual strength values were used to model liquefiable soils in the post-earthquake analysis. The stress-dependent strength values were estimated using a correlation with corrected SPT blow counts. Since our liquefaction analysis indicated factors of safety between 1.0 and 1.2 for much of the native sands, we modified the friction angles for this formation based on estimating excess pore pressures. This analysis was extended to the upper dredge fills that were assumed to be uncompacted after placement. A summary of post-earthquake soil parameters employed in our analyses is presented in Table 6.5.

Table 6.5: Post Earthquake Soil Properties, Stability Assessment

Soil Unit	Moist Unit Weight (pcf)	Internal Friction Angle (phi')	$s_u(_{liq})/\sigma'_v$
Berm Fill	135	35	NA
Contaminated Dredged Material	120	0	0.05
CDF Fill	120	27	NA
CDF Surface Layer	125	35	NA
Liquefied Native Sands	120	0	0.20
Native Sands	120	30	NA

The factor of safety relative to shallow, surface movement was 1.04. The factor of safety for the deep shear surfaces that intersect the dredged sediments was 1.35. These values indicate that the berm will be susceptible to surface distress after the CLE event but that the contained sediments are not susceptible to release.

6.6 Seismically-Induced Berm Deflection

The post-earthquake stability analyses provide the margin of safety against slope deformation for conditions that exist immediately after the ground shaking has stopped. At this time it is conservatively assumed that all excess pore pressures that may have been generated during the cyclic loading still exist in the soil layers and possible degradation in soil strength is incorporated into the stability model. While this procedure provides a useful assessment for the likelihood of permanent earthquake-induced deformations, it does not provide explicit estimates of the likely slope movement. As previously addressed, the CDF berm can undergo limited, tolerable deformations and continue to contain the contaminated soils in an acceptable manner. A deformation-based method of design, similar to that adopted for large earth dams, has been employed on this project.

The range of permanent, earthquake-induced deformations of the berm is a function of the cyclic loading, including both the intensity and duration of the ground motions. For this reason, the deformation analyses must be performed for both the CSZ and the local crustal earthquake scenarios. Two procedures have been utilized to bracket the range of likely slope movement. The first is a chart solution based on 2D nonlinear, effective stress analyses performed for slopes with and without variable thicknesses of liquefiable soil in the profile. The analyses were performed to evaluate the permanent deformations that would be expected for highway embankments in Oregon (Dickenson et al., 2002). Many of the general embankment geometries in the numerical modeling study were similar to the CDF berm. The slope deformation is estimated using the post-earthquake factor of safety, the magnitude of the scenario earthquake as a proxy for duration, and the PGA of the ground motion. This method has been found in comparisons with field case studies to provide conservative, yet reasonable estimates for slope deformation. The second method of analysis for estimating earthquake-induced slope deformations was the well-known Newmark analysis, wherein the sliding mass is treated as a rigid, perfectly plastic block that translates or rotates during cyclic loading leading to cumulative deformations. The Newmark analysis requires the post-earthquake factor of safety as well as a collection of acceleration time histories that are representative of the motions at the base of the slide plane. For this project the Newmark solution developed by Jibson and Jibson (2003) was used. The ground surface PGA values and a large suite of representative input motions were used for the analysis.

The results of the slope deformation modeling are presented in Table 6.6. Application of the chart solution developed for the ODOT indicates that permanent slope displacements of up to 5 feet may be realized for shallow slide planes near the toe of the berm during the M_w 9.0 CSZ scenario earthquake. This deformation is considered tolerable as it is localized, does not include the majority of the CDF berm, and it is highly unlikely that this would lead to the release of contaminated sediments into the river. The Newmark solution for this same scenario indicates a much smaller range of potential slide deformations (roughly 2 to 3 feet). The potential for large-scale, deep-seated sliding is a much more critical situation for the containment of the contaminated sediments. The chart solution and Newmark procedures were applied for the deep slide plane. The range of estimated displacements was less than 1 to 2 feet for all scenarios, demonstrating tolerable deformations in all cases.

These simplified deformation analyses are useful as screening tools that provide reasonable estimates of the range of displacement expected during the design level earthquakes. The displacements provided by these simplified procedures, using conservative input parameters, demonstrate tolerable deformations. It is anticipated that more sophisticated analysis procedures would yield similar results; therefore, the benefits of supplementary 2D analyses are considered to be very minor.

Table 6.6: Estimated Earthquake-Induced Slope Deformation

Scenario Earthquake	Range of Estimated Slope Displacement (ft)			
	Shallow Slip Plane		Deep Slip Plane	
	Chart	Newmark	Chart	Newmark
Cascadia Subuction Zone event (M 9.0, PGA 0.2g)	4.0 to 5.0	2.5 to 4.0	1.0 to 2.0	< 0.5
Local Crustal event (M 6.2, PGA 0.33g)	2.0 to 3.0	1.0 to 2.5	0.5 to 1.0	< 0.5

7.0 DISCUSSION

Based upon our analysis, the CDF structure as proposed is protective of the contaminated sediments placed within the CDF. The structure will adequately protect and contain the dredged material.

Static factors of safety in excess of 1.5 and seismic factors of safety in excess of 1.1 are broadly considered acceptable for earth structures in cases where nominal permanent deformations are tolerable. For all cases, the factors of safety against a deep slope movement were far in excess of these values. Supplementary deformation analyses of the berm indicate that tolerable deformations would result during the design earthquake scenarios. The berm as designed will prevent the physical release of contaminated sediment.

Our analysis did indicate the potential for permanent deformations of the berm face during the CLE. The slope movement is considered to be within tolerable ranges, although such deformations would require rebuilding the outer face of the berm, our analysis indicates that the contaminated sediment within the CDF would not be impacted. The risks associated with shallow surface sloughing are comparable to the risks associated with most waterfront facilities in the Portland area including petroleum storage tank facilities.

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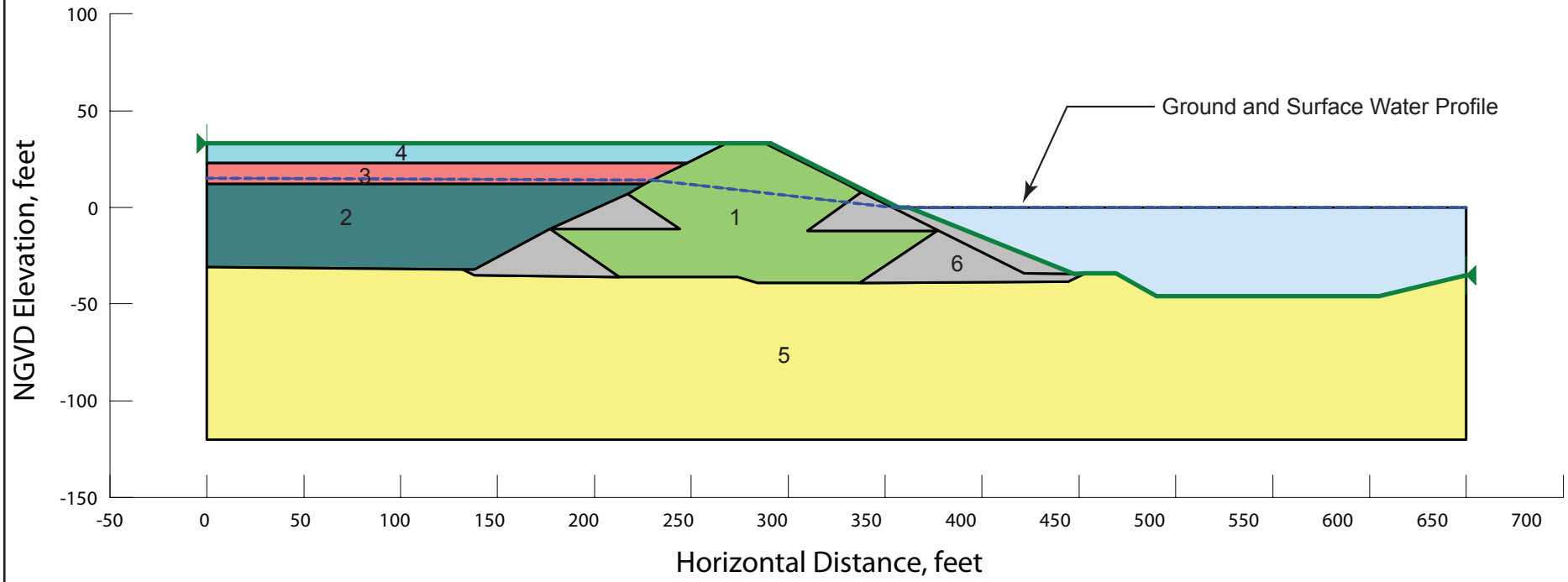


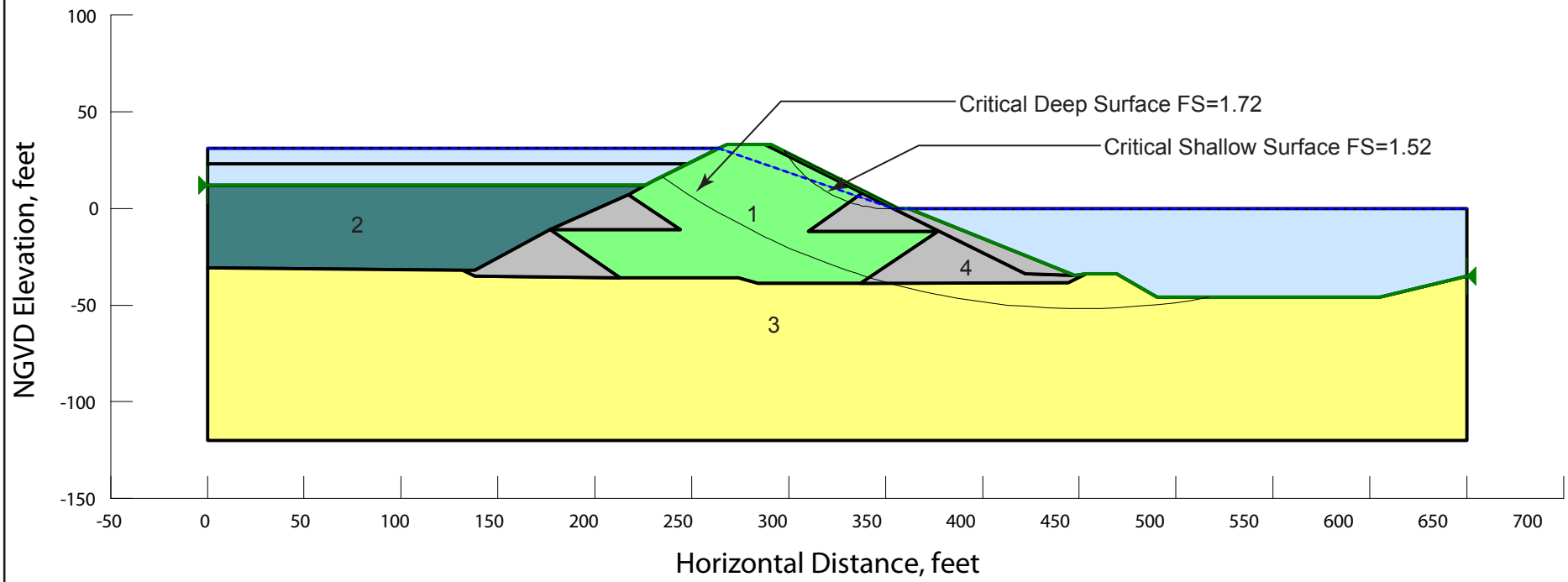
Soil Unit	Material
1	Berm Fill
2	Contaminated Dredged Material
3	CDF Fill
4	CDF Surface Layer
5	Native Sands
6	Quarry Spalls

