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2003

EPA Superfund
Record of Decision:

HARBOR ISLAND (LEAD)
EPA ID: WAD980722839
OU 08
SEATTLE, WA
09/11/2003

Harbor Island Superfund Site
West Waterway Operable Unit
Seattle, Washington

Record of Decision

September 11, 2003

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ACRONYMS AND ABBREVIATIONS

ARAR	applicable or relevant and appropriate
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CSL	cleanup screening level
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
LDW	Lower Duwamish Waterway Superfund site
MLLW	mean lower low water
NCP	National Contingency Plan
NMFS	National Marine Fisheries Service
NPL	National Priorities List
OU	operable unit
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyls
PSDDA	Puget Sound Dredged Disposal Analysis
RI/FS	remedial investigation/feasibility study
RME	reasonable maximum exposure
ROD	Record of Decision
SMS	Washington State Sediment Management Standards
SQS	sediment quality standard
TBT	tributyltin
TOC	total organic carbon
USFWS	U.S. Fish and Wildlife Service
VOC	volatile organic compound
WWOU	West Waterway Operable Unit

PART 1: THE DECLARATION

Site Name and Location

The Harbor Island Superfund site, which includes the West Waterway Operable Unit (OU), is located in King County, Washington. The U.S. Environmental Protection Agency (EPA) identification number for the Harbor Island site is WAD980722839. The Harbor Island site was listed on the National Priorities List (NPL) in 1983.

The Harbor Island Superfund site is composed of an upland portion and a marine sediment portion, with a total of seven OUs. The West Waterway OU is addressed by this Record of Decision, and includes approximately 70 acres of marine sediments in the West Waterway.

Statement of Basis and Purpose

This decision document presents the basis for the determination that no remedial action is necessary at the West Waterway OU, which was chosen in accordance with the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), as amended, and to the extent practicable, the National Contingency Plan (NCP). This decision is based on the Administrative Record file for this OU.

The Washington State Department of Ecology (Ecology) concurs that the no action decision for the West Waterway OU is consistent with CERCLA/NCP requirements. Ecology further recognizes that this no action decision is based on a Superfund risk assessment that is similar to, but is not entirely consistent with the requirements of the State of Washington's Model Toxics Control Act Cleanup Regulation (MTCA), Chapter 173-340 WAC. Therefore, at this time, Ecology cannot conclude the risk calculated for the OU meets the MTCA cleanup requirements. This determination was made in accordance with the Interagency Agreement between EPA and Ecology, "Superfund Management in Washington," dated February 23, 2000, which delineates lead and support agency roles for Superfund sites in Washington. This concurrence does not preclude the state from taking future cleanup action at this OU under its own authorities.

Description of Selected Remedy

For the West Waterway OU, EPA has determined that no action is necessary to protect public health or welfare or the environment. No CERCLA action is necessary because environmental investigations and site-specific risk assessments found that chemical concentrations in marine sediments within the operable unit do not pose unacceptable risks to human health and the environment. A five-year review for the Harbor Island site will be performed for all OUs. As part of the five-year review process, EPA may authorize monitoring of the OU to verify that the sediment continues to pose no unacceptable risks to human health and the environment.

Authorizing Signature

________//s//____________________ ____11 Sept 2003______________

Mike Gearheard, Director — Date

Environmental Cleanup Office

PART 2: DECISION SUMMARY

1. Site Name, Location, and Description

The Harbor Island Superfund site, which includes the West Waterway Operable Unit (OU), is located about 1 mile southwest of downtown Seattle, in King County, Washington (Figure 1). The island lies at the mouth of the Duwamish Waterway on the southern edge of Elliott Bay, along the eastern shoreline of Puget Sound. The U.S. Environmental Protection Agency (EPA) identification number for the Harbor Island site is WAD980722839. EPA is the lead agency and the Washington State Department of Ecology (Ecology) is the support agency.

The Harbor Island site was listed on the National Priorities List (NPL) in 1983 due to the release of lead from a secondary lead smelter and the release of other hazardous substances from other industrial operations on the island. Preliminary investigations revealed contamination of soil on Harbor Island and of sediments adjacent to Harbor Island. The contaminants of concern identified in soils and sediments as known or suspected releases at the time of listing included lead, mercury, copper, zinc, polycyclic aromatic hydrocarbons (PAHs), volatile organic compounds (VOCs), and polychlorinated biphenyls (PCBs). Suspected sources of chemicals found in sediments included historical disposal practices, direct discharge of waste, storm drains, and other nonpoint discharges.

The Harbor Island Superfund site is composed of an upland portion and a marine sediment portion, with a total of seven OUs. The upland portion of the site is addressed by a 1993 Record of Decision for the Soil and Groundwater OU, and a 1994 Record of Decision for the upland Lockheed Shipyard OU. Additionally, the petroleum tank farms located at the upland site are being addressed by State of Washington cleanup regulations. The marine sediment portion of the site is divided into four OUs: the Lockheed Martin Corporation (Lockheed) Shipyard Sediment OU, the Todd Shipyard Sediment OU, the West Waterway OU, and the East Waterway OU. The Lockheed and Todd Shipyard Sediment OUs are addressed by a 1996 Record of Decision for the "Shipyard Sediment OU" (separate shipyard OUs were established in 1999) and by subsequent Explanations of Significant Differences in 1999, 2002, and 2003. The West Waterway OU is addressed by this Record of Decision, and the East Waterway OU will be addressed at a future time.

The West Waterway OU includes approximately 70 acres of estuarine sediments located in the West Waterway on the western side of Harbor Island (Figures 2 and 3). The West Waterway is a dredged navigable channel used extensively for industrial and port purposes. The waterway consists primarily of subtidal sediments, which remain under water even at low tides. The shoreline of the West Waterway is predominantly pilings, bulkhead, and riprap. Areas of intertidal sediments along the shorelines adjacent to the West Waterway OU are generally nonexistent.

The West Waterway OU was established *after* the sediments with the highest chemical concentrations in the West Waterway were designated for clean up under EPA's 1996 Record of Decision for the Shipyard Sediment OU (Todd and former Lockheed Shipyards). As shown in Figures 3, 4, and 5, the former Lockheed Shipyard is located in West Waterway and the Todd Shipyard is located in both West Waterway and Elliott Bay. These shipyard sediments and related cleanups remain part of the Todd and Lockheed Shipyard Sediment OUs, and the remediation for these OUs is not changed by this ROD. The shipyard sediments are distinct from other contaminated sediments at Harbor Island because they are predominately contaminated with hazardous substances (e.g., metals, tributyltin) and shipyard wastes (primarily sandblast grit) released by shipbuilding and maintenance operations at the shipyards. In 1999, the Shipyard Sediment OU was separated into the Lockheed Shipyard Sediment OU and the Todd Shipyard Sediment OU for implementation of remedial design and remedial action.

As shown on Figure 3, the West Waterway OU does not include: 1) sediments associated with the Lockheed and Todd Shipyard Sediment Operable Units; 2) sediments in a portion of the waterway that are considered native, post-dredge sediments near Terminal 5, which is an area that was dredged in 1998 for navigational purposes by the Port of Seattle under the Puget Sound Dredged Disposal Analysis (PSDDA) program (all materials were disposed of at an open-water PSDDA site; and, 3) sediments in the northwest portion of the waterway that are located within the boundaries of Ecology's Lockheed (Yard 2) Aquatic Area site, which is a sediment site being addressed by Ecology's Toxics Cleanup Program.

The West Waterway OU is located within the boundaries of the federally-adjudicated Usual and Accustomed Fishing Area for the Muckleshoot Indian Tribe.

Threatened and endangered species potentially occurring within the local area include the bald eagle and bull trout, which are listed by the U.S. Fish and Wildlife Service (USFWS) as threatened species, and the chinook salmon, which is listed by the National Marine Fisheries Service (NMFS) as threatened species.

2. Site History and Enforcement Activities

Overview –

The purpose of this section is to summarize the extensive environmental investigations and administrative actions that pertain to the sediments in the West Waterway OU. This summary includes the time line and rationale for the numerous studies performed initially for all sediments surrounding Harbor Island, as well as subsequent studies performed in the West Waterway area. As a result of these studies, the most contaminated sediments in the West Waterway were designated for cleanup under EPA's ROD for the Shipyard Sediment OU. Subsequently, more studies were performed within the remaining sediments in the West Waterway (now identified as the West Waterway OU). Based on study results, EPA proposed a no action decision for the West Waterway OU (Proposed Plan, 1999). Subsequent to the proposed plan, EPA re-evaluated the available information and considered new studies and new information to evaluate whether our determination should be changed (e.g., particularly with respect to the human health risk assessment). Throughout the process for the West Waterway OU, EPA designed and implemented studies that are beyond the scope of typical studies conducted for sediment sites. For example, the studies performed at this site have been used to support a regional approach to assessing tributyltin (TBT) contamination in sediments, and at the time it was completed, the human health risk assessment was the most comprehensive approach considered for a Region 10 sediment site. A brief summary follows.

When the Harbor Island site was listed in 1983, the focus of investigations and enforcement activities were on the upland portion of the site. Although a Preliminary Investigation (Black and Veatch 1985) reviewed existing literature regarding potential sediment contamination around Harbor Island, a sediment sampling effort was not conducted.

In 1985, as part of the EPA National Estuary Program (Urban Bay Action Program), sediment chemical and biological data were collected in the West Waterway, as well as throughout the Lower Duwamish Waterway and Elliott Bay. Although data collected in the West Waterway indicated potential adverse effects to biota, primarily at stations in or near the shipyards, only one sediment toxicity bioassay test was performed.

In 1990, the EPA's Phase 1 remedial investigation for the Harbor Island Superfund site (Ebasco 1990) did not include studies on marine sediments adjacent to Harbor Island. Subsequently, EPA initiated a fund-lead sediment remedial investigation for the site in 1991, which sampled sediments around Harbor Island. In 1995, the sediment Remedial Investigation/Feasibility Study (RI/FS; Weston 1994, 1995) was completed. The clear indication of sediment contamination associated with the shipyards led EPA to issue a ROD for the Shipyard Sediment OU (Todd and Lockheed Shipyards) in 1996.

For the remainder of the Harbor Island sediments, however, additional sediment investigations were necessary because the RI/FS did not adequately define the extent of surface sediments that may potentially warrant cleanup based on Washington State Sediment Management Standards (SMS) chemical and biological criteria. The primary data gap was that biological data (e.g., sediment toxicity tests) had not been collected and were necessary to accurately evaluate ecological risks. Other data gaps included the lack of information on how to evaluate TBT-contaminated sediments.

In 1996, EPA negotiated an Order with several Respondents to perform additional sediment chemistry and toxicity bioassay testing (including stations in the West Waterway OU). Because existing approaches (e.g., performing sediment toxicity tests, comparing data to a sediment criteria) to evaluating risks due to TBT were not possible, EPA developed an interagency group to set a regional approach for addressing this problem.

After results from the additional chemistry/toxicity testing showed that sediment cleanup was not warranted based on the state's biological standards, EPA's efforts became more focused on the remaining issue – assessing potential ecological impacts associated with exposure to TBT in sediments. EPA negotiated a second Order with several Respondents to perform TBT-specific studies. In that Order, EPA also required the Respondents to prepare a human health risk assessment for the seafood consumption pathway in response to a request from the Muckleshoot Tribe. The TBT studies were completed in 1999 and the human health risk assessment was completed in 2000.

> Initially, sediments within the West Waterway were studied as part of investigations performed for the "Sediments Operable Unit" of the Harbor Island Superfund site, which generally consisted of all sediments surrounding Harbor Island. Subsequently, sediments within the West Waterway were studied as part of investigations performed for the "Waterway Sediment Operable Unit," which generally consisted of sediments in both the West and East Waterways. To more efficiently complete the sediment investigations, EPA designated the sediments being studied in the West Waterway as the West Waterway OU and the sediments being studied in the East Waterway as the East Waterway OU.

Upon completion of the human health risk assessment, EPA continued to identify any new studies or new information that may affect results of that risk assessment. EPA prepared addenda to the risk assessment each time a new consumption study was completed. Addenda were prepared to incorporate alternative consumption rates from the Asian Pacific Islander Consumption Survey and, in response to a request from the Suquamish Tribe, the Suquamish Fish Consumption Survey. In 2000, EPA decided again to delay the final decision for the West Waterway OU until the NPL listing decision was made for the Lower Duwamish Waterway (LDW) Superfund site, which is south of and contiguous with the West Waterway OU. After the LDW listing in September 2001, EPA waited until the tribal seafood consumption exposure parameters were identified for the scoping phase human health risk assessment for the LDW site, and EPA incorporated that new information into the West Waterway OU risk evaluation. EPA concluded that these re-evaluations do not change the risk assessment conclusions presented in the 1999 Proposed Plan for the West Waterway OU, and concluded that a No Action ROD is appropriate.

A more detailed presentation of Site History is provided below.

Site History--

Harbor Island and the surrounding estuarine environment are highly industrialized. Prior to 1905, the area consisted of tideflats with a few piling-supported structures. The island was created between 1903 and 1905 with dredged material from construction of the East and West Waterways and the main navigational channel of the Duwamish Waterway. Since construction, the island has been used for commercial, industrial, and port activities.

Since 1985, numerous environmental studies and investigations have been completed to identify potential adverse human health and ecological effects associated with marine sediments at the Harbor Island Superfund site (see Table 1 and Figure 6). EPA completed a fund-lead Remedial Investigation and Feasibility Study (RI/FS) for all Harbor Island sediments in 1995. The RI primarily focused on identifying physical and ecological characteristics of the area, and evaluating the nature and extent of sediment contamination.

Subsequent to EPA's RI/FS, two supplementary remedial investigations were performed for Harbor Island sediments, with EPA oversight, in accordance with legal agreements between EPA and various PRPs. These supplementary studies were undertaken to more thoroughly evaluate the nature and extent of potential sediment contamination through the collection of sediment and the performance of chemical and toxicity analyses, and to evaluate potential ecological and human health concerns associated with three bioaccumulative compounds – polychlorinated biphenyls (PCBs), tributylin (TBT), and mercury. In general, only data located within the boundaries of the West Waterway OU are presented in this ROD.

In 1999, EPA released a Proposed Plan for the West Waterway OU that indicated that sediments did not pose unacceptable risks to human health or the environment, and recommended that no remedial action was necessary. In 2002, EPA completed a technical memorandum that used new information that became available between 1999 and 2002 to re-evaluate the human health risk assessment characterization for the West Waterway OU. EPA concluded that the re-evaluations did not change the conclusions presented in the 1999 Proposed Plan.

Other marine sediment studies performed within the West Waterway, but outside the boundaries of the West Waterway OU, include activities associated with the Todd and Lockheed Shipyard Sediment OUs of the Harbor Island Superfund site, the completed Port of Seattle's Terminal 5 project, and the Ecology Lockheed (Yard 2) Aquatic site.

Chronology of EPA's Administrative Decisions in the West Waterway –

A general time line of administrative decisions and investigations associated with the West Waterway OU is presented in Figure 6 and Table 1.

In 1995, the fund-lead Harbor Island RI/FS (Weston 1994, 1995) identified four "prioritized cleanup areas" for the sediment within the Harbor Island Superfund site. These four areas included the West Waterway, East Waterway, Northwest Harbor Island, and Northeast Harbor Island.

Subsequently, an Administrative Order on Consent between participating PRPs and EPA was signed in 1995 to conduct additional sediment investigations prior to issuing a Proposed Plan and proposing a remedy for Harbor Island sediments. The objective of this supplementary Remedial Investigation was to collect supplemental data to the original RI to be used by EPA to determine areas requiring active remediation, natural recovery, or no further action. As an example, sediment toxicity test data were not available from the original RI and were collected as part of the supplementary RI.

After reviewing supplementary RI data, EPA determined that the majority of the Northeast Harbor Island area was in compliance with state sediment standards and would not require remediation. EPA also determined that the highest concentrations of chemicals in the West Waterway were associated with the "shipyard sediments." In 1996, EPA issued a Record of Decision (ROD) for the Shipyard Sediment OU of the Harbor Island Superfund site. This

ROD selected a remedy for contaminated sediments adjacent to the former Lockheed Martin shipyard, which was located in the West Waterway prioritized cleanup area, and sediments adjacent to the active Todd Shipyard, which was located in a portion of both the West Waterway and Northwest Harbor Island prioritized cleanup areas. In 1999, the Shipyard Sediment OU was separated into the Lockheed Shipyard Sediment OU and the Todd Shipyard Sediment OU and since then EPA has issued four Explanation of Significant Differences for these two OUs.

Based on the 1996 Shipyard Sediment OU ROD, the Northwest Harbor Island and West Waterway areas were redefined. The Northwest Harbor Island area essentially became the Todd Shipyard portion of the Shipyard Sediment OU, and the remaining waterway sediments not included within the Shipyard Sediment OU became part of the West Waterway prioritized cleanup area (which is currently defined as the West Waterway OU).

In 1998, a second Administrative Order on Consent between three respondents and the EPA was entered into to collect and analyze additional sediment and tissue data associated with the West and East Waterways. The primary focus of the work was to collect supplemental data to assess ecological and human health risks associated with three bioaccumulative chemicals (mercury, PCBs, and TBT).

No removals or early actions were completed in the West Waterway OU.

The current status of cleanup actions within and adjacent to the Harbor Island Superfund site is provided in Table 2.

3. Community Participation

Community involvement activities have occurred at the Harbor Island site since the 1980s. Activities consisted primarily of distribution of fact sheets, maintenance of the information repository, updates to the site web page, and newspaper advertisements announcing the release of significant documents and comment periods. The Harbor Island site mailing list, which has approximately 200 addressees, has been used to send fact sheets to community members throughout the West Waterway process. Stakeholder involvement for the West Waterway OU has been state and federal trustee agencies and the Muckleshoot Tribe. No environmental group and only one interested party has contacted EPA regarding activities at the West Waterway OU.

The Proposed Plan for the West Waterway OU was released for public comment in November 1999. An announcement of availability of this plan was published in the Seattle Times. The public comment period closed on January 14, 2000. EPA received five written comment letters.

Subsequent to the Proposed Plan, EPA prepared technical memoranda on specific issues that were also shared with stakeholders. For example, EPA summarized all information regarding PCBs in sediments in the West Waterway OU (December 21, 1999, revised May 7, 2002). Also, EPA updated the human health risk assessment using new Suquamish Tribe seafood consumption data and using assumptions developed for the Phase 1 risk assessment for the Lower Duwamish Waterway (LDW) Superfund site (EPA, December 16, 2002). On December 8, 2002, EPA provided a presentation for the Washington State Department of Ecology, which summarized information related to the risk management decision for the West Waterway OU.

EPA's response to comments received during the public comment period is included in the Responsiveness Summary, which is included as Part 3 of this ROD. The decision in this ROD is based on the administrative record for this site.

4. Scope and Role of Operable Unit or Response Action

The Harbor Island Superfund site is composed of an upland portion and a marine sediment portion. The upland portion of the site is addressed by a 1993 Record of Decision for the Soil and Groundwater OU and a 1994 Record of Decision for the upland Lockheed Shipyard OU. Additionally, the petroleum tank farms located at the upland site are being addressed by State of Washington Department of Ecology using the state's cleanup regulations. The marine sediment portion of the site is divided into four areas: the Lockheed Shipyard Sediment OU, the Todd Shipyard Sediment OU, the West Waterway OU, and the East Waterway OU. The Shipyard Sediment OUs are addressed by a 1996 Record of Decision, and includes marine sediments adjacent to the Todd Shipyard and the former Lockheed Martin Shipyard (see Figures 4 and 5). Also, the Lockheed Shipyard Sediment OU is addressed by two Explanation of Significant Differences (ESD) dated February 2002 and March 2003 and the Todd Shipyard Sediment OU is addressed by two ESDs dated December 1999 and March 2003. The East Waterway OU will be addressed at a future time.