Basic Stability Model

Seismic and Stability Evaluations
Terminal 4 Slip 1 CDF
Portland, Oregon

Ash Creek Associates, Inc.
Environmental and Geotechnical Consultants

Project Number	1165-00	Figure
August 2011		1



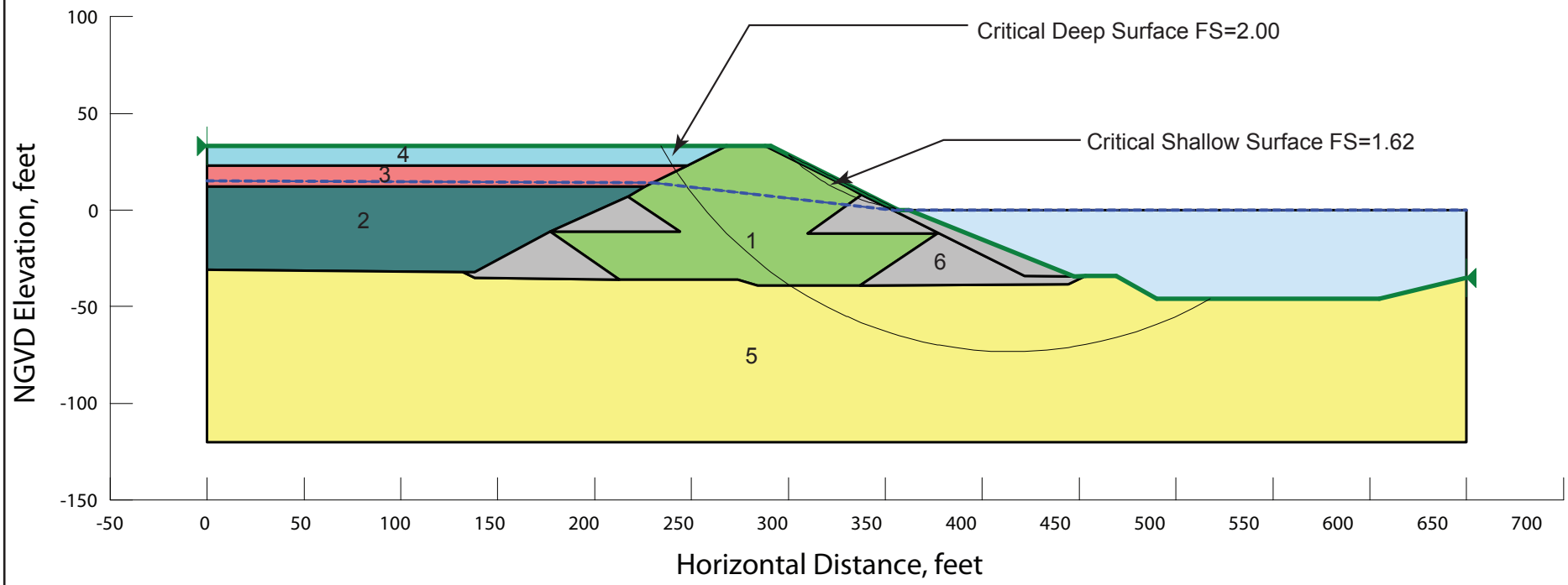
Soil Unit	Material	Unit Weight pcf	Friction Angle degrees	Cohesion psf
1	Berm Fill	135	35	0
2	Contaminated Dredged Material	120	24	0
3	Native Sands	120	35	0
3	Quarry Spalls	135	43	0

Short Term Operational Stability

Seismic and Stability Evaluations
Terminal 4 Slip 1 CDF
Portland, Oregon

Ash Creek Associates, Inc.
Environmental and Geotechnical Consultants

Project Number	1165-00	Figure
August 2011		2



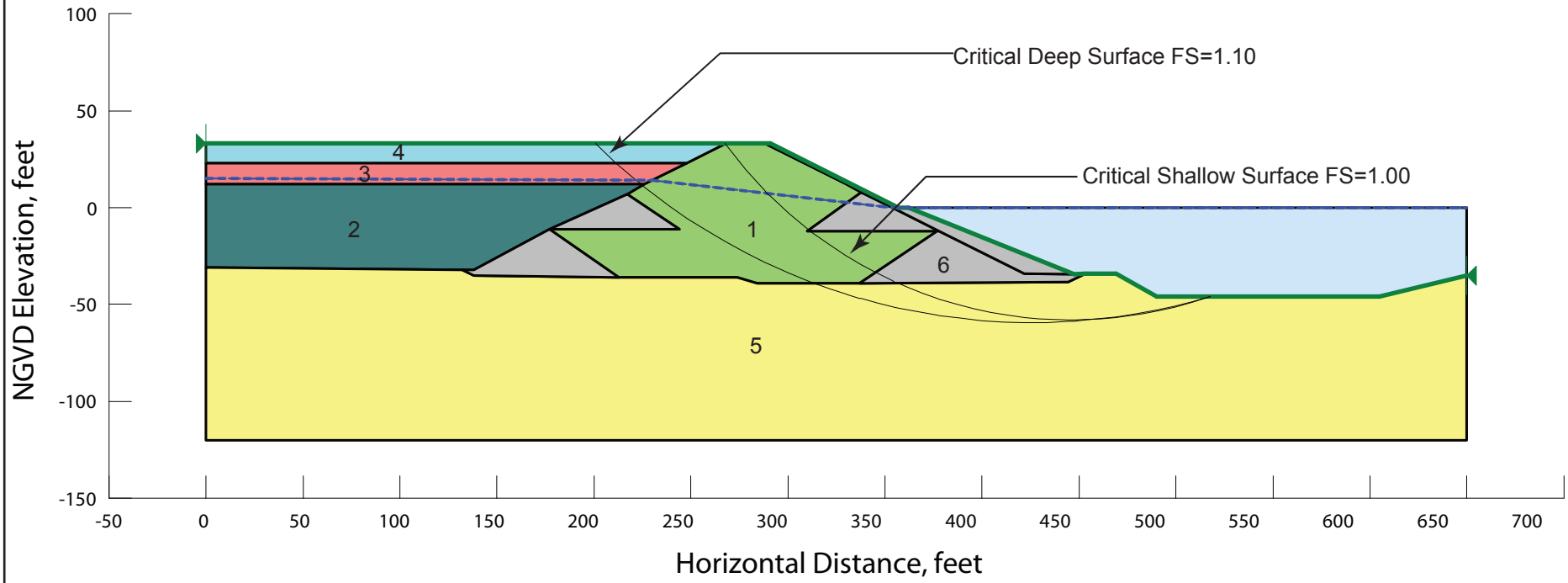
Soil Unit	Material	Unit Weight pcf	Friction Angle degrees	Cohesion psf
1	Berm Fill	135	35	0
2	Contaminated Dredged Material	120	24	0
3	CDF Fill	120	32	0
4	CDF Surface Layer	125	35	0
5	Native Sands	120	35	0
6	Quarry Spalls	135	43	0

Long Term Static Stability

Seismic and Stability Evaluations
Terminal 4 Slip 1 CDF
Portland, Oregon

Ash Creek Associates, Inc.
Environmental and Geotechnical Consultants

Project Number	1165-00	Figure
August 2011		3



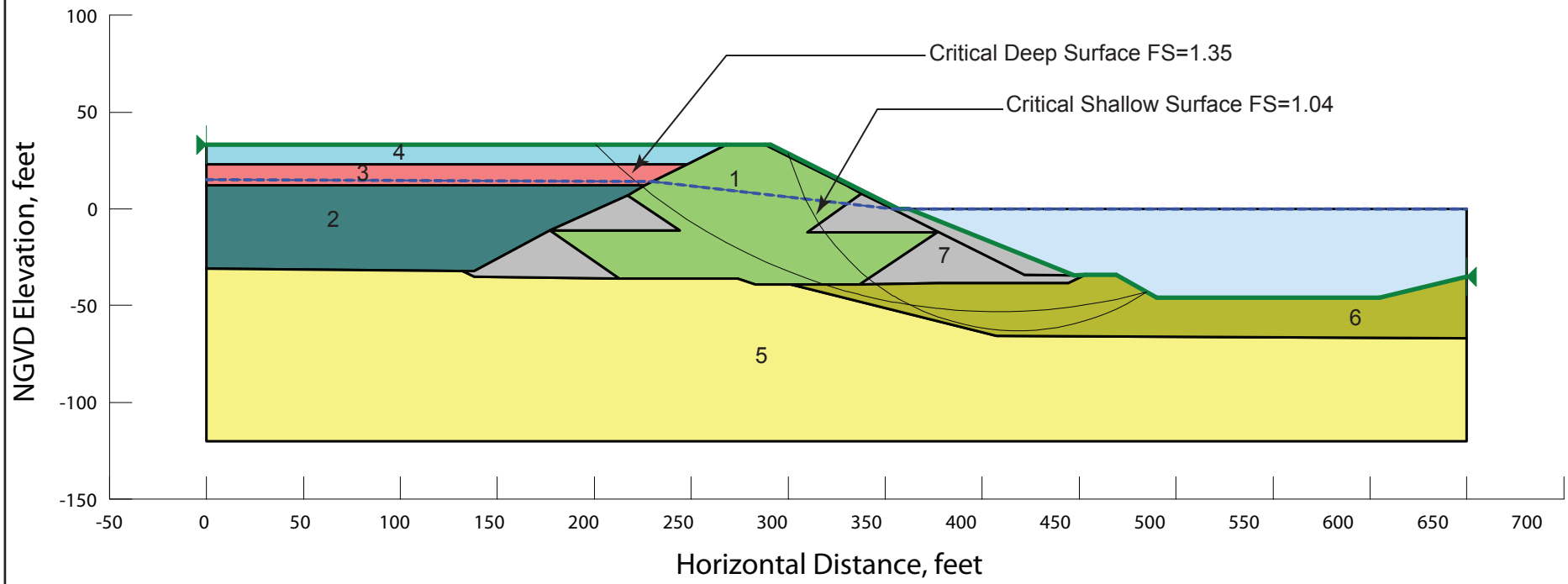
Soil Unit	Material	Unit Weight pcf	Friction Angle degrees	Cohesion psf
1	Berm Fill	135	35	0
2	Contaminated Dredged Material	120	24	0
3	CDF Fill	120	32	0
4	CDF Surface Layer	125	35	0
5	Native Sands	120	35	0
6	Quarry Spalls	135	43	0

Seismic (Pseudostatic) Stability

Seismic and Stability Evaluations
Terminal 4 Slip 1 CDF
Portland, Oregon

Ash Creek Associates, Inc.
Environmental and Geotechnical Consultants

Project Number	1165-00	Figure
August 2011		4



Soil Unit	Material	Unit Weight pcf	Friction Angle degrees	Su/δ'vo
1	Berm Fill	135	35	0
2	Contaminated Dredged Material	120	0	0.05
3	CDF Fill	120	27	0
4	CDF Surface Layer	125	35	0
5	Native Sands	120	30	0
6	Liquefied Native Sands	135	0	0.20
7	Quarry Spalls	135	43	0

Post Earthquake Stability

Seismic and Stability Evaluations
Terminal 4 Slip 1 CDF
Portland, Oregon

Ash Creek Associates, Inc.
Environmental and Geotechnical Consultants

Project Number	1165-00	Figure
August 2011		5

APPENDIX I
FLOOD ANALYSIS

Parsons Brinckerhoff Quade & Douglas, Inc.
400 Sixth Avenue
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Portland, OR 97204-1633
503-274-8772
Fax: 503-274-1412

November 7, 2006

Mr. Tom Wang
Anchor Environmental, Inc.
1423 Third Avenue, Suite 300
Seattle, WA 98101

Re: Confined Disposal Facility, Slip 1, Port of Portland Terminal 4

Dear Tom:

As you requested, Parsons Brinckerhoff (PB) has evaluated the potential floodway impacts of the preliminary 60% design for a confined disposal facility (CDF) at the Port of Portland's Terminal 4 (T-4) Slip 1. In particular, the 60% CDF design was compared to the CDF design in the Floodway EE/CA analysis. Anchor Environmental (Anchor) provided the 30% CDF design electronically to PB and indicated that no changes to the berm occurred between the 30% and 60% designs.