The West Waterway OU is addressed by this Record of Decision, which presents the basis for the determination that no CERCLA action is necessary at this site to protect human health or the environment.

5. Site Characteristics

This section summarizes information obtained as part of RI and supplementary RI activities associated with the West Waterway OU.

General Site Features –

The West Waterway OU consists of approximately 70 acres of subtidal estuarine sediments in the West Waterway on the western side of Harbor Island (Figures 2 and 3). West Waterway is approximately 6,000 ft long, with a maximum width of 750 feet. The orientation of the waterway is north to south, and it is used extensively as a major transportation corridor. The West Waterway has piers, steel bulkheads, and shipping docks along its eastern and western shores. The U.S. Army Corps of Engineers (Corps) is authorized to maintain the waterway at a depth of approximately -30 ft MLLW. However, natural processes tend to maintain the channel at depths ranging from approximately -34 to -63 ft MLLW, with an average depth estimated at

-50 ft MLLW, precluding the need for maintenance dredging in most cases. Nearshore areas along the West Waterway have been occasionally dredged by private interests.

Although intertidal areas exist within the West Waterway, intertidal areas within the boundaries of the West Waterway OU were not identified in videos and photographs that were taken during extreme low tides in 1999 (documentation from Environmental Solutions Group to Karen Keeley, EPA, dated August 10, 1999). No shoreline public access areas exist in the West Waterway OU. Aerial photographs of West Waterway are shown in Figure 7.

Conceptual Site Model –

The generalized Conceptual Site Model for potential contaminant releases to sediments in the West Waterway OU and potential ecological receptors is presented in Figure 8. A generalized Conceptual Site Model for potential contaminant releases to sediments in the West Waterway OU and potential human health receptors is presented in Figure 9. The risk assessments for this OU are based on these Conceptual Site Models. A general discussion of sources and source control efforts, which were completed in advance of the completion of the ecological and human health risk assessments for this OU, are provided below.

Source Control –

During the RI, general sources of potential contamination to the sediments surrounding Harbor Island were identified as direct discharge of waste, spills, historical disposal practices, atmospheric deposition, groundwater seepage, storm drains, combined sewer overflow systems, and other nonpoint discharges. Sediment contamination of the estuarine environment surrounding Harbor Island may also have resulted from upstream sources. The potential upland industrial sources at the Harbor Island Superfund site included metal smelting, metal plating, scrap metal recycling, ship repair, battery recycling, and oil recycling.

As part of the investigations and remediation of the uplands portion of the Harbor Island site, numerous source control efforts and cleanup actions were completed for the Soil and Groundwater OU and the upland Lockheed Shipyard OU. Cleanup actions for the Todd and Lockheed Shipyard Sediment OUs, which are adjacent to the West Waterway OU, are scheduled to start in mid-2003. A summary of the major completed and ongoing cleanup actions under EPA or Ecology authorities for the Harbor Island area is shown in Table 2. Although the above-referenced actions were completed to meet the cleanup requirements for other Operable Units of Harbor Island site, those actions also served as source control efforts that have reduced potential releases of contaminants to sediments in the West Waterway OU. As noted above, most of these cleanup actions were finished prior to the completion of the risk assessments for the West Waterway OU.

In conclusion, as part of the upland and source control investigations and cleanups for the Soil and Groundwater OU and the upland Lockheed Shipyard OU, EPA evaluated the potential for releases of contaminants from the uplands portion of the Harbor Island site to adjacent sediments, including sediments in the West Waterway OU. EPA believes that all actions necessary to control contaminant releases from the uplands portion of the site that may pose unacceptable risk to adjacent sediments in the West Waterway OU have been completed or will be addressed through ongoing actions. The identification of potential "major sources" to sediments in the West Waterway OU, and a more complete listing of all source control efforts for the Harbor Island site, is unnecessary for this ROD since EPA has determined that a No Action decision is appropriate for this OU.

Surface Sediment Investigations –

Numerous environmental investigations have been completed to identify potential adverse ecological effects and human health risks associated with marine sediments in the West Waterway OU (see Figure 6, Table 1, and the general overview provided in Section 2). Results from these environmental studies were used to define the nature and extent of sediment contamination at the site, and to evaluate potential risks to the environment and to humans from these sediments. Sampling station locations were placed both randomly and biased for areas with known contamination (e.g., shipyards). Ecological evaluations focused on the effects of sediment contaminants on marine animals. These ecological evaluations consisted of sediment chemical analyses, sediment toxicity testing, bioaccumulation testing, and an assessment of bioaccumulation potential for mercury, PCBs, and TBT. Sediment toxicity and bioaccumulation testing were performed in a laboratory by exposing marine animals to sediment from the study area. Human health evaluations focused on potential risks associated with contacting sediment, or eating seafood, from the study area.

During the initial RI and supplementary RI investigations, the surface sediments were analyzed for many groups of possible contaminants, including selected metals and metalloids, tributyltin, volatile organic compounds, semivolatile organic compounds (including PAHs and PCBs), pesticides, and conventional parameters. In the initial RI, surface sediments were sampled at 0 to 2 cm, and in the supplementary RI sediments were sampled at 0 to 10 cm[1]. Both assessments focused on evaluating surface sediments because benthic organisms live only in these surface sediments; benthic organisms do not live in the deeper sediments in the West Waterway. Sampling strategies were based on random sampling designs selected to provide adequate spatial coverage, as well as focused sampling in areas with known contamination (e.g., shipyards).

The 1991 RI included 33 surface sediment sampling locations within the area now defined as the West Waterway OU[2], and an additional 17 surface sediment sampling stations

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1. Both the Puget Sound Estuary Program sampling protocols ("Recommended Protocols for Measuring Selected Environmental Variables in Puget Sound, EPA, R10, Seattle, WA") and the state Sediment Management Standards recommend sampling surface sediments at depths of 0 to 10 cm when assessing potential adverse risks to benthic organisms.

2. The 1991 RI stations include W-7, 8, 9, 10, 12, 13, 14, 15, 16, 17, 18, 19, 20, 22, 23, 26, 27, 29, 32, 33, 35, 36, 39, 40, 41, 42, 43, 44, 47, 48, 52, 55, and N-09. This list excludes stations in areas that have been dredged near Terminal 5 (e.g., stations W-11, W-24, and W-30) and stations located within the Lockheed and Todd Shipyard Sediment OU boundaries.

within the West Waterway but outside the West Waterway OU. The supplementary RI included 25 surface sediment sampling locations within the West Waterway OU[3], and an additional 8 sampling stations within the West Waterway but outside the West Waterway OU. Certain stations were co-located with 1991 RI sample locations (see Figure 3). The supplementary RI also included 18 stations (co-located with bulk sediment stations) that were sampled for three sediment toxicity tests per station in accordance with state SMS[4]. This testing included a 10-day amphipod acute mortality test using *Rhepoxynius abronius*, a 20-day juvenile polychaete growth test using *Neanthes arenaceodentata*, and a 60-hour bivalve larvae mortality/abnormality test using the mussel *Mytilus* spp. Bulk sediment and toxicity stations are shown in Figure 3.

Sediment chemistry data collected during the initial RI indicated that there were certain chemicals that were frequently detected in sediments around Harbor Island at concentrations exceeding the chemical criteria that are set to protect bottom-dwelling animals pursuant to the Washington State Sediment Management Standards (see inset on next page). Although exceedances of State sediment standards are generally determined based on clusters of three stations, a more conservative approach was used for the Harbor Island RI evaluations (as well as the supplementary RI evaluations) -- individual chemical concentrations from a single station were directly compared to the corresponding state chemical Sediment Management Standard.

Data Summary – Remedial Investigation Studies

58 Stations - Surface Sediment Chemistry (some stations were sampled in the RI and then repeated in the supplementary RI)

18 Stations - Sediment Toxicity Bioassays (co-located with bulk sediment stations; three bioassays/station)

30 Stations - TBT Bulk Sediment and Porewater

20 Stations - TBT Laboratory Bioaccumulation (worm, clam)

Crab, English sole, Perch Tissue - Collected and analyzed for the human health risk assessment.

Overall, for Harbor Island sediments, the chemicals that most often exceeded individual chemical Sediment Quality Standard (SQS; see inset for definition) were arsenic, copper, lead, mercury, zinc, bis(ethylhexyl)phthalate (BEHP), PCBs, and polycyclic aromatic hydrocarbons (PAHs).

However, for the RI samples located within the West Waterway OU, there were only four chemicals that exceeded the state's chemical Cleanup Screening Level (CSL; see inset for definition) at more than one station. Mercury exceeded the state chemical CSL at 11 stations,

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3. SRI stations include WW-01, 2, 3, 4, 5, 6, 7, 8, 9, 10, 14, 15, 16, 18, 19, 20, 21, 22, 23, 24, 25, 27, 28, 29, and 31. This list excludes stations in areas that have been dredged near Terminal 5 (e.g., stations WW-11) and stations located within the Lockheed and Todd Shipyard Sediment OU boundaries.

4. An additional four sediment toxicity bioassay stations were sampled within the West Waterway but outside the boundaries of the West Waterway OU.

State of Washington Sediment Management Standards

The State of Washington Sediment Management Standards (SMS), WAC 173-204, were used to evaluate potential ecological risk for sediments in the West Waterway OU because these effects-based standards can be used to evaluate toxicity to ecological receptors exposed to contaminated sediment. The SMS currently contain chemical and biological effects levels for the protection of marine animals living in the bottom sediments (the "benthic community").