PB electronically overlaid Anchor's CDF design with the EE/CA floodway analysis CDF design using site features and topographic lines for reference. Based on the design overlays, Anchor's CDF design does not encroach within the floodway of the Willamette River and extends less than five feet riverward of the CDF design from the EE/CA analysis. No other modifications were made to the proposed condition HEC-RAS model besides the 60% CDF design.

Anchor's 60% CDF design was incorporated into the HEC-RAS hydraulic model of the Willamette River that was developed for the T4 EE/CA analysis. The HEC-RAS model output indicated that the proposed 60% CDF design would not impact the floodway or 100-year flood elevations.

Please call me at 503-274-7217 if you have any questions or require additional details.

Best regards,

Cynthia Lowe

Cynthia Lowe, P.E.
PB Ports & Marine
Parsons Brinckerhoff Quade & Douglas, Inc

PB Ports & Marine, Inc.
A Parsons Brinckerhoff Company
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March 11, 2005

Anne Summers
Port of Portland
121 NW Everett
Portland, OR 97209

Dear Anne:

It is our understanding that the Port of Portland (Port) is under an Administrative Order on Consent (AOC) with the U.S. Environmental Protection Agency (EPA) to perform a removal action at the Port's Terminal 4 (T-4) site pursuant to the Comprehensive Environmental Response & Liability Act (CERCLA). T-4 is included in the Initial Study Area of the Portland Harbor Superfund Site. The Port submitted a preliminary Draft Engineering Evaluation/Cost Analysis (EE/CA) for EPA's review on January 26, 2005. The Draft EE/CA evaluates and ranks four alternatives for the removal action against EPA's criteria and preliminarily identifies a preferred alternative. As requested, Parsons Brinckerhoff (PB) has analyzed the potential floodplain impact of the preferred alternative at the Port's T-4 site, which is located on the right (north) overbank of the Willamette River between River Miles (RM) 4.2 and RM 4.8. The preferred alternative includes an at-grade confined disposal facility (CDF) in Slip 1, dredging in Slip 3 and capping at multiple locations, including a small area in the northeast corner of Berth 401, portions of the slope at Wheeler Bay, under the pier at Berth 411 and the nearshore slopes around Slip 3 (hereinafter "proposed removal action").

Under Federal Emergency Management Agency (FEMA) criteria, a planned development, in conjunction with existing and anticipated development, must not cause any rise to occur at any location, relative to the existing 100-year floodway elevations. To fulfill the 'no-rise' criteria, PB developed two hydraulic computer models. The first model represents the existing condition and establishes the existing 100-year floodplain and floodway elevations. The second model, termed the proposed condition, incorporates the proposed removal action into the existing condition model to determine the potential impacts.

This transmittal provides a description of the methodology and results for the hydraulic modeling efforts.

Background
The effective FEMA Flood Insurance Study (FIS) of the Willamette River for the City of Portland, Oregon is dated October 19, 2004. T-4 is located on the effective FEMA Flood Insurance Rate Maps (FIRM) panel number 4101830060E, for the City of Portland, dated October 19, 2004. As shown on the FIRM, the Willamette River is delineated as Zone AE in the vicinity of the project site with base flood elevations and a floodway determined.

While the FIS and FIRM are dated 2004, the hydraulic computer model used to develop the FIS and FIRM has not been updated since the U.S. Army Corps of Engineers (USACE) developed the Willamette River hydraulic model in 1979. A telephone conversation with Dave Carlton, FEMA Region X engineer, on November 24, 2004, confirmed that the current FIS did not update the computer model of the Willamette River.

The 2004 FIS and FIRM update did shift the vertical datum used to report flood elevations. The previous standard vertical datum for FIS and FIRMs was the National Geodetic Vertical Datum of 1929 (NGVD); however, recent updates are using the newly adopted standard vertical datum of the North American Vertical Datum of 1988 (NAVD). The conversion factor from NGVD to NAVD is +3.5 feet. For example, 27 feet NGVD corresponds to 30.5 feet NAVD. As the hydraulic computer model had not been updated since 1979, the vertical datum used in the FIS model was NGVD, and this modeling effort has maintained the use of NGVD.

Conceptual Design

The proposed conceptual designs for the CDF, dredging and capping at T-4 have been developed by Blasland, Bouck & Lee (BBL) and the Port, and the design details are considered preliminary. The conceptual CDF design includes construction of an earthen berm at the mouth of Slip 1 to isolate proposed dredged material placement within the slip. The toe of the earthen berm extends slightly beyond the mouth of Slip 1 into the river channel but not beyond the harbor line or floodway boundary. As the conceptual CDF berm would not encroach within the floodway, the CDF would not impact floodway elevations.

While dredging is proposed within Slip 3 as a part of the conceptual design, the proposed dredging represents a single event and is not a part of the Port's ongoing maintenance dredging program. Based upon discussions with Port of Portland personnel, the Port intends to continue its current practice of maintaining Slip 3 to at least -40 feet CRD (-38.3 feet NGVD), as required by the Port's lease with tenant Kinder Morgan. As such, the hydraulic models developed reflect the currently maintained depth of -38.3 feet NGVD in Slip 3

Capping is proposed at multiple locations in T-4 including a small area in the northeast corner of Berth 401, portions of the slope at Wheeler Bay, under the pier at Berth 411 and the nearshore slopes around Slip 3. Comparing the conceptual plans with the FIRM map indicates that minor floodway encroachments may occur from the capping at Berth 401 and at the upstream end of Slip 3. However, the capping at Wheeler Bay does not encroach within the floodway. While it is likely possible that future capping design refinements could avoid floodway encroachments, the hydraulic modeling performed included the floodway encroachments due to capping as shown in the existing conceptual design. Based on information from BBL, the preliminary capping thickness is three feet at Berth 401 and Wheeler Bay and three to four feet at Slip 3.

HEC-RAS Model

Developed by the USACE Hydrologic Engineering Center and adopted by FEMA, the River Analysis System (HEC-RAS) is a step-backwater one-dimensional hydraulic computer program that is used to estimate flood elevation profiles along a waterway for a given set of circumstances. The Willamette River hydraulic model was developed using HEC-RAS version 3.1.2, which was released April 2004. Input to the HEC-RAS model includes the channel geometry of the river, flood event flows, and initializing boundary conditions such as the downstream water surface elevations or critical water depth.

The channel geometry of the lower Willamette River was represented by cross-sections taken from the 1979 FIS hydraulic model and 2003 hydrographic survey data provided by BBL. Oriented looking downstream in the direction of flow, the cross-sections extend from the left (south) overbank, across the river to the right (north) overbank.

The HEC-RAS model was run for the 100-year flood event and floodway using the flows specified in the currently effective Willamette River FIS. In addition, the downstream water surface elevations utilized the flood elevations provided in the currently effective Willamette River FIS.

Currently Effective FIS Modeling
The currently effective 1979 FIS model for the Willamette River was developed using the computer program HEC-2, which was a precursor to HEC-RAS. In order to verify the FIS floodway widths and elevations, PB imported the existing FIS HEC-2 model data of the Willamette River into HEC-RAS.

From the mouth of the Willamette River upstream past the Burlington Northern Railroad Bridge (cross-section 7.68), the FIS HEC-RAS model output replicated the 100-year floodplain and floodway elevations in the FIS Floodway Data Table. The FIS HEC-RAS model also reproduced the floodway widths and velocities specified in the FIS Floodway Data Table.

Existing Condition HEC-RAS Modeling
To represent the existing condition, the hydraulic analysis developed a computer model of the Willamette River, starting at RM 0.38 and extending upstream of T-4 to RM 7.68. Data from the 1979 Willamette River FIS model were utilized for 14 of the cross-sections. An additional ten cross-sections were located in the vicinity of the project site: cross-sections 4.25, 4.26, 4.27, 4.34, 4.43, 4.6, 4.68, 4.74, 4.75 and 4.8. Figure 1 provides the cross-section locations for the existing condition model and the project site features (attached).

As shown in Figure 1, new cross-sections at RM 4.43 and RM 4.68 were added to incorporate the T-4 Slips 1 and 3, respectively, into the hydraulic model. Additional cross-sections were added to reflect the proposed capping at RM 4.25, 4.26, and 4.27 for Berth 401, RM 4.6 for Wheeler Bay, and RM 4.74 and 4.75 for Slip 3. New cross-sections were also added at RM 4.34 (downstream of Slip 1) and RM 4.8 (upstream of Slip 3) to provide transition.

Due to past dredging practices in the vicinity of T-4, the hydrographic survey indicates deeper channel depths than the FIS model. The existing water depths in excess of -60 and -70 feet NGVD would not be maintained through dredging. In order to reflect the long-term channel condition, the channel geometries from FIS cross-sections 4.54 and 5.0 were used to develop the new cross-sections. Ineffective flow areas were defined within T-4 Slips 1 and 3 because the slips would not convey floodwaters during an event.

Proposed Condition HEC-RAS Modeling
Once the existing condition HEC-RAS model was completed and checked, it served as the basis for the proposed condition HEC-RAS model. The proposed condition model incorporated the proposed CDF at cross-

section 4.43, the capping at Berth 401 at cross-section 4.26, the capping at Wheeler Bay at cross-section 4.6 and the capping at Slip 3 at cross-section 4.75 into the existing condition model to estimate the potential impacts.

100-year Floodplain Results

Table 1 provides the model-predicted 100-year floodplain elevations for the existing and proposed conditions, rounded to the nearest 0.001 foot. As shown, the proposed project does not increase the existing 100-year floodplain elevations.