The SMS establish two types of levels for chemical concentrations and biological effects: 1) the Sediment Quality Standard (SQS), a "no effects" level, and 2) the Cleanup Screening Level (CSL), a "minor adverse effects" level. The SQS and CSL criteria are generally applied to station clusters of potential concern, which would be evaluated by the average of the highest chemical concentrations or the highest degree of biological effects from a set of three associated stations. The SQS levels, which are the lower of the two standards and are established as a sediment quality goal for Washington State sediments, represent levels below which adverse effects are not expected. Between the SQS and the CSL are levels at which adverse biological effects are expected to be minor. The CSL establish the levels above which station clusters of potential concern are defined as cleanup sites, per the procedures of WAC 173-204-530.

The SQS and CSL *chemical* criteria are based on numerical concentrations of chemicals. The SQS and CSL *biological* criteria are based on adverse effects to organisms as measured in biological tests, such as the sediment toxicity bioassays tests. When using biological tests to determine if station clusters exceed the CSL, test results from at least two acute effects tests and one chronic effects test shall be evaluated.

When there are both chemical and biological effects data collected from a site, the SMS give precedence to the biological effects data in determining whether a remedial action is necessary (i.e., the biological effects data "override" the chemical concentration data because biological effects data are considered to better reflect the *in*

BEHP exceeded the state chemical CSL at 8 stations, benzo(g,h,i)pyrelene exceeded the state chemical CSL at 2 stations, and phenol exceeded the state chemical CSL at 2 stations. For the other 44 chemicals measured at each of these 33 stations, the state chemical CSL was not exceeded or was only exceeded at one station -- as noted in the inset "State of Washington Sediment Management Standards" a single exceedance of a chemical at a station is not considered a "hot spot" under the state SMS rule and does not require further evaluation. Sediments at the RI stations were also analyzed for pesticides and volatile organic compounds, and these chemicals were not identified as chemicals of concern based on comparison of results to background concentrations, cleanup screening levels used by other regulatory programs, or cleanup criteria selected at other Superfund sites. No state sediment standards exist for pesticides and volatile organic compounds. Thus, for most chemicals and most stations, the states chemical CSL criteria are not exceeded, and as described below, these chemical exceedances were subsequently "over-ridden" by results of biological data that were collected in 1995 in the West Waterway.

For the supplementary RI samples located within the West Waterway OU, sediment chemistry data indicated that mercury exceeded the state chemical CSL at 14 stations, and zinc exceeded the state chemical CSL at 2 stations. Enrichment ratios for both mercury and zinc were between 1 and 2. For the other 45 chemicals at these 25 stations, the state CSL was not exceeded or was only exceeded at one station. The previous CSL exceedances of bis(ethylhexyl)phthalate, benzo(g,h,i)pyrelene, and phenol that were found during the initial

RI/FS were not found during this investigation. Potential reasons for this difference could be due to any or all of the following: the difference in sample intervals (RI samples were collected from 0 to 2 cm, supplementary samples were collected from 0 to 10 cm); the higher percentage of fines present overall in the RI samples (primarily because RI samples were collected at 0 to 2 cm rather than 0 to 10 cm); natural recovery (i.e., a trend of decreasing concentrations over time); and, the result of sampling heterogeneity and analytical imprecision. Sediments at the supplementary RI stations were also analyzed for pesticides and volatile organic compounds, and these chemicals were again not identified as chemicals of concern based on comparison of results to background concentrations, cleanup screening levels used by other regulatory programs, or cleanup criteria selected at other Superfund sites. No state sediment standards exist for pesticides and volatile organic compounds.

In summary, mercury exceedances of the state chemical CSL occurred at stations throughout the West Waterway in the RI and the supplementary RI. However, as noted below, subsequent biological tests in the West Waterway OU showed no exceedances of the state biological CSL criteria. Further, the CSL exceedances of bis(ethylhexyl)phthalate, benzo(g,h,i)pyrelene, and phenol that were found during the initial RI/FS were not found during the supplementary RI investigation. Finally, the zinc exceedances of the state's chemical CSL criteria at 2 stations sampled during the supplementary RI is not considered significant given the low number of stations with exceedances, the low enrichment factors for these data (compared to state chemical SQS), and the results of subsequent biological tests which showed no exceedances of the state biological CSL criteria.

A primary objective of the supplementary RI was to collect synoptic surface sediment chemistry and bioassay data for evaluation in accordance with state SMS. Results from the sediment toxicity bioassays indicated that none of the stations sampled in the West Waterway OU failed the state's CSL biological criteria, which over-rides any concerns identified solely by the chemical data (see "State of Washington Sediment Management Standards" inset).

Based on an evaluation of all data, it was concluded that sediment cleanup in the West Waterway OU was not warranted based on state SMS chemical and biological standards.

However, further evaluations were performed to address concerns regarding potential ecological and human health risks associated with three bioaccumulative chemicals (i.e., mercury, PCBs, and tributyltin) in sediments at the site, which were not addressed by comparison to state standards. As shown in the inset "Sediment Management Standards", the state standards are based on protection of benthic communities (not other aquatic species). Summary data for direct toxicity for these three bioaccumulative chemicals are provided below:

Mercury

- Sediment cleanup is not warranted based on the state SMS ecological standard.
- Although 11 of 33 (RI; 0-2 cm samples) and 14 of 23 (supplementary RI; 0-10 cm samples) stations exceeded the state's CSL chemical criterion of 0.59 ppm

mercury, none of the co-located biological stations failed the state's over-riding CSL biological criteria.

- Mercury sediment concentrations ranged from undetected to 1.42 ppm (RI; 0-2 cm samples) and undetected to 2.23 ppm (supplementary RI; 0-10 cm samples).

Total PCBs[5]

- Sediment cleanup is not warranted based on the state SMS ecological standard.

- Only 1 of 58 stations exceeded the state's CSL chemical criterion (65 ppm-oc[6] total PCBs) (see Table 9 and Figure 10), and none of the co-located biological stations failed the state's CSL biological criteria (see EPA Technical Memorandum December 1999 (revised May 7, 2002) for a complete summary of PCB information).

- Approximately 56% of the stations have total PCB values that are greater than the state's SQS chemical criterion and less that the CSL chemical criterion.

- Per state SMS, total PCBs ranged from undetected to 43.9 ppm-oc, with a single outlier[7] value of 81 ppm-oc (Station WW-25). It is noted that a station located less than 200 ft northeast of Station WW-25 reported a value of 12 ppm-oc total PCBs, which is equivalent to the state SQS for total PCBs.

- Total PCB dry weight values range from undetected to 0.6 ppm dw, with a single outlier value of 1.46 ppm dw.

- Using all data, the median concentrations for total PCBs are 0.092 ppm dw for the RI (0-2 cm samples) and 0.29 ppm dw for the supplementary RI (0-10 cm).

- Using *all* of the combined data from the RI and SRI (including the single outlier value at Station WW-25), the area-weighted average for total PCBs in the West Waterway OU is 0.206 ppm dw total PCBs and 14 ppm-oc total PCBs, based on

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5. Total PCB sediment concentrations are calculated using a sum of individual Aroclors. The state SMS and the PSDDA program determine total PCBs by summing only the detected Aroclor concentrations (i.e., undetected individual Aroclors were assumed to be zero). Other approaches recommend summing detected Aroclors using one-half the detection limit for undetected individual Aroclors. Both approaches are presented herein.

6. For total PCBs, the state SMS criteria are given in units that are carbon-normalized (i.e., "ppm-oc"), while other regulatory programs may use dry weight units (i.e., ppm dw). Thus, both unit measurements are provided herein for total PCBs.

7. The value at Station WW-25 is a statistical outlier, as determined by comparison to the mean + 2 Standard Deviations.

inverse distance weighting performed in the Fully Integrated Environmental Location Decision Support (FIELDS) system.

- It is noted that the stations sampled during the supplementary RI (EVS, 1995) were not selected using either a random or systematic process: "Stations were selected at historical locations where hazardous substances were found at elevated concentrations relative to the Cleanup Screening Level". At this site, the result of this sampling approach is that spatially weighted total PCB concentrations are likely to be biased high.

TBT

- No state or federal sediment criteria exist for TBT.

- Tributyltin sediment concentrations ranged from 253 ppb dw to 1,988 ppb dw (supplementary RI maximum; 0-10 cm samples) and to 15,255 ppb dw (RI maximum; 0-2 cm).

Tributyltin Study –

Based on data initially collected during the RI and the supplementary RI, it was known that there were high concentrations of tributyltin (TBT) in sediments in the West Waterway as compared to concentrations in other parts of the Lower Duwamish Waterway system. Currently, there are no federal or state sediment quality guidelines or standards for evaluating TBT concentrations in sediment. TBT is of concern because TBT can affect the growth, reproduction, and survival of marine organisms, particularly snails and clams. Site-specific TBT studies were focused on ecological effects because it was believed that the potential need for remediating TBT-contaminated sediments would be driven by potential adverse ecological effects due to TBT (rather than human health risks due to eating TBT-contaminated seafood).

In 1996, an interagency work group was formed to identify and evaluate various approaches to derive a sediment effects-based cleanup level for TBT for use in Puget Sound (EPA 1996). Work group members included representatives from the Muckleshoot and Suquamish Tribes, NOAA, National Marine Fisheries Service (NMFS), U.S. Fish and Wildlife Service, Army Corps of Engineers, Washington Departments of Ecology and Natural Resources, EPA (Superfund and Aquatic Resource Unit) and the PRPs involved in the sediment study for the West Waterway. The work group evaluated available sediment and tissue data sets and concluded that bulk sediment concentrations appeared to be poor predictors of the bioavailable TBT fraction (EPA 1996). Few studies showed good correlations between laboratory bioassay or *in situ* benthic community responses and TBT concentrations in sediments. The group recommended that when TBT is a contaminant of concern in sediment, interstitial water and bulk sediment concentrations should be measured and that *in situ* or laboratory bioaccumulation testing should be conducted to confirm the ecological significance of measured interstitial water and bulk sediment concentrations.

In 1998, the work group completed a review of literature to identify paired tissue residue and effects data for marine invertebrates and fish (ESI 1999a). Effects considered relevant for the development of a site-specific tissue trigger level included mortality, reduced growth, and reproductive impairment. The tissue residue data from the literature were used to develop site-specific, effects-based trigger concentrations (ESI 1999a), which were reviewed by the work group. EPA proposed a weight-of-evidence approach for development of a tissue trigger level for TBT. A number of scientifically sound methods are available for deriving sediment criteria and guidelines, but each method has its own advantages and limitations (EPA 1992).

Given the uncertainties in any one method, a tissue trigger level derived from a weight-of-evidence considers all available information. Different methods evaluated in the weight-of-evidence approach were based on sublethal tissue residue effects data for TBT reported in the scientific literature (see Table 2-2 of ESI 1999a), and included:

1. Identification of the lowest observed adverse effect level and the highest observed no-effects level reported in scientific literature for marine invertebrates

2. Calculation of selected percentiles for sublethal effects data for marine invertebrates

3. Estimation of the geometric mean of paired no-effect/low effect tissue data for marine invertebrates

4. Derivation of critical body residues

5. Estimation of a sublethal tissue residue threshold based on application of an acute-to-chronic ratio (based on water-only effects data) to tissue residue effects data for mortality.

EPA approved a final site-specific, effects-based tissue trigger level of 3 ppm dw TBT, which could be used in comparison with site-specific laboratory bioaccumulation test results to determine the need for cleanup of TBT-contaminated sediments in the West Waterway OU (EPA 1999).

In 1999, a TBT field and laboratory study was initiated to evaluate ecological impacts associated with exposure to TBT in site sediments (EVS 1999). The overall purpose of the TBT field study was to collect data for comparison to the site-specific tissue trigger concentration of 3 ppm dw TBT that could be used to determine the need for remediation of TBT-contaminated sediments in the West Waterway (generally inclusive of the West Waterway OU and the Todd and Lockheed Shipyard Sediment OUs). Sediment toxicity bioassay tests were not conducted for this study because there are no approved toxicity bioassay protocols for test species that have demonstrated a sensitivity to TBT.

The selection of stations for which sediment samples would be collected and then submitted for *in situ* bioaccumulation testing was based on providing a representative range of TBT bulk sediment concentrations as well as a geographic distribution throughout the West

Waterway (including areas that are currently located defined as the West Waterway OU and the Todd and Lockheed Shipyard Sediment OUs). Surface sediments (top 10 cm) were collected from 25 stations in the West Waterway OU, 3 stations in the West Waterway that are within the Lockheed Shipyard Sediment OU, 3 stations in the West Waterway that are within the Todd Shipyard Sediment OU, and 3 stations that are not in the West Waterway (they are near Elliott Bay) but are within the Todd Shipyard Sediment OU (Figure 11). For purposes of this discussion, the 30 sediment stations[8] located within the general West Waterway area are presented below.

The 30 sediment samples from the general West Waterway area were analyzed for bulk sediment TBT, filtered and unfiltered porewater TBT, total organic carbon, and grain size (Figure 11; see data in Table 3-1 of TBT Study). Unfiltered TBT porewater samples from twenty-four of the thirty stations in the West Waterway and Lockheed Shipyard Sediment OUs exceeded the porewater trigger value of 0.15 μg/L TBT, which had been previously established by regulatory agencies as the point above which laboratory bioaccumulation tests should be performed to assess potential ecological risk to benthic organisms (as discussed in Section 7). Sediment samples from twenty of the thirty stations (Figure 12) were used for bioaccumulation testing in a laboratory using a clam, *Macoma nasuta,* and a worm, *Nephtys caecoides,* exposed to sediments for 45 days under flow-through conditions with periodic additions of site sediments. The resulting measured concentrations of TBT in the tissues of both test organisms were all below a site-specific TBT tissue trigger value of 3.0 ppm dry weight (dw) TBT, which was developed as a part of this study to determine whether sediment remediation was warranted (Table 3-4 from the TBT Study). The site-specific TBT trigger value was approved for use by all representatives of the interagency work group prior to the receipt of the tissue data from the West Waterway study.

As a result of these studies, bioaccumulation of TBT from sediments was not identified as a concern in the areas tested within the overall West Waterway area, including the West Waterway OU.

Assessment of Bioaccumulation Potential for TBT, Mercury, and PCBs –

In concert with the previously-described TBT field study, a literature review of scientific bioaccumulation studies was performed for TBT, mercury, and PCBs. Results from the literature review of tissue residue-effects data were used to develop a tissue residue effects level for TBT (as referenced above), and to determine whether tissue concentrations of PCBs or mercury determined to be protective of human health from seafood consumption would also likely be protective of aquatic receptors (i.e., aquatic invertebrate and fish species). Results of this evaluation found that aquatic receptors would be protected at levels that were higher than tissue chemical concentrations associated with human health endpoints (i.e., the potential need

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8. At the time the final TBT report was prepared, data for Station TBT-34, as well as the other three stations located near Todd Shipyard and Elliott Bay, was not considered part of the West Waterway study because the station was added at the request of Todd for comparative purposes only (see page 2 of the EVS 1999 TBT Study).

for remediating sediments with PCBs or mercury was estimated to be driven by potential human health risks and not by potential ecological risks).

Subsurface Sediment Investigations –

The West Waterway is currently deeper than necessary for navigation purposes and future dredging projects, which may potentially expose subsurface sediments, are not planned.

Limited subsurface sampling data are available for the West Waterway OU, as the majority of subsurface sampling has been focused within the Lockheed and Todd Shipyard Sediment OUs, for which sources and evidence of subsurface contamination existed. With the exception of the two shipyards, potential upland sources (e.g., major combined sewer outfalls or major industrial NPDES-permitted outfalls) that might contribute to deep sediment contamination in the West Waterway have not been identified. Further, the available subsurface data for the West Waterway OU do not indicate that further evaluation of subsurface chemical concentrations is necessary.

For the West Waterway OU, subsurface data are described in the 1995 RI for 3 low-resolution cores, advanced to a maximum depth of 10 feet, and two high resolution cores, advanced to a maximum depth of 20 cm. In the 1996 supplementary RI, subsurface data exist for 30 composite sediment core samples from 10 low-resolution cores in the East and West Waterways.

Resuspension –

The potential for resuspension of bottom sediments into the overlying water column, and their subsequent re-deposition in other areas, is difficult to model, particularly in areas with anthropogenic impacts (e.g., ship scour). A study on sediment transport in the Elliott Bay and Duwamish Waterway system showed slight net accretion (addition of sediments) in West Waterway, which would suggest existing sediments may be buried by newly deposited sediments. Another study also concluded that the West Waterway is not erosional, and that sediment deposition is adequate to consider natural recovery as a viable option (Supplementary Remedial Investigation 1996). However, a third study evaluated bathymetric surveys and concluded that in the long-term, there is either stability or net erosion in West Waterway (Feasibility Study 1995). In summary, and in consideration of site-specific considerations for the West Waterway (e.g., lack of chemical "hot spots"), there is no information to suggest that off-site movement of sediments from the West Waterway to other portions of the Elliott Bay and Duwamish Waterway system is a significant issue that should be addressed.

Surface Sediment and Seafood Tissue Data used in the Human Health Risk Assessment –

As discussed previously, numerous environmental investigations have been completed to identify potential adverse human health risks associated with marine sediments in the West Waterway OU (see Figure 6, Table 1, and the general overview provided in Section 2). This section summarizes the environmental data that were used to examine three potential pathways of exposure by humans to contaminated sediments: 1) dermal contact with sediment; 2) incidental ingestion of sediment; and, 3) consumption of fish and shellfish that may contain chemicals bioaccumulated from sediments.

Subtidal surface (0-2 cm) sediment data from the RI were used to evaluate the pathways for dermal contact and incidental ingestion of sediment for four study areas around Harbor Island: Kellogg Island, West Waterway, East Waterway, and North Harbor Island. Based on a screening process (RI 1994), six chemicals were retained for the sediment ingestion pathway and three chemicals were retained for the sediment dermal exposure (see below). For each study area, exposure point concentrations (EPCs) were calculated based on the upper 95 percent confidence limit of the arithmetic mean (95 percent UCL) for each chemical:

Chemical	Maximum EPC from Four Study Areas	Study Area with Maximum EPC	EPC for West Waterway Study Area
BEHP	4.4 ppm	West Waterway	4.4 ppm
PAHs*	1 - 2.5 ppm	North Harbor Island	2 ppm
Heptachlor	0.0038 ppm	East Waterway	0.0022 ppm
PCBs	0.16 - 0.52 ppm	East Waterway	0.039 - 0.079 ppm
Arsenic*	23 ppm	North Harbor Island	20 ppm
Beryllium*	0.31 ppm	Kellogg Island	0.16 ppm

The EPC is the value that represents a protective estimate of the chemical concentration available from a particular medium or route of exposure. The EPC is used in conjunction with other exposure factors to estimate quantitative risks associated with site chemicals.

For the seafood consumption risk assessment, potential chemicals of concern included mercury, TBT, and PCBs. Existing seafood tissue data were tabulated for mercury, TBT, PCBs, and lipid content in target fish and shellfish species (i.e., English sole, perch, and crab), as summarized in Table 3. These individual target species were selected to represent three species groups or categories of seafood consumed by humans: benthic group - English sole; pelagic group - perch; shellfish group - crab. Previously unpublished English sole (*Parophrys vetulus*) tissue data collected by EVS Environment Consultants, Inc. for the Port of Seattle in 1996 were also used in this study. To supplement existing data, striped perch (*Embiotoca lateralis*) and Dungeness crab (*Cancer magister*) tissue were collected in 1998. Consumption of anadromous fish (i.e., salmon) was excluded from the baseline risk assessment because bioaccumulation of contaminants in salmon is primarily attributable to dietary sources outside the West Waterway OU. The Exposure Point Concentrations used in the baseline risk assessment for the West Waterway OU are provided below. The EPC was selected as the lower of the 95% UCL and the maximum.