Table 1: 100-year Floodplain Elevations for the Willamette River, RM 0.38 to RM 7.68

	100-year Floodplain Elevations (ft NGVD)		Difference (ft)
Cross-Section (RM)	Existing Condition	Proposed Condition	(Proposed – Existing)
0.38	25.900	25.900	0.000
1.52	26.039	26.039	0.000
2.4	26.107	26.107	0.000
3.03	26.109	26.109	0.000
3.5	26.087	26.087	0.000
4.25	26.205	26.205	0.000
4.26	26.206	26.206	0.000
4.27	26.210	26.209	-0.001
4.34	26.212	26.212	0.000
4.43	26.225	26.221	-0.004
4.54	26.224	26.223	-0.001
4.6	26.212	26.210	-0.002
4.68	26.243	26.242	-0.001
4.74	26.241	26.239	-0.002
4.75	26.238	26.236	-0.002
4.8	26.240	26.239	-0.001
5.0	26.237	26.236	-0.001
6.0	26.321	26.320	-0.001
6.7	26.430	26.428	-0.002
6.94	26.533	26.531	-0.002
7	26.545	26.544	-0.001
7.07	26.607	26.606	-0.001
7.68	26.819	26.818	-0.001

100-year Floodway Results

Table 2 provides the model-predicted 100-year floodway elevations for the existing and proposed conditions, again rounded to the nearest 0.001 foot. For the preliminary CDF design provided, the proposed project does not increase the existing 100-year floodway elevations, thus fulfilling FEMA's 'no-rise' criteria.

Table 2: 100-year Floodway Elevations for the Willamette River, RM 0.38 to RM 7.68

	100-year Floodway Elevations (ft NGVD)		Difference (ft)
Cross-Section (RM)	Existing Condition	Proposed Condition	(Proposed – Existing)
0.38	26.700	26.700	0.000
1.52	26.841	26.841	0.000
2.4	26.907	26.907	0.000
3.03	26.909	26.909	0.000
3.5	26.886	26.886	0.000
4.25	26.988	26.988	0.000
4.26	26.988	26.988	0.000
4.27	26.989	26.989	0.000
4.34	26.990	26.990	0.000
4.43	26.995	26.995	0.000
4.54	27.003	27.003	0.000
4.6	26.984	26.984	0.000
4.68	27.016	27.016	0.000
4.74	27.018	27.017	-0.001
4.75	27.018	27.018	0.000
4.8	27.028	27.028	0.000
5.0	27.031	27.031	0.000
6.0	27.108	27.109	-0.001
6.7	27.222	27.222	0.000
6.94	27.295	27.295	0.000
7	27.307	27.307	0.000
7.07	27.384	27.384	0.000
7.68	27.598	27.598	0.000

Results

In compliance with FEMA's 'no-rise' criteria, the HEC-RAS model results indicate that the proposed CDF and capping sites do not increase the 100-year floodplain or floodway elevations at any location relative to the existing condition.

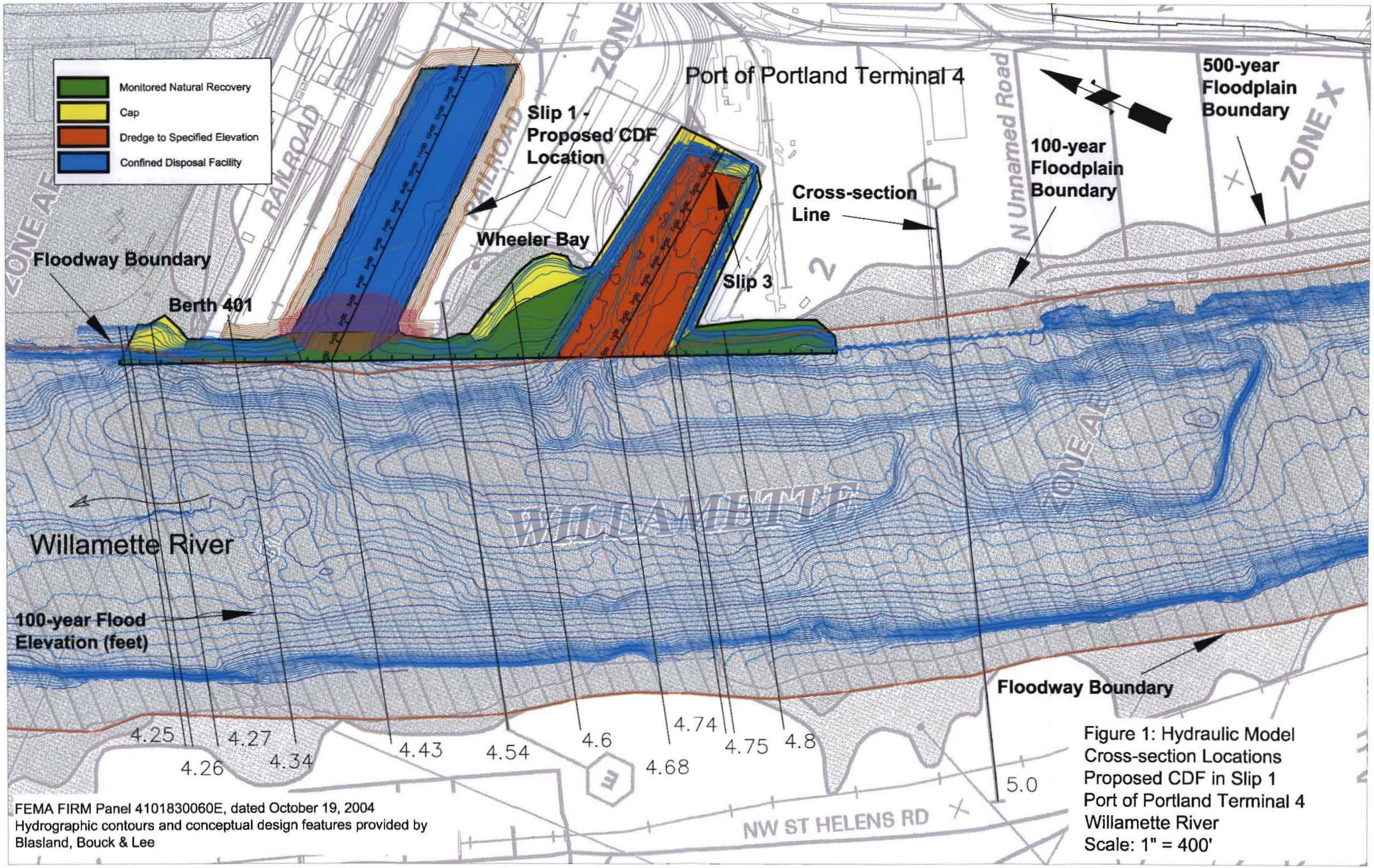
The impacts of sedimentation, erosion and debris were not considered in the hydraulic analysis performed, in accordance with FEMA criteria. Sedimentation and erosion can modify the channel geometry of the waterway and possibly affect the model-predicted flood elevations. In addition, the hydraulic analysis addressed only the potential impacts of the proposed CDF to flood elevations and did not consider the issues of slope stability, bankline protection, scour or other geotechnical matters.

Please call me if you have any questions or if I can be of further assistance to you.

Best regards,

Cynthia Lowe

Cynthia Lowe, PE
PB Ports and Marine
Parsons Brinckerhoff Quade & Douglas, Inc.



FEMA FIRM Panel 4101830060E, dated October 19, 2004
Hydrographic contours and conceptual design features provided by Blasland, Bouck & Lee

Figure 1: Hydraulic Model Cross-section Locations Proposed CDF in Slip 1 Port of Portland Terminal 4 Willamette River Scale: 1" = 400'

Attachment K-2

Technical Memo by Parsons Brinckerhoff on Floodway and Flood Storage Technical Explanation and Analysis

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Memorandum

To: Anne Summers, Port of Portland

From: Cynthia Lowe, PE and Karl Krcma, PE

Date: May 2, 2005

Subject: Floodway and Flood Storage Technical Explanation and Analysis

I. Introduction

The Port of Portland (Port) is required to perform a removal action at Terminal 4, which is located within the Initial Study Area of the Portland Harbor Superfund Site near River Mile (RM) 4.5 on the east bank of the Willamette River. The Port prepared a draft Engineering Evaluation/Cost Analysis (EE/CA) for the U.S. Environmental Protection Agency (EPA). In that report, the Port evaluates and ranks four alternative removal actions according to EPA criteria and guidance. One alternative, Alternative C, includes a confined disposal facility (CDF) in Slip 1, dredging of Slip 3, and capping at multiple locations, including a small area in the northeast corner of Berth 401, portions of the slope at Wheeler Bay, under the pier at Berth 411 and the nearshore slopes around Slip 3.

The purpose of this memorandum is to explain technical aspects of the Federal Emergency Management Agency (FEMA) flood hazard regulations in relation to the proposed removal action (Alternative C) at the Port's Terminal 4. Although FEMA does not regulate flood storage, the memorandum includes an analysis of potential flood storage impacts because EPA is required to evaluate the impacts to floodplains under other federal regulations (Executive Order 11988, Floodplain Management, May 24, 1977 and 40 C.F.R. Part 6, Appendix A). In response to your request, the memorandum also evaluates whether the removal action would have an impact on the community flood insurance rating and discount in the City of Portland.

II. Floodway or Flood Rise Regulations

A. National Flood Insurance Program

FEMA developed the National Flood Insurance Program (NFIP) for floodplain management and flood insurance purposes in the early 1970s. To implement the NFIP, FEMA prepares Flood Insurance Studies (FIS) for waterways across the United States, which provides communities with flood elevations and floodplain boundaries.

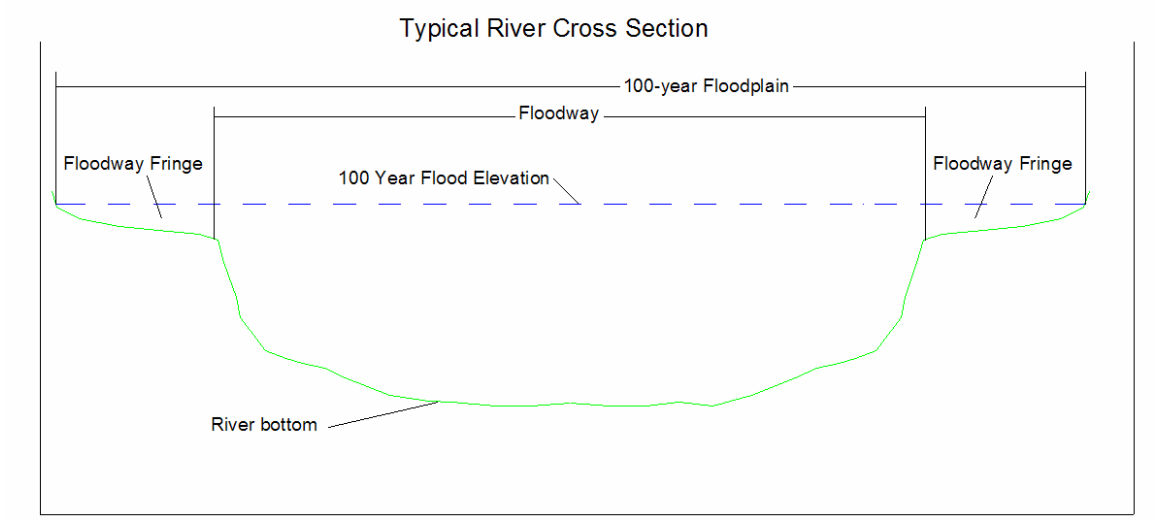
Floodplain/Floodway

The NFIP has adopted the 100-year flood as the national standard for floodplain management. For clarification, the 100-year flood is also termed the “base flood” or the one percent flood as the 100-year flood has a one percent chance of being equaled or exceeded in any year. In addition, the 100-year floodplain is defined as any land area susceptible to being inundated by water due to the base flood.