	Number of Data Points	Mean (ppb wet weight)	Standard Deviation (ppb ww)	95% UCL (ppb ww)	Maximum Detected Concentration (ppb ww)	EPC (ppb ww)
Total PCBs						
Perch w/skin	3	136	58	233	184	184
Perch w/o skin	3	94	28	141	121	121
English sole	3	336	110	842	462	462
Red rock crab	3	51	15	75	63	63
Total mercury						
Perch w/skin	3	NC	NC	NC	30	30
Perch w/o skin	3	NC	NC	NC	20	20
English sole	3	23	5.3	39	29	29
Red rock crab	3	30	20	127	50	50
TBT (ion)						
Perch w/skin	3	9.3	2.1	13	11	11
Perch w/o skin	3	16	5.5	26	20	20
English sole	3	1.4	0.9	3.2	2.1	2.1
Red rock crab	3	NC	NC	NC	1.0	1.0

Note: All fish samples were composites of skinless filets unless otherwise noted; all shellfish samples were edible muscle meat; all samples uncooked. Means, maxima, and standard deviations calculated assuming one-half detection limit for non-detect values.
NC = Not calculated; fewer than two detected concentrations in this group.

6. Current and Potential Future Site and Resource Uses

The current and future uses associated with the West Waterway OU consist of utilizing the waterway for navigational purposes, as well as recreational boating use. Current upland commercial/industrial/port use near the waterway, such as the Port of Seattle's Terminal 5, are expected to continue. In addition, the waterway is located within the Usual and Accustomed Fishing Area for the Muckleshoot Tribe. The waterway also serves as habitat for marine and estuarine organisms.

7. Site Risks

As part of the RI/FS and supplementary investigations, EPA conducted risk assessments to evaluate the current and future effects of contaminants on the environment and human health (see Figure 6). This section summarizes the evaluation of site risks to ecological receptors and humans. The ecological risk assessment consisted of an assessment of sediment toxicity and a bioaccumulative assessment to estimate risks of chemicals in sediments to representative marine organisms. The human health assessment of West Waterway OU sediments was conducted to identify potential risks to humans posed by chemicals detected in sediments or seafood from the OU.

Ecological Risks –

The ecological evaluation consisted of an *assessment of sediment toxicity* throughout the waterway and an *assessment of bioaccumulation potential* for PCBs, TBT, and mercury. The *assessment of sediment toxicity* focused on the direct impact of contaminants on bottom-dwelling organisms (e.g., worms, clams), know as the "benthic community." The *assessment of bioaccumulation potential* focused on the potential for adverse impacts to organisms due to accumulation of certain chemicals from sediments to tissues of organisms. Further details are provided below.

Sediment Toxicity Assessment –

The primary objective of the sediment toxicity assessment was to identify any potential areas that may pose a risk to organisms that live within the surface sediments of the waterway. The sediment toxicity assessment was based primarily on the evaluation of the following types of information collected about individual stations: 1) results of comparisons between concentrations of individual chemicals in surface sediments and the corresponding Washington State sediment chemical Cleanup Screening Level (CSL) criteria; and, 2) results of surface sediment toxicity tests performed in a laboratory by exposing three different marine animal species to sediment from the bottom of West Waterway, and comparison of those results to appropriate Washington State biological CSL criteria (see previous inset "State of Washington Sediment Management Standards").

Data comparisons between West Waterway OU sediments and state SMS were provided in the previous section. Results showed that even though some individual stations had chemical concentration(s) that exceeded the state's CSL chemical criteria, the state CSL biological criteria was not exceeded at any station, which indicates that under the SMS decision-making provisions, no remediation is required with respect to chemicals for which there are SMS numeric standards. However, the long-term effects of TBT, mercury, and PCB bioaccumulation were not addressed using the SMS toxicity tests and further assessment was required by EPA to identify any potential adverse effects.

Assessment of Bioaccumulation Potential–

Although chemicals in sediments were not found to pose a risk to benthic communities, it was recognized that the long-term effects of PCBs, tributyltin, and mercury bioaccumulation were not addressed using the state's SMS (which is set to be protective of benthic organisms). Because of those concerns, EPA required an additional sediment and tissue investigation that included: 1) a tributyltin field and laboratory study, and 2) a literature review of tissue residue effects data for PCBs, tributyltin, and mercury in marine organisms (see Figure 6).

In the laboratory study, all worm and clam tissue TBT concentrations were below the site-specific TBT tissue trigger value of 3.0 ppm dry weight TBT. Therefore, although TBT was found at elevated concentrations in the sediments, it was not bioaccumulating to levels of concern in the test animals. Based on this assessment, TBT in sediments in the West Waterway OU was not found to cause adverse effects on marine animals and cleanup of sediments containing TBT is not necessary to protect the environment. This situation is different for the Todd Shipyard Sediment OU where TBT and other chemical concentrations are much higher, and the remedial designs and remedial actions for that OU are being implemented pursuant to the Shipyard Sediment ROD and subsequent ESDs for the Todd Shipyard Sediment OU.

The literature review of tissue residue effects data for PCBs and mercury in aquatic organisms (specifically all marine and freshwater fish and invertebrate species for which data were available) was completed to determine whether tissue concentrations of PCBs and mercury in fish and shellfish determined to be protective of human health (via the seafood consumption pathway) would also likely be protective of aquatic receptors. The effects endpoints considered were mortality, growth, and reproductive effects. Results of this evaluation found that, based on existing science, lower tissue concentrations of PCBs and mercury in aquatic species are needed to protect human health (via the seafood ingestion pathway) than are needed to protect the health of those aquatic species (i.e., the decision on whether to remediate sediments with PCBs or mercury would be determined based on results of the human health risk assessment, and not the ecological risk assessment).

Other Evaluations–

An additional sediment study (Geraghty & Miller 1996) was performed within the West Waterway OU in an area adjacent to the ARCO facility pursuant to Washington State's Model Toxics Control Act (see Table 1; facility location shown in Figure 3). Results confirmed that chemical concentrations were low in this area compared to state SMS, and sediment cleanup was not warranted.

Uncertainties–

Risks to ecological receptors may be over- or underestimated based on the accuracy of the laboratory bioassays and bioaccumulation tests in predicting impacts to *in situ* receptors, the assumptions regarding the bioavailability and effects of contaminants (particularly with respect to TBT), and the sediment chemistry sampling and analysis.

Conclusion –

Chemicals in sediments within the West Waterway OU do not pose a risk to the benthic community that live in the sediments. Further, the bioaccumulative chemicals (PCBs, TBT, and mercury) in sediments that are protective of human health risk (as evaluated below) would also be protective of aquatic invertebrates and fish. Thus, based on the ecological and human health risk assessments, sediments in the West Waterway OU do not require remediation to address ecological concerns.

Human Health Risks –

At the West Waterway OU, the human health risk assessment examined three potential pathways of exposure by humans to contaminated sediments. These included: 1) dermal contact with sediment; 2) incidental ingestion of sediment; and, 3) consumption of fish and shellfish that may contain chemicals bioaccumulated from sediments. EPA's method for estimating exposure to chemicals in seafood depends upon the chemical concentration in the seafood tissue (which was actually measured in seafood tissue for this site), the amount and types of seafood eaten, how long and how often seafood is eaten, and the body weight of the person eating the seafood.

The initial RI only evaluated potential human health risks to tribal fishers that may be exposed to contaminated marine sediments while net fishing within the general area of the Harbor Island Superfund site. The RI concluded that estimating potential risks to humans ingesting seafood from the general area of the Harbor Island Superfund site was not feasible due to the high mobility of fish and the contamination that existed in off-site areas. Subsequently, the Muckleshoot Tribe met with EPA to discuss potential concerns associated with the bioaccumulative compounds PCBs, mercury, and TBT. Based on a recommendation from that meeting, a human health risk assessment was completed in 1999 for those three substances, focusing on chemicals that may potentially bioaccumulate from site sediments to fish and shellfish consumed by people.

Risk Characterization –

Human health risk assessment results are presented in the form of *excess cancer risk* for carcinogens, and potential adverse *non-cancer health effects* for non-carcinogens. *Excess cancer risk* is defined as the risk of cancer over a lifetime that is in excess of the risk from all other sources besides the study area. EPA's acceptable risk range is 1 in 10,000 to 1 in 1,000,000 (i.e., 10^{-4} to 10^{-6} or 1E-4 to 1E-6), as designated in the National Contingency Plan. This acceptable risk range means that an individual could face a 1 in ten thousand to a 1 in a million additional risk of developing cancer (over a lifetime) related to site-specific exposure conditions evaluated. EPA's Superfund Program evaluates "excess lifetime cancer risk" because it would be in addition to the risks of cancer individuals face from other causes such as smoking. [Note: The chance of an individual's developing cancer from all other causes has been estimated to be as high as one in three]. For sites where the cumulative excess lifetime cancer risk to an individual based on RME for both current and future use is less than 10^{-4}, action generally is not warranted under CERCLA.

The potential for *non-cancer health effects* is evaluated by comparing an exposure level over a specified time period (e.g., a lifetime) with a reference does derived for a similar exposure period. A reference dose represents a level that an individual may be exposed to that is not expected to cause any deleterious effect. The ratio of exposure to toxicity is called a hazard quotient (HQ). If an HQ is less than 1, non-cancer health effects are not expected from contaminant exposures to that chemical at a site. It should be noted that HQ values above 1 do not mean that non-cancer health impacts will occur, but rather than the potential for such impacts increases as 1 is exceeded. The potential for impacts depends on a number of factors, including the protectiveness of both the reference dose and the exposure assumptions used to calculate the HQ.

Incidental Ingestion of Sediment and Dermal Contact with Sediment for Tribal Net Fishers –

To estimate potential risk due to contact (ingestion and dermal exposure under a Reasonable Maximum Exposure scenario) with subtidal sediment by tribal net fishers, the general area of the site was divided in the RI into four study areas: Kellogg Island, East Waterway, West Waterway, and North Harbor Island. Results from one of those four study areas (i.e., West Waterway) is presented in this ROD, as well as comparison information from the other study areas. The chemicals of potential concern and EPCs are provided in Section 5 of this ROD. The exposure factors that were used for the sediment ingestion and sediment dermal contact intakes are shown in Tables 4 and 5, respectively, excerpted from the RI.

For the dermal exposure pathway, the 1994 RI stated that, because of the considerable uncertainty associated with this pathway, dermal contact is only considered in the sensitivity analysis portion of the risk assessment. Further, the RI stated that PAHs were not assessed because the carcinogenic effects of these contaminants could not be quantified using oral slope factors, and dermal risks from inorganics were not assessed because of their negligible percutaneous absorption. BEHP was the only maximum EPC that occurred in West Waterway – all other maximum EPC occurred in other areas of Harbor Island.

For the four study areas, results indicate potential excess cancer risk from exposure to sediments ranged from 10^{-5} to 10^{-6}. For the West Waterway area, the total estimated potential excess cancer risk is 10^{-5}. Further, all total hazard indices are below 1.0. Results are shown in Tables 6 and 7, excerpted from the RI.

In 1999, at the request of the Muckleshoot Tribe, EPA completed a re-evaluation of the RI human health risk assessment with respect to tribal net fishers that may be exposed to contaminated marine sediments while net fishing within the general area of the site. This revised assessment also included inorganics in the calculation of dermal risks. Based on results of this re-evaluation, potential excess cancer risk results slightly decreased based on the revised toxicity values for PCBs, certain PAHs, and arsenic and based on the revised dermal absorption factors. Excess cancer risk estimates decreased from 1.2 x 10^{-5} to 1.0 x 10^{-5}; however, given the uncertainties inherent in the risk assessment process, emphasis is placed on the order of magnitude (e.g., 10^{-5}) estimated.

Sediment Contact, Conclusion –

For the West Waterway OU, results indicate potential excess cancer risk from exposure to sediments is 10^{-5}, which falls within the range of acceptable risk listed in the National Contingency Plan. Further, all total hazard indices are below 1.0, indicating that non-cancer health effects are not expected from contaminant exposure to sediments at the site.

Seafood Consumption –

The 1999 human health risk assessment consists of a site-specific baseline risk assessment for current and future use scenarios for the West Waterway OU, as well as additional information on risk characterization of contiguous waterbodies (i.e., East Waterway, Elliott Bay, Lower Duwamish River, Upper Duwamish River). Cancer and non-cancer risks were estimated. The two primary objectives of this human health risk assessment for the West Waterway OU were to provide upper bound (high end) and central tendency (average) baseline risk estimates to support potential sediment risk management decisions.

Two exposure scenarios were developed: 1) the reasonable maximum exposure (RME) scenario was intended to represent tribal fishers, who are considered to be a population with high exposure, and 2) the central tendency (CT) scenario was intended to represent non-tribal recreational fishers. Tribal fishers were selected for the RME scenario because they tend to consume greater amounts of fish and shellfish than do non-tribal fishers. For both scenarios, it was assumed that an individual obtained all of their Puget Sound caught seafood diet from the West Waterway OU for the entire exposure duration (i.e, 30 years for the initial RME scenario); thus, it was assumed that all seafood consumed, except for seafood consumed from grocery stores, restaurants, or outside of Puget Sound, was caught <u>only</u> from the West Waterway OU and not from any other Puget Sound area, and that all seafood consumed had the equivalent of the **maximum** concentration measured in tissue from the West Waterway OU. The maximum concentration was used because the calculated 95% UCL of the mean was greater than the maximum measured concentration. The exposure scenario represents current use of the site, and given the protective assumptions made in the exposure assessment (see below), the estimated future use of the site would be expected to be very similar to the current use of the site. Also, the study area is heavily industrialized and its use is not expected to change. Therefore, no separate exposure scenario was evaluated for future use of the site.

Subsequent addenda to the risk assessment were also prepared in 1999 and 2000 using alternative RME scenarios developed using the Asian Pacific Island seafood consumption study, the Suquamish Tribal seafood consumption study, and the results of the Phase 1 scoping RI for the Lower Duwamish Waterway site.

For the human health risk assessment, fish and shellfish species that may be present in the West Waterway were categorized as either anadromous fish (migrating up rivers from the sea to breed in fresh water – such as salmon), pelagic fish (living in the open water – such as perch), benthic fish (living on or near the bottom – such as English sole), or shellfish (e.g., crab). Specific species were selected for collection and analysis after reviewing consumption studies conducted in the study area and in Puget Sound to determine what species were most likely to be consumed. Perch, English sole, and crab were used as surrogates to represent pelagic, benthic, and shellfish categories, respectively. For the baseline risk assessment, consumption of anadromous fish, i.e., salmon, was excluded because bioaccumulation of contaminants in salmon is primarily attributable to dietary sources outside the Superfund site.

Human health risk assessment results were presented in the form of *excess cancer risk* for PCBs, and potential adverse *non-cancer health effects* for PCBs, mercury, and TBT. *Excess cancer risk* is defined as the risk of cancer over a lifetime that is in excess of the risk from all other sources besides fish and shellfish ingested from the study area. EPA's acceptable risk range is 1 in 10,000 to 1 in 1,000,000 (i.e., 10^{-4} to 10^{-6} or 1E-4 to 1E-6), as designated in the National Contingency Plan. For sites where the cumulative excess lifetime cancer risk to an individual based on RME for both current and future use is less than 10^{-4}, action generally is not warranted under CERCLA.

The potential for *non-cancer health effects* is evaluated using a hazard quotient (HQ). If an HQ is less than 1, non-cancer effects are not expected from contaminant exposures to that chemical at a site.

The values used for daily intake calculations are shown in Table 8. The EPCs for the RME value were provided in Section 5. Based on Toy et al. 1996, the seafood ingestion rates used for the baseline risk assessment for the West Waterway OU were 7 g/day pelagic fish, plus 8.5 g/day benthic fish, plus 61 g/day shellfish, for a total of 76.5 g/day seafood.

For the initial baseline risk assessment RME scenario, excess cancer risk for PCBs was 1 in 10,000 (10^{-4}) for the West Waterway OU. The non-cancer risk (HQ) for PCBs was 6.5. HQ estimates for mercury and TBT were below 1. HQs for individual chemicals with similar toxicological endpoints may be summed to yield a hazard index (HI). The HQs for PCBs and TBT were summed because the reference doses are both based on immunological endpoints. The non-cancer risk (HI) for summed PCB and TBT HQs was 6.5, which was the same value as for the HQ for PCBs.

As part of the initial baseline risk assessment, an evaluation was also performed for an RME scenario for Asian and Pacific Islanders (API; see Appendix D of the HHRA). To simplify the comparison between risk estimates for the tribal RME scenario and the API RME scenario, identical values for all exposure parameters (including EPCs) except consumption rate were selected. Consumption rates were taken from the seafood consumption study for API (EPA

1999), using species categories identical to the tribal RME scenario (i.e., shellfish, pelagic, and benthic). The consumption rates used for this analysis were 90th percentiles for each species group weighted across the 10 ethnic groups included in the study. These values were multiplied by the percentage of the total seafood harvested in King County, Washington (see Table D-1 in the 1999 HHRA). Excess cancer risk estimates for the West Waterway OU in the API RME scenario were 2 x 10-5, and total HQs were 1.3 for PCBs, and much less than 1 for mercury and TBT.

In 2000, another seafood consumption study was completed in the Puget Sound area ("Fish consumption survey of the Suquamish Indian Tribe of the Port Madison Indian Reservation, Puget Sound Region"). In that report, Suquamish Tribe consumption rates were provided for adults and children eating many types of aquatic biota (see EPA technical memorandum, May 8, 2000, revised). Again, identical values for all exposure parameters used in the baseline risk assessment (including EPCs) except consumption rate were selected to estimate potential excess cancer risks for the West Waterway OU (EVS, May 31, 2000). Consumption rates were 6.6 g/day pelagic fish, 3.3 g/day benthic fish, and 24 g/day shellfish (crab only). Using these consumption rates, the estimated excess cancer risk is 5 x 10-5.

Uncertainties –

The purpose of a risk assessment is not to predict the actual risk of exposure to an individual. Rather, risk assessments are a management tool for developing conservative estimates of health hazards in order to be protective for the majority of the population and to compensate for uncertainties inherent in estimating exposure and toxicity. As a result, the numerical estimates in a risk assessment (risk values) have associated uncertainties reflecting the limitations in available knowledge about site chemical concentrations, exposure assumptions (e.g., pathways, frequency, and duration), chemical toxicity assessment, and risk characterization. Risks to human health may be over- or underestimated based on the appropriateness of this information.

For the seafood consumption pathway, the parameters around which more potential uncertainty exists are the exposure point concentration, the ingestion rate, the fraction ingested by species, and the exposure duration. For the sediment ingestion and dermal contact pathway, the parameters around which more potential uncertainty exists are the exposure point concentrations, the exposure factors assumed for direct contact with sediment via net fishing, and the estimated bioavailability of contaminants through the use of absorption factors. These inherent uncertainties, which may over- or underestimate risks, were accounted for by making assumptions that tended to overestimate risk.