Recognizing the appeal of developing along waterways, FEMA developed the concept of a floodway as a floodplain management tool for communities. The floodway concept involves dividing the 100-year floodplain into two components: a floodway and a floodway fringe. The floodway represents the main channel of the waterway and any overbank area needed to convey the 100-year flood without causing an unacceptable increase to the 100-year flood elevations. The minimum Federal standard limits the allowable flood elevation increase to one foot above the 100-year flood elevation at any location along the waterway. Communities that adopt the FEMA floodway and participate in the NFIP must enforce FEMA regulations prohibiting placement of fill or structures within the floodway unless it can be shown that the proposed development does not increase the base flood elevation.

The floodway fringe represents the balance of the 100-year floodplain that does not lie within the floodway (Figure 1). The NFIP does allow fill to be placed within the floodway fringe, recognizing that the fill’s impacts on flood elevations is managed through the floodway concept. Based on the definition of the floodway, the floodway fringe could be completely filled on both sides of a waterway and not increase the 100-year flood elevations by more than one foot at any location.

Figure 1.



The floodway is typically calculated for FEMA flood studies using the U.S. Army Corps of Engineers Hydrologic Engineering Center computer programs HEC-2 and HEC-RAS. HEC-2 was developed in the mid 1970's and uses a standard-step backwater calculation to determine water surface profiles. HEC-RAS (River Analysis System) is an updated version of HEC-2 that incorporates, among other enhancements, a graphical user interface. Both programs are one-dimensional and model the geometry of the river by cross sections aligned perpendicular to the flow of the river. Water surface profiles are determined by interpolating between the model's cross sections.

FEMA Floodway Regulations

The following quote is taken directly from the FEMA NFIP Regulations for Floodplain Management and Flood Hazard Identifications, Code of Federal Regulations (CFR):

> *44CFR §60.3(d)(3) Prohibit encroachments, including fill, new construction, substantial improvements, and other development within the adopted regulatory floodway unless it has been demonstrated through hydrologic and hydraulic analyses performed in accordance with standard engineering practice that the proposed encroachment would not result in any increase in flood levels within the community during the occurrence of the base flood discharge;*

This regulation is commonly referred to as the "no rise" criteria. The intent of the regulation is to prevent any impedance to the conveyance of floodwaters within the floodway. By protecting the floodway and hence a waterway's conveyance, the "no rise" criteria provides upstream property owners with protection from increased floodway levels due to downstream development.

If the hydrologic and hydraulic analyses indicates an increase in flood levels due to the proposed encroachment in the floodway, provisions exist to still allow the development in the form of mitigation. Most commonly, the loss of conveyance due to the proposed development is mitigated by compensating actions to restore lost conveyance, such as dredging, reshaping the banks through grading, removing obstructions, or other reductions to improve the flow of floodwaters. One condition FEMA imposes for mitigating compensation is that it must be maintained for perpetuity.

Alternatively, FEMA has provisions for revising a floodway boundary via redelineation. The floodway revision process tends to be rather lengthy due to the public approval period, FEMA's technical review, and the hydraulic analysis required. Technically the floodway could be revised (narrowed) as long as the one foot flood elevation increase is not exceeded at any point along the waterway.

The City of Portland follows FEMA guidelines for controlling development in the floodplain, and the City has adopted ordinances which FEMA designed to reduce future flood losses. The City's flood plain management ordinance is found at PCC 24.50.060.D of the city's zoning ordinances. This ordinance follows the FEMA CFR in essence and provides the City a means to enforce the FEMA NFIP "no rise" regulation. The ordinances also fulfill a FEMA requirement to allow the community to purchase federal flood insurance through the NFIP.

C. Application to Terminal 4 Removal Action

According to FEMA, no increase in the base flood elevation can result due to placement of fill or placement of structures within a floodway. Consequently, if the CDF or sediment caps are placed within the floodway boundary, this would require an analysis to demonstrate that the encroachment into the floodway will not increase the base flood elevation.

Two of the three cap placements proposed encroach into the floodway. For the two floodway encroachments, one cap is located near the downstream end of Berth 401 and the other near the upstream end of Slip 3. Based on the conceptual design, only around 2,000 square feet of cap placement intrudes into the floodway at Berth 401 and approximately 470 square feet near Slip 3. A HEC-RAS model was used to analyze the proposed cap placements. The HEC-RAS modeling results indicated no rise in the base flood elevations due to the proposed cap placements. This is documented in PB's letter to the Port dated March 11, 2005.

The proposed CDF in Slip 1 is in the floodway fringe, but outside of the floodway limits. Therefore, according to FEMA regulations, the fill is allowable. The fill also meets the requirements of City of Portland floodway ordinance (PCC 24.50.060.D). Even though the CDF does not encroach within the floodway, a HEC-RAS analysis was still performed to assure that the CDF would not cause a rise in the base flood elevations. The results of the analysis indicated that no rise resulted from filling the slip based on the conceptual design. This is also documented in PB's letter to the Port dated March 11, 2005.

III. Flood Storage Evaluation

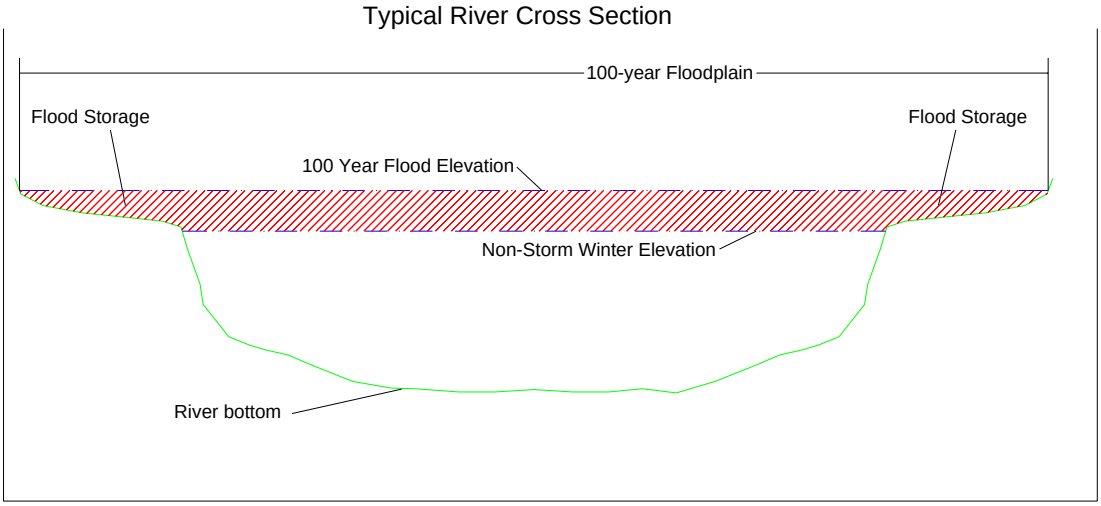
Although FEMA does not have a regulation regulating flood storage, EPA is required to evaluate the impacts to floodplains under other federal regulations (Executive Order 11988, Floodplain Management, May 24, 1977 and 40 C.F.R. Part 6, Appendix A). Evaluation of flood storage is important to ensure that the quantity of water reaching the watercourse (and ultimately downstream property) is not increased. An analysis of flood storage impacts was conducted to ensure that the removal action will not increase flood hazards to downstream property owners.

A. Flood Storage

Flood storage refers to the temporary filling of overflow areas or retention/delay of runoff during a flood event. Typically a rainfall storm event occurs such that the rainfall runs overland, after saturating the ground, and eventually into a stream. If the overland flow is high enough or takes place over a long enough period of time, the capacity of the stream is exceeded. Floodwaters that spill out of the stream's banks flow into overflow (floodplain) areas. The water that is spilled into the overbank areas is temporarily "stored", thus reducing the quantity of flow downstream in the main channel of the stream. As the flood recedes, the overland areas drain back into the stream.

The area available for flood storage is the area above the stream level just preceding the storm event, termed the non-storm winter stage, up to the 100-year flood elevation, as shown in Figure 2. Because the area below the non-storm winter stage is already inundated when the storm event occurs, it provides no flood storage during a storm event.

Figure 2.



An example to compare the effects of flood storage is the difference between typical streams in rural versus urban settings. The rural stream would typically have more overland storage due to less development of the floodway fringe areas, resulting in some floodwaters temporarily held in the overbank areas. However, the typical urban stream would have less storage due to floodway fringe development, which would confine the floodwaters to the main channel, resulting in a quicker rise of water surface and a greater peak discharge. In summary, the flood event without storage rises quicker and would have a slightly greater peak discharge than a flood event on a stream with greater flood storage.

The effectiveness of the flood storage, however, is not the same for every stream. The effectiveness depends upon the size of the drainage basin, the amount of storage, the location of the storage, characteristics and timing of the design storm event, and characteristics of the riverine hydraulics. For example, Johnson Creek in the Portland Metro area has a drainage basin of 54 square miles. The 100-year flood event on Johnson Creek has a peak discharge of 2,780 cubic feet per second (cfs) and the flood generally takes place over 24 hours or less. The drainage basin of the Willamette River is 11,600 square miles with a 100-year peak discharge of 375,000 cfs and a duration of the flood event occurring over 2 days or more. An effective overbank flood storage volume of 300,000 cubic yards (cyd) would have the effect of reducing the time of flooding on Johnson creek 48 minutes versus 22 seconds on the Willamette River. A 300,000 cyd flood storage volume would probably provide a noticeable difference to the peak discharge and consequently reduced flood impacts downstream on Johnson Creek; however, the same volume would not provide a noticeable difference to peak discharge or downstream impacts on the Willamette River.

B. Evaluation of Terminal 4 Removal Action

CDF

A portion of the CDF will be located above the non-storm winter stage and some flood storage will be lost by placement of the CDF. However, the lost flood storage from filling Slip 1 has an insignificant effect in reducing flood hazard due to the relative size of the Columbia and Willamette River drainage basins, the location of Terminal 4, the amount of storage provided by Slip 1 relative to the drainage basin, the duration of the flood events on the Willamette River, and the riverine hydraulics.

Terminal 4 is located near the outlet of the Willamette River drainage basin. The drainage basin of the Willamette River is 11,600 square miles with a 100-year peak discharge of 375,000 cfs and a duration of the flood event occurring over two days or more. In addition, the hydraulics of the lower Willamette River is impacted by backwater effects from the Columbia River which encompasses an even larger drainage basin than the Willamette River.

The regulatory 100-year flood elevation on the Willamette River is computed by analyzing river stage statistics for the Portland harbor and the Columbia River. Two types of flooding can impact Portland harbor:

1) Willamette River floods that usually occur in winter months (around November through February) and
2) Columbia River floods that usually occur during spring freshet (May through July).

The drainage basin of the Columbia River above the confluence with the Willamette River is approximately 241,000 square miles, and the modeled 100-

year discharge is 565,000 cfs. Since the 100-year elevation is computed on stage statistics, the discharge for purposes of modeling a floodway on the Willamette and Columbia Rivers is determined by modeling various flows until the statistically determined stage is achieved. The dominating elevation for the 100-year flood in the vicinity of Terminal 4 is actually the backwater from the Columbia River flood.

The volume of potential flood storage that would be lost as a result of the CDF construction was calculated. Digital bathymetry and topographic information supplied by BB&L, Inc. was utilized to develop a digital terrain model of the site. For purposes of comparison, two volumes were computed:

1) the difference between the 100-year flood elevation and ordinary high water (OHW) representing the bank full stage, and
2) the difference between the 100-year flood and the 50% exceedance (high tide) stage for Portland harbor, representing an “average” river stage.