Key uncertainties are fully described in Section 7 of the HHRA and Section 6 of the RI, and a brief summary is provided below:

- Sampling data that may not fully characterize the site
- Inherent variability in analytical results
- Variability of chemicals in fish and shellfish species

- Toxicity values that are extrapolated from animal or laboratory studies
- Fraction of dose obtained from site
- Single species (e.g., perch) served as surrogates for each seafood group (e.g., pelagic fish)
- Differences in studies may affect comparability of data
- Effects of food preparation
- Seafood consumption studies that may not accurately represent ingestion rate
- Lack of information on tribal-specific consumption rates for the Muckleshoot Tribe
- Our limited knowledge of the mechanisms which cause disease.

A further discussion of uncertainties related to the risk management decision are discussed in the next section.

Seafood Consumption, Conclusion –

For the initial baseline risk assessment RME scenario, excess cancer risk for PCBs was 1 in 10,000 (10^{-4}) for the West Waterway OU. This level of risk is within EPA's acceptable risk range of 1 in 10,000 to 1 in 1,000,000 (i.e.,10^{-4} to 10^{-6}), and the most likely risk is less than 1 x 10^{-4} when you consider site-specific conditions and the protective nature of the human health risk assessment, as discussed below.

The non-cancer risk (HQ) for PCBs was 6.5. The NCP does not set a numeric target range for non-cancer risks, but states that acceptable exposure levels shall represent concentrations at which the human population, including sensitive subgroups, may be exposed without adverse effect during a lifetime or part of a lifetime, incorporating an adequate margin of safety. Because of the protective assumptions built into the risk assessment and into the reference dose used to calculate the HQ, EPA believes that sediments in the West Waterway are protective of non-cancer risks.

HQ estimates for mercury and TBT were below 1, so non-cancer effects are not expected from chemical exposures at this site. The non-cancer risk (HI) for summed PCB and TBT HQs was 6.5, which was the same value as for the HQ for PCBs, and is not considered a human health risk given the protective nature of the risk assessment, as discussed below.

EPA's Decision and Factors Related to EPA's Decision –

EPA believes that the sediments in the West Waterway OU do not pose unacceptable risks to human health and sediment cleanup is not warranted. In reaching this determination, EPA considered many site-specific factors that are listed below and followed by a more detailed discussion.

Key Factors Regarding PCB Sediment Concentrations--

PCBs were identified as one of the primary potential chemicals of concern. Information on PCB concentrations in the West Waterway OU were evaluated using numerous approaches (EPA 1999), and some key results are summarized below:

- No PCB "hot spots" were identified within West Waterway OU. One sample was significantly higher than all other samples, but for the reasons discussed in the ROD, it is not considered a "hot spot."

- Only 1 of 58 stations in the West Waterway OU exceeded the state's chemical CSL criterion of 65 ppm-oc total PCBs, and none of the co-located biological stations failed the state's biological CSL criteria.

- The area-weighted average of total PCBs in sediments in the West Waterway OU was 14 ppm-oc. For comparison purposes, the state's sediment chemical "no effects" level is 12 ppm-oc PCBs. Given that the primary exposure pathway of concern has been identified as fish and mobile shellfish at the site that may be ingested, it is not unreasonable to consider area-weighted average concentrations.

- EPA's decision regarding PCBs in sediments at the West Waterway OU is consistent with decisions made regarding PCBs in sediments at the Commencement Bay Nearshore/Tideflats Site, which is also located in Puget Sound, Washington.

Key Factors Regarding Protectiveness of the Human Health Risk Assessment, Seafood Consumption Pathway--

Key factors considered by EPA in making the determination for no action at the West Waterway OU are described below:

- The RME scenario is expected to be protective of individuals from a population whose potential exposure to contaminated fish and shellfish is greatest. For the West Waterway OU, tribal fishers were selected for the RME scenario because it is assumed they consume greater amounts of fish and shellfish than do non-tribal fishers.

- Sediments do not trigger cleanup action under Superfund based on estimated potential risks to both current and future tribal fishers consuming seafood from the West Waterway OU for a lifetime. For the tribal fisher *reasonable maximum exposure (RME)* scenario, potential excess cancer risk for PCBs was 1 in 10,000 (10^{-4}) for the West Waterway OU. This level of risk is within EPA's acceptable risk range of 1 in 10,000 to 1 in 1,000,000 (i.e.,10^{-4} to 10^{-6}), and the most likely risk is less than 1 x 10^{-4} considering site-specific conditions and the protective nature of the human health risk assessment. Alternative consumption exposure factors were evaluated, and EPA concluded that these re-evaluations do not change the original risk assessment conclusions.

- Available tribal consumption studies (i.e., Tulalip/Squaxin study and Suquamish study) considered for the West Waterway OU cover a much larger and more diverse ecosystem and a much broader U&A than is available for the Muckleshoots in the Duwamish/Elliott Bay system and specifically the West Waterway OU. The West Waterway OU is much more industrialized and urban than the harvest areas used by Tulalip/Squaxin and Suquamish Tribes.

- Selection of the tribal fisher RME scenario is *also* considered to be protective of other groups that may consume fish and shellfish from the West Waterway OU. Based on data collected from non-tribal consumption surveys, substantially lower amounts of fish and shellfish are consumed by Asian Pacific Islanders and non-tribal King County fishers (see Table 10).[9]

- It is recognized that uncertainty exists in risk estimates because actual tribal consumption data is not known. For this site, no specific consumption data were available for the Muckleshoot Tribe. Although it is known that the Muckleshoot tribal members consume salmon from the Duwamish/Elliott Bay system, we have no information on any other seafood consumed by the tribe from the LDW or Harbor Island sites. However, we believe that the assumptions used in our risk assessment are more likely to lead to an overestimation of risk, rather than an underestimation of risk (see below).

The human health risk assessment is considered protective for the following reasons:

- The ingestion rate for fish and shellfish used in the risk assessment assumed that **all** pelagic fish, **all** bottom-dwelling fish, and **all** shellfish that were consumed by the Tulalip/Squaxin Tribe from Puget Sound could and would be consumed from the West Waterway OU by tribal fishers, when it is known that all Puget Sound species are **not** naturally present in the West Waterway, and there is no information about which species are actually consumed by the Muckleshoot Tribe in the West Waterway.

- The risk assessment assumes that a tribal fisher consumes all of their Puget Sound caught seafood from the 70 acres of the West Waterway OU for a lifetime. However, the ingestion rate used is based on tribal harvest and consumption of seafood from the *entire* Usual and Accustomed Fishing Area (thousands of acres)

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9. Ingestion rates (excluding anadromous fish) estimated from tribal consumption studies performed outside of the Duwamish/Elliott Bay system range from approximately 30 to 80 g/day, while the King County data estimates that the non-tribal seafood ingestion rate for the Duwamish River is 3 g/day. It is noted that some have stated that the King County survey was not a statistically valid survey.

associated with a tribe. Thus, the amount of seafood consumed by the Muckleshoots in the 70 acres of the West Waterway OU is likely to be much lower than the value used in the risk assessment.

- Ingestion rates used for the tribal fisher in West Waterway OU are likely to overestimate risk because those consumption rates come from tribes that fish from a much larger and more diverse ecosystem and a much broader U&A than is available for the Muckleshoot Tribe in the West Waterway OU. Lower ingestion rates are expected for the West Waterway OU because it consists only of subtidal sediments, it is a navigable waterway, and there is a lack of public access along the shoreline.

- For the RME, the "person" that consumes the 95th percentile (g/day) of shellfish also consumes the 95th percentile of benthic fish and the 95th percentile of pelagic fish. This is probably an overestimate of total seafood consumption.

A more detailed discussion is presented below

- A seafood consumption study from a Puget Sound Native American tribe was used to represent Native American tribal seafood consumption habits for the West Waterway OU. Specifically, an ingestion rate for Puget Sound caught seafood from the Tulalip/Squaxin consumption study was used, representing consumption of all pelagic fish, all bottom-dwelling fish, and **all** shellfish [an ingestion rate for "**all** shellfish" was used in lieu of the fact that species-specific shellfish rates were unavailable from the Tulalip/Squaxin study -- i.e., it was assumed that all shellfish (e.g., clams, crabs, snails, abalone, squid) could and would be consumed from the West Waterway, when it is known that all Puget Sound shellfish species are **not** naturally present in the West Waterway[10]][11].

- The two tribal consumption studies (i.e., Tulalip/Squaxin study and Suquamish study[12]) considered for the West Waterway OU cover a much larger and more diverse ecosystem and a much broader U&A than is available for the Muckleshoots in the Duwamish/Elliott Bay system and specifically the West

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10. See file documentation, including Elliott Bay Action Program (1988), EPA RI/FS (Weston 1994, 1995), SRI (EVS 1996), Human Health Risk Assessment (ESG 1999), video documentation (August 1999), and general knowledge regarding marine invertebrate habitats.

11. It is recognized that uncertainty exists in risk estimates because actual tribal consumption data is not known. For this site, no specific consumption data were available for the Muckleshoot Tribe. Although it is known that the Muckleshoot tribal members consume salmon from the Duwamish/Elliott Bay system, we have no information on any other seafood consumed by the tribe from the LDW or Harbor Island sites. However, we believe that the assumptions used in our risk assessment are more likely to lead to an overestimation of risk, rather than an underestimation of risk.

12. The Tulalip/Squaxin study was used in the original human health risk assessment. When the Suquamish study became available, it was used in an addendum to the original risk assessment.

Waterway OU. The West Waterway OU is much more industrialized and urban than the harvest areas used by Tulalip/Squaxin and Suquamish Tribes. Therefore, it is unlikely that harvesting (and consumption) rates from the West Waterway OU will be as high as for the tribal rates for the larger and more diverse ecosystem.

- It is likely that the characteristics of the West Waterway (e.g., a navigable waterway utilized extensively by marine traffic) and the lack of public access along the shoreline (e.g., there are no public access ramps and no fishing piers along the shoreline -- access is restricted to boaters) would cause the ingestion rates to be lower in the West Waterway OU than those provided in the available tribal consumption studies. Thus, using ingestion rates from existing tribal consumption studies in the risk assessment overestimates total seafood consumption