Table 1 lists the results for the two volumes and includes the time required to fill the storage volume during the 100-year flood event. The previously stated 100-year discharge for the Willamette River in the T-4 reach of 375,000 cfs was used to calculate the fill time. In order to provide a more conservative estimate, a Willamette River flood without influence from Columbia River backwater effects was assumed.

Table 1. T-4 CDF Flood Storage Calculations

Description	Volume (cyds)	Time to fill (seconds)
OHW to 100-year	265,700	19
50% exceedance to 100-year	458,000	33

Using the Johnson Creek example as a comparison, assume that 458,000 cyds of flood storage is lost. That would equate to 1.24 hours of storage on Johnson Creek for a flood that takes place over 24 hours or less versus 33 seconds on the Willamette River by Terminal 4 for a flood that lasts two days or more. On Johnson Creek the storage would probably be effective in reducing downstream peak flows; however, on the Willamette River at this location, the flood storage of 458,000 cyds is insignificant and would result in no noticeable increase in peak discharge.

This conclusion is further highlighted by comparing the flood storage at Slip 1 to the flood storage of the overall system. Since the 1930’s, Federal and private dams have been built in the Willamette and Columbia River drainage basins to store water for flood control, generate hydroelectric power, and for other purposes. There are 32 major reservoir projects operated by the Corps of Engineers, in addition to 45 other non-federal projects including three Canadian

reservoirs. The combined flood storage of the system exceeds 39 million acre-feet of storage. A storage volume of 458,000 cyds equals approximately 284 acre-feet. Compared to upstream flood control storage projects, the 284 acre-feet is only 0.00073% of the total storage (39 million acre-feet). Consequently, the loss of flood storage at Terminal 4 would not have a noticeable impact downstream.

Based on these factors, Slip 1 provides insignificant effective flood storage at this location on the Willamette River and the loss of flood storage from the CDF would not have a noticeable impact downstream.

Capping

Capping is proposed at multiple locations in T-4 including a small area in the northeast corner of Berth 401, portions of the slope at Wheeler Bay, under the pier at Berth 411 and the nearshore slopes around Slip 3. Based on information from BBL, the preliminary capping thickness is three feet at Berth 401 and Wheeler Bay and three to four feet at Slip 3. From a technical standpoint. no flood storage would be lost because the cap as proposed will be placed below the non-storm winter stage. In other words, because the location of the proposed cap is already inundated before the floodwaters arrive, no storage would be lost by placement of a cap, and consequently no impact on flood storage would occur.

C. Portland's Flood Insurance

While FEMA does not have a flood storage regulation, FEMA has a Community Rating System (CRS) as a part of the NFIP that credits communities for various floodplain management criteria. The City of Portland receives some credit for flood storage protection through the CRS. In response to your request an evaluation considered whether removal of the flood storage at Slip 1 would have an impact on the City of Portland's flood insurance rating and discount.

The CRC implements a point system that awards points based on a total of 18 floodplain management activities which are organized under four general areas: 1) public information, 2) mapping and regulations, 3) flood damage reduction, and 4) flood preparedness. The point system determines the class rating and discount applicable in the community. The City of Portland is rated as a Class 6 CRS community and receives a 20% discount on flood insurance due to their rating.

Some criteria for Portland's CRS rating include but are not limited to: having a requirement that homes are elevated a minimum of one foot above the base flood elevation, providing open space along waterways, participating in a repetitive loss program, and having a balanced cut and fill ordinance (PCC 24.50.060.F.8). The Class 6 rating requires a total of 2,000 to 2,499 points, of

which a provision for compensating storage awards up to 70 points. According to FEMA's last verification, the City of Portland has a total of 2,194 points in the CRS rating. Of the 2,194 points, the City received 28.7 points for the balanced cut and fill requirement in PCC 24.50.060.F.8. Even if the removal of the flood storage at Terminal 4 caused the NFIP to take away the City's points for this category, which is not likely, the City of Portland would retain its Class 6 rating.

IV. Conclusions

As modeled using HEC-RAS, the proposed caps and CDF at Terminal 4 result in no increase to base flood elevations, thus fulfilling FEMA regulations and the City of Portland 24.50.060 provisions for flood hazard reduction.

The caps are proposed to be placed below the OHW water level; therefore, the capping would not remove any flood storage from the Willamette River basin..

The proposed CDF does remove flood storage, however, due to the insignificant volume compared to the Columbia/Willamette drainage basins, no noticeable impact to flooding in the Willamette River would occur as a result of the CDF.

REFERENCES

Atkinson, Denise, E-mail correspondence with Cynthia Lowe re City of Portland CRS Questions, March 15, 2005

City of Portland, Code and Charter, Title 24 Building Regulations, Chapter 24.50 Flood Hazard Areas, February 4, 2005

Code of Federal Regulations, Title 44, Emergency Management and Assistance, Revised October 1, 2004

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Federal Emergency Management Agency, Flood Insurance Study, City of Portland, Oregon, Revised October 19, 2004

Metro, Title 3 Model Ordinance, Growth Management Committee, May 28, 1998

U.S. Army Corps of Engineers, February 1996 Postflood Report, Hydrometerorological Evaluation, September 1997

U.S. Geological Survey, Water-Data Report OR-03-1, Water Resources Data Oregon Water Year 2003, June 2004

APPENDIX J
CONFINED DISPOSAL FACILITY SEDIMENT MANAGEMENT PLAN

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CONFINED DISPOSAL FACILITY SEDIMENT MANAGEMENT PLAN

(PREFINAL 60 PERCENT TERMINAL 4 CDF DESIGN SUBMITTAL)

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August 2011

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LIST OF ACRONYMS AND ABBREVIATIONS

AOPCs	Areas of Potential Concern
CDF	Confined Disposal Facility
CQAP	Construction Quality Assurance Plan
cy	cubic yards
DAR	Design Analysis Report
H:V	horizontal to vertical
LTMRP	Long-term Monitoring and Reporting Plan
LWG	Lower Willamette Group
NGVD	National Geodetic Vertical Datum
Port	Port of Portland
ROD	Record of Decision
SAP	sampling and analysis plan
T4	Terminal 4
USEPA	U.S. Environmental Protection Agency
WQMP	Water Quality Monitoring Plan

1 INTRODUCTION

This Confined Disposal Facility (CDF) Sediment Management Plan describes the procedures that will be implemented to manage the placement of contaminated dredged sediments into the Slip 1 CDF, anticipated to be primarily by mechanical means, as well as placement of imported fill and structural fill materials; appropriate management practices to prevent the release of sediments and contaminants during and between placement events; and quality assurance procedures to ensure the CDF is constructed according to specifications.

This plan describes the management of the Terminal 4 (T4) CDF activities following the construction of the containment berm, including placement of dredged sediments into the CDF from T4 and other Portland Harbor remediation sites, through construction of the surface cover layer.

1.1 Background

An at-grade CDF having a footprint of approximately 14 acres will be constructed in T4 Slip 1. The primary purpose of the CDF is to protect human health and the environment by permanently containing contaminated sediment dredged from the Portland Harbor Superfund Site. Sediments to be placed in the CDF will include sediments over-excavated from the berm key area of Slip 1, Phase II Removal Action sediments removed from T4 Slip 3, and dredged sediment from other Areas of Potential Concern (AOPCs) in Portland Harbor. Groundwater modeling results show that sediments from ten high-priority AOPCs in Portland Harbor would be suitable for placement in the T4 CDF (see Appendix A to the Design Analysis Report [DAR]). However, the CDF must be selected as an appropriate disposal site through the Portland Harbor Record of Decision (ROD).

By constructing the CDF to an at-grade surface, the newly gained land can be used for water-dependent commercial purposes. A containment berm will be constructed at the mouth of Slip 1 to serve as an isolation/retention structure for the dredged sediment. Section 5 of the DAR provides more details on the conceptual design of the CDF.

Long-term management activities (following CDF construction completion) will be addressed in the Long-term Monitoring and Reporting Plan (LTMRP), which will be completed as part of the T4 CDF 100 Percent Design submittal (see also Appendix K to the DAR).

1.2 CDF Characteristics

A containment berm will be constructed at the mouth of Slip 1 and Slip 1 will be filled with contaminated dredged material, then covered with imported fill and structural fill to the surrounding upland grade. Drawing C-25 of DAR Appendix B shows the layout of the CDF, and drawing C-26 is a generalized cross section through the containment berm. Existing structures within Slip 1 will be demolished and properly removed. Outfalls currently discharging into Slip 1 will be rerouted to the Willamette River. The remainder of this section describes the design of these different elements, the sequencing of the work, and anticipated construction volumes.

The CDF will consist of four main components, as follows:

- **CDF Containment Berm.** The configuration of the CDF containment berm incorporates a 2 horizontal to 1 vertical (2H:1V) outward-facing slope, and a 1.5H:1V inward-facing slope. The crest of the structure will be constructed to elevation 33 feet National Geodetic Vertical Datum (NGVD), and is approximately 20 feet wide. To improve the berm stability, the foundation of the berm will be overexcavated and backfilled with structural fill. For the majority of the berm structure foundation, the removal of loose sediment will likely be less than 5 feet, but in some locations the removal thickness could be up to 10 feet. The berm material will consist of sandy gravel or gravelly sand and the training dikes will consist of quarry spalls.
- **Dredged Sediment for Confinement**. The physical and chemical properties of contaminated sediment from T4 and other AOPCs within the Portland Harbor Superfund Site will be reviewed for suitability and may be placed in the CDF after being deemed acceptable by the U.S. Environmental Protection Agency (USEPA) and the Port of Portland (Port). Groundwater modeling results show that sediments from

ten high-priority AOPCs in Portland Harbor would be suitable for placement in the T4 CDF (see Appendix A to the DAR).

- **Imported Fill.** Imported fill material, including dredged sediment and soil, will be placed as cover material above the water table in the CDF to bring the facility up to its design elevation. Imported fill material will be protective of human health and the environment; specific acceptance criteria for imported fill material will be developed in the T4 CDF 100 Percent Design submittal.
- **CDF Surface Layer.** A 4.5-foot-thick surface layer will be placed above the imported fill layer. This layer is designed to support the end use of the CDF surface. The layer will consist of 4 feet of compacted structural fill with 6 inches of compacted crushed rock.

1.3 CDF Fill Sequence (Elevation Control)

The CDF consists of a sand and gravel berm spanning the mouth of Slip 1 with an engineered fill sequence placed behind the berm, terminating at the final upland design elevation. The fill sequence consists of the following:

Design Elevation (NGVD)	
Base of Slip 1	~-35.0 feet
Top of Contaminated Fill	+9.5 feet
Top of Imported Fill	+28.7 feet
Final Elevation	+33.2 feet

Contaminated dredged sediment from T4 and other AOPCs in Portland Harbor will be placed within the saturated zone of the CDF (i.e., below the water table) to minimize the leachability and mobility of contaminants. Groundwater modeling results have shown that the elevation of permanent saturation in the CDF under critical low-flow conditions is +9.5 feet NGVD (Anchor 2006). This represents the upper limit for placement of contaminated sediments from Portland Harbor.

1.4 CDF Capacity

The total CDF capacity and the estimated volumes of various fill materials are listed below:

Fill Material Volume (cubic yards [cy])	
Contaminated Fill (T4 and other AOPCs)	670,000 cy
Imported Fill and Surface Layer	610,000 cy
Total CDF Capacity	1,280,000 cy

1.5 Sediment Acceptance Criteria

Dredged sediments proposed for placement in the CDF will need to meet certain physical and chemical acceptance criteria. These criteria include the following:

- **No Hazardous Waste.** Sediments designated as hazardous waste, whether listed waste or characteristic waste, are not eligible for placement in the CDF without adequate treatment.
- **No Free Oil.** Sediments containing "free oil" are not eligible for placement in the CDF without adequate treatment.
- **Suitable Geotechnical Properties.** The geotechnical properties of the fill materials must be of an acceptable quality such that they do not impact the long-term performance of the CDF; e.g., they must be free of debris and significant organics (i.e., wood chips), which could cause unacceptable obstructions, settlement, or gas generation.
- **Suitable Geochemical Properties.** The geochemical properties of the contaminated dredged sediments, primarily their leaching characteristics, must be shown to provide long-term protection of human health and the environment, and the beneficial uses of the Willamette River.
- **Other Considerations.** The Port and USEPA may consider other factors in determining acceptability of contaminated dredged material for placement in the CDF, including presence of principal threat compounds, physical nature of the material, form of the chemical contaminants, quantity of the material, long-term site liability, indemnification, and cost.

The sediment acceptance criteria will be refined as part of the T4 CDF 100 Percent Design submittal after the Portland Harbor performance standards have been finalized.

2 INSPECTIONS AND QUALITY CONTROL BETWEEN FILLING EVENTS

Physical inspections of the CDF will be completed between future filling events as described below. Results of the inspections will be provided to USEPA in a memorandum within 45 days of the completion of the filling event.

2.1 Physical Inspections of the CDF

The CDF containment berm will be inspected once at the end of each filling season until the CDF is completed. At that time, the monitoring program described within the LTMRP will be implemented. Inspections to be completed while the CDF is being constructed include the following:

- The crest and exposed face of the berm will be visually inspected for signs of erosion or slumping
- The submerged exterior face of the berm will be surveyed to confirm no signs of erosion or slumping

In the event of a design-level flood or earthquake event, the containment berm will be inspected for signs of erosion or slumping immediately following the event.

2.2 Physical Inspections of the Placed Material

A bathymetric and/or topographic survey will be completed after each of the following events:

- After placement of the sediments from each AOPC
- After completion of a filling season (if different from the above)
- After the final placement of all contaminated sediments
- After placement of the imported fill and prior to placement of the surface layer (this survey will be completed with upland topographic survey equipment)

The bathymetric and topographic surveys will be used to confirm placement in accordance with the CDF design, and to document the elevations of the different fill layers. The

Construction Quality Assurance Plan (CQAP; Appendix D to the DAR) and the Construction Specifications (Appendix C to the DAR) provide more details on the survey requirements.

2.3 Interim Wildlife Protection

The CDF will remain open, potentially through several work windows, until it is filled to its ultimate capacity with 670,000 cy of contaminated fill material from Portland Harbor. A concern that has been raised during the design process is that aquatic bird species may be impacted by contact with the contaminated sediments in the CDF while it is open. Water quality in the CDF before completion of filling above the water surface is also a concern. Wildlife protection during filling of the CDF will include placing a thin layer of clean material over the contaminated sediment when the average expected water depth after a filling event is shallow enough that potential wildlife exposures may exist. During the majority of the filling operations, wildlife protection will not be necessary due to the significant water depths over the sediment and the initial removal of fish from the CDF following berm closure. These factors minimize the potential contact of piscivorous birds with affected sediments or prey in the CDF.

3 MANAGEMENT OF FILLING EVENTS

3.1 Port of Portland and USEPA Administration

This section will describe the framework and responsibilities for administration of CDF activities, as well as the mechanisms by which potential users will apply for placement of their sediments in the CDF.

3.1.1 Application for Filling

3.1.1.1 Port of Portland and USEPA Contacts

Kelly Madalinski at the Port and Sean Sheldrake at USEPA will direct the review and approval of requests for placement of material in the CDF and coordinate the details related to the filling activities.

3.1.1.2 Application Requirements

Applicants must submit the following:

- Sediment quality characterization data and physical/geotechnical data sufficient for the Port and USEPA to evaluate the suitability of the proposed dredged material for placement in the CDF. Further details on the data requirements needed to apply for a suitability determination will be provided in the T4 CDF 100 Percent Design submittal. Lower Willamette Group (LWG) bulk sediment and leachate testing results may be used to satisfy some or all of the data requirements (see Appendix A to the DAR).
- If existing data are not sufficient to support a suitability determination, a sampling and analysis plan (SAP) will be submitted for Port and USEPA review and approval to provide adequate characterization of the proposed material.
- Estimated dredge volume
- Schedule for placement including anticipated daily rates of placement and total duration of filling
- Proposed method of transport (mechanical or hydraulic)

3.1.2 Scheduling of Filling Operations – Operating Days and Hours

The filling of the CDF will be allowed during any time of the day as long as City of Portland ordinances related to lighting and noise are observed.

3.2 Management of Offloading

3.2.1 Estimated Offloading Rates

Sediment offloading and conveyance capabilities will be designed by the contractor and located at the new Replacement Berth 405 facility. The speed at which the material is placed within the CDF is a function of two factors: 1) how fast the material can be physically offloaded from barges and pumped into the CDF; and 2) how available the material is. The offloading facility would likely be sized to offload 2,000 to 4,000 cy per day, assuming a 10- to 12-inch diameter hydraulic pump, respectively. Assuming there are 100 working days per in-water work season (6 days per week between July 1 and October 31) the maximum quantity of material that could reasonably be offloaded would be 200,000 to 400,000 cy per season.

3.2.2 Offloading Methods

3.2.2.1 Mechanical Offloading

Offloading of mechanically dredged sediments will most likely be performed with a high solids pump. The dredged material will arrive on haul barges docked at the Replacement Berth, and will be pumped to a diffuser barge outlet in the CDF. Any make-up water used to create a dredge slurry for pumping shall be drawn from within the CDF. The Construction Specifications (Appendix C to the DAR) provide performance requirements for the design of the offloading system by the contractor.

3.2.2.2 Hydraulic Offloading

There is a possibility that sediments could be dredged hydraulically from a limited number of AOPCs in the vicinity of T4, and pumped directly into the CDF. In this case, the dredge pipe would connect directly to the diffuser barge. The current CDF 60 Percent Design submittal

assumes that filling by hydraulic dredging will not be used. Should future circumstances change such that filling by hydraulic dredging is proposed, substantial new design analyses will be required to evaluate both short- and long-term impacts on CDF filling, possible berm overflow, groundwater quality, and other items.

3.2.3 Spill Prevention

Barges bringing sediment to the CDF shall be in good condition with no leaks in the hull. During pumping of the dredged material, the system will be continually monitored for leaks. Sediment sampling at the offloading berth will be performed following completion of offloading activities to confirm spill control. The CQAP (Appendix D to the DAR) and the Construction Specifications (Appendix C to the DAR) provide more detailed requirements of contractors for spill prevention.

3.2.4 Placement of Dredged Sediment

3.2.4.1 Inlet Diffuser

An inlet diffuser system will be used for filling the CDF. The CDF inlet diffuser will be manipulated to minimize re-suspension and maximize settling when placing sediments. The diffuser will be mounted on a barge and have the ability to move around the CDF. The diffuser discharge elevation will be adjustable to provide significantly reduced discharge velocities within a few feet of the current mudline. The Construction Specifications (Appendix C to the DAR) provide performance requirements for the design of the diffuser by the contractor.

3.2.4.2 Targeted Filling Areas

The sampling results of prospective fill materials may indicate the need to place the material at certain elevations and/or locations in the CDF to maximize the environmental protectiveness of the facility. This will be accomplished by strategically placing the diffuser within the CDF and appropriately sequencing the filling events, as necessary.

3.3 Water Quality Monitoring

Sediment Offloading at Replacement Berth. After USEPA and the Port designate the material as acceptable for placement in the CDF, sediment from approved AOPCs in Portland Harbor will be transported to the new Berth 405 for offloading into the CDF. Mechanically dredged sediment will most likely be brought to the CDF via haul barge, then transferred into the CDF with a pumping system. Water quality monitoring will be performed during sediment offloading to ensure that there are no adverse effects in the river as a result of this activity. Water quality compliance criteria and water quality monitoring locations, depths, and schedules are presented in the Water Quality Monitoring Plan (WQMP; Appendix E to the DAR).

Groundwater Seepage at Berm Face. For the pumping system, the contractor will be required to draw any make-up water directly from the CDF pond as needed to slurry the dredged material into the CDF. As a result, there will be no significant rise in the pond level of the CDF, and there will be no overflow or direct effluent discharge to the river. Therefore, short-term (construction-related) groundwater seepage at the berm face is not a pathway of concern for this project. In the event that hydraulically dredged sediment is pumped directly into the CDF, causing a significant water level difference across the berm, the WQMP will be amended to specify monitoring requirements for groundwater seepage.

CDF Effluent Discharge. In the event that hydraulically dredged sediment is pumped directly into the CDF, the dredging will be managed such that there will be no overflow and no direct effluent discharge to the river. Therefore, this is not a pathway of concern for this project. If filling by hydraulic dredging is proposed, new short-term and long-term groundwater modeling analyses may be required.

3.4 Environmental Controls

A number of environmental controls will be followed during the filling process depending on the elevation of the material being placed. The following subsections describe these controls.

3.4.1 Surface Water Management

Management of the surface water within the CDF will be accomplished by controlling material placement rates throughout the filling operations to regulate the depth of water ponded within the containment area.

3.4.2 Dust Control

Dust will be controlled as appropriate. Based on the anticipated filling procedures for the contaminated dredged material (i.e., hydraulically pumped from a barge), no dust control measures will be needed during that part of the filling operation. However, during placement of imported fill and surface layer material above the water table, dust will be controlled by use of water trucks. Water trucks will apply water to dry areas as necessary. Once the surface layer of crushed rock is placed and compacted, the project will be complete.

3.4.3 Erosion Control

As the fill surface extends above the water line, there is a potential for erosion of materials into nearby water bodies. However, the fill area will be below surrounding grade elevations, relative to the containment berm and adjacent terminal areas, so loss of eroded material will not occur. Once the site achieves a grade where off-site transport of surface materials is possible, a compacted crushed rock surface layer will be placed. This layer will seal potentially erodible materials below.

4 REFERENCES

Anchor. 2006. Design Analysis Report (Prefinal 60 Percent Design Deliverables): Terminal 4 Early Action, Port of Portland, Portland, Oregon. Prepared for the Port of Portland. December 2006.

APPENDIX K
LONG-TERM MONITORING AND REPORTING PLAN (OUTLINE)

APPENDIX K

LONG-TERM MONITORING AND REPORTING PLAN (OUTLINE)

(PREFINAL 60 PERCENT TERMINAL 4 CDF DESIGN SUBMITTAL)

PORT OF PORTLAND, PORTLAND, OREGON

Prepared for

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August 2011

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APPENDIX L
ENGINEERING COST ESTIMATE

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ENGINEERING COST ESTIMATE
(BASED ON PREFINAL 60 PERCENT TERMINAL 4 CDF DESIGN)
PORT OF PORTLAND, PORTLAND, OREGON

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1 COST ESTIMATE SUMMARY

The Terminal 4 (T4) Confined Disposal Facility (CDF) 60 Percent Design Engineering Cost Estimate details the anticipated costs necessary to implement the T4 CDF construction. The cost estimate includes direct and indirect construction costs. The long-term monitoring costs are estimated based on the activities described in Section 5.10 of the Design Analysis Report (DAR), pending finalization of the Long-term Monitoring and Reporting Plan (LTMRP; see Appendix K).

Each of the main costs is summarized below by the different stages of construction (see Section 9 of the DAR for sequencing of the different stages):

Stage 1 Construction	**Cost in $Million**
Overwater structure and miscellaneous demolition	$5.7
Stormwater and outfall structures relocation	$2.0
Containment berm construction	$11.4
Replacement berth construction	$4.2
Stage 2 Construction	
Place contaminated sediment	$0
Stage 3 Construction	
Place imported fill	$2.1 to $13.8
Place CDF cover layer	$5.4
Other costs associated with each of the stages:	
Mobilization/demobilization	$0.8
Water quality monitoring	$0.3
Habitat and other mitigation	$1.5 to $5.0
Indirect construction costs	$3.0 to $4.3
Long-term monitoring and maintenance	$1.5
Construction contingency (15%)	$5.7 to $8.2
Total Estimated Cost	**$43.6 to $62.6**

2 COST ESTIMATE ASSUMPTIONS

2.1 Direct Construction Costs

The direct construction costs comprise the following elements:

- Mobilization and demobilization
- Overwater structure and miscellaneous demolition
- Containment berm construction
- Replacement berth construction
- Stormwater and outfall structures relocation
- CDF completion
- Miscellaneous construction-related direct costs

2.1.1 Mobilization and Demobilization Assumptions

- A number of pieces of equipment will need to be mobilized at the start and demobilized at the end of each construction season.
- Site preparation costs include setting up a project office, security fencing, preparation of contractor laydown areas and parking, and other associated costs.
- Survey and grade control costs cover installation of a survey control system for the work and survey control during construction. Additional survey costs are included in the specific construction elements as necessary.
- Contractor work plan costs cover the preparation of the work plans by the contractor prior to beginning the construction work.

2.1.2 Overwater Structure and Miscellaneous Demolition Assumptions

- Demolition and disposal costs are based on a number of factors including the construction and materials of the structures to be demolished, access to the structures, condition of the structures, and recently completed demolition projects.
- The work would be completed primarily from water with a derrick. Pile removal, break off, and/or cutoff will be completed with a clamshell bucket.
- Material would be disposed at an approved landfill.
- Crews would work 10- to 12-hour shifts, 6 days per week.

- Estimated costs for these tasks were based on experience on similar port projects and previous bid information. Professional judgment was also factored into these cost estimates.

2.1.3 Stormwater and Outfall Structure Relocation Assumptions

- Materials costs were estimated based on the information shown on the construction Drawings by contacting local suppliers and vendors (C-9 through C-22, Appendix B to the DAR).
- Piping was assumed to be corrugated HDPE. Manholes and outfalls were assumed to be precast structures.
- Much of the excavation was assumed to require shoring.
- Demolition and resurfacing of existing pavement areas was assumed at select locations of the alignment.
- Estimated costs for these tasks were based primarily on recent experience with competitive bids and tabulations from open bidding processes that have occurred within the last 12 months. To a lesser degree, Washington State Department of Transportation (WSDOT) and Oregon Department of Transportation (ODOT) bid tabulations, which are accessible on their respective websites, were also used. Professional judgment was also factored into these cost estimates.
- Labor, equipment, and material costs were increased from the 2006 engineer's estimate using best professional judgment.

2.1.4 Containment Berm Construction Assumptions

- Material quantities were estimated using CAD software and the grades presented in the construction Drawings (C-25 and C-26, Appendix B to the DAR). The berm was estimated to settle 4 feet during construction—this settlement was accounted for by increasing the berm volume accordingly.
- Berm foundation dredge volumes were estimated using CAD software and the grades presented in the construction Drawings (C-24, Appendix B to the DAR). Dredge volumes include 1 foot of additional dredge volume below the neatline elevation as presented on the Drawings.

- The berm foundation dredging cost was estimated assuming an 8-cubic yard (cy) clamshell dredge and a bottom-dump barge.
- Training terraces and toe buttress material construction costs assume a derrick with a clamshell and/or skip box will be used.
- Select fill placement costs assume that the material is placed between the training terraces either by a bottom-dump barge, pushing the material off the side of the scow barge, or with a clamshell bucket.
- The costs assume that once the berm is above water, the berm will be completed with upland equipment.
- Armor placement costs assume a derrick and clamshell will be used to place the material on the face of the berm.
- Crews would work 10- to 12-hour shifts, 6 days per week.
- Material costs were obtained by contacting local aggregate suppliers.
- Labor and equipment costs were estimated using prevailing wages for labor, prevailing fuel costs, and contractor rental equipment rates. Production rates were based on equipment size and capabilities, professional judgment, and experience working under similar conditions.
- Labor and equipment costs were increased from the 2006 engineer's estimate using best professional judgment. Material prices were updated based on discussions with a local supplier.

2.1.5 Replacement Berth Construction Assumptions

- Material quantities were estimated from the design presented in the construction Drawings (S-1 through S-24, Appendix B to the DAR).
- Material pricing was estimated from recent experience on a similar project at the Port of Portland (Port) and data available from Means Heavy Construction Cost Data.
- Costs for labor and equipment assume the pier would be constructed from water.
- Crews would work 8- to 10-hour shifts, 5 days per week.
- Estimated labor costs for these tasks were based on a recent construction project at the Port, and production rate/cost given in Means Heavy Construction Cost Data.
- Labor, equipment, and material costs were increased from the 2006 engineer's estimate using best professional judgment.

2.1.6 CDF Completion Assumptions

- Material quantities were estimated using CAD software and the grades presented in the construction Drawings (C-23 and C-26, Appendix B to the DAR).
- The offloading facility cost was estimated assuming a 10- to 12-inch dredge pump will be purchased to offload the sediments. A second, slightly smaller, pump will be purchased to pump make-up water from the CDF to slurry the dredge material. Costs also include material for piping and construction and materials for a diffuser barge. The dredge pump will be maneuvered into the haul barge with either a crane or a trackhoe.
- The contaminated sediment and imported fill material were assumed to be brought to the site by barge and offloaded using a hydraulic pump to slurry the material and pump it over the berm into the CDF. Water from inside the CDF will be used as make-up water to slurry the material off of the barge.
- It is assumed that the cost of dredging, hauling, and placement of contaminated sediment will be borne by the parties that generated the dredged sediment and, therefore, those costs are not included here.
- The price range for the imported fill material assumed two different sources of material:
  - The lower end range assumed that the material is dredge material from navigational dredging delivered to the site for free. The dredge material would meet the chemical criteria for the imported fill. The only cost is to place the material in the CDF.
  - The upper end range assumed that the material is purchased from an upland source. The cost includes purchase, delivery, and placement of the material in the CDF.
- The select fill and base/top course material were assumed to be brought to the site by truck or barge. If the material is brought to the site by barge, the material would be offloaded mechanically over the containment berm.
- Material costs were obtained by contacting local aggregate suppliers.
- Labor and equipment costs were estimated using prevailing wages for labor, prevailing fuel costs, and contractor rental equipment rates. Production rates were

based on equipment size and capabilities, professional judgment, and experience working under similar conditions.

- Labor and equipment costs were increased from the 2006 engineer's estimate using best professional judgment. Material prices were updated based on discussions with a local supplier.

2.1.7 Miscellaneous Construction-Related Direct Costs Assumptions

- Water quality monitoring costs are based on the extensive monitoring program presented in the Water Quality Monitoring Plan (Appendix E to the DAR).
- Costs assume a field crew with a boat and monitoring equipment every day of in- or near-water construction.
- Laboratory analyses costs were obtained by contacting local laboratories and assuming that a 72-hour turnaround will be required.
- Costs for mitigation are based on the previous process for determining a mitigation project for the full Removal Action as documented in the Draft Mitigation Plan (60 Percent Design document) and subsequent meetings with the U.S. Environmental Protection Agency (USEPA) and its federal, state, and tribal partners. The acres of mitigation for the CDF are, therefore, assumed to range from 2.5 to 5.0 acres of shallow water habitat. Although the Port recognizes that the mitigation requirement will be updated based on developments that occur through the Harbor-wide Feasibility Study (FS) process, this acreage is the best available information to be used here.
- The per-acre cost (in 2010 dollars) is based on Anchor QEA's experience in the region on estimating costs for similar type restoration/mitigation projects in an urban environment and focus on creating shallow water habitat (most limiting in the lower Willamette River) from existing upland. The cost range was developed as follows:
  - The $1.5 million low end of the range was derived from the cost provided in the full T4 Removal Action 60% design in 2006.
  - The $5.0 million high end range was derived based on the mitigation per-acre cost estimates currently being used in the FS by the Lower Willamette Group (LWG) and the upper end of the mitigation project size range of 5.0 acres from the full T4 Removal Action 60% design in 2006. The per-acre mitigation cost range currently

being used in the FS by the LWG is $0.3 to $2.0 million based on creating shallow water habitat from existing upland inside and outside of the study area. The costs assume that any excavated upland areas are not contaminated and can be disposed of accordingly. For the upper end of the cost range provided in the DAR, the 5.0 acres was multiplied by $1.0 million, which is the mid-point of the per-acre cost range being used in the FS.

- In EPA's view, the high end of presented estimates present what will likely be mid-range cost requirements for a mitigation project, based on the last T4 CDF mitigation project discussions undertaken.
- The Port recognizes that the mitigation requirement will be updated based on developments that occur through the Harbor-wide FS process; and this acreage and cost per-acre information is the best available information for this design analysis.

2.2 Indirect Construction Costs

- Construction management and daily oversight are assumed to be roughly 3 percent of the total direct costs.
- Engineering support during construction was assumed to be approximately $75,000 to $150,000 per construction season, depending on the activities.
- Special insurance and bonding was assumed to be approximately 5 to 6 percent of the total direct costs.

2.3 Long-Term Monitoring and Maintenance Costs

Long-term management activities will be addressed in the final LTMRP that will be included as part of the 100 Percent Design. An outline of the LTMRP is presented in Appendix K. Long-term monitoring activities are expected to include:

- Visual Monitoring
  - Armor Layer Stability, which will be assessed though a visual survey of the portion of the CDF armor layer that is above the water line. Transects will be walked at low water levels to complete the visual surveys.
- Physical Monitoring

  - Armor Layer Stability, which will be assessed through a bathymetric survey of the portion of the CDF armor layer that is below the water line.
  - Consolidation and Settlement Monitoring, which will be assessed though a survey of eight monuments located on the CDF berm and CDF surface.
  - Groundwater Level Monitoring within the CDF, which will be assessed through water level measurements at five monitoring well locations within the extent of the contaminant fill area of the CDF. In addition, water level monitoring will be conducted at the six chemical monitoring well locations described below.

- Chemical Monitoring
  - Groundwater Quality Monitoring at the CDF, which will be assessed through collection of groundwater samples at three downgradient monitoring well locations in the CDF berm, one upgradient location, and two lateral locations (six monitoring wells total). Long-term groundwater quality parameters and criteria are provided in DAR Table 6-1.

Long-term monitoring activities will be performed at the completion of construction (Year 0) as well as during eight post-construction events (Years 2, 5, 7, 10, 15, 20, 25, and 30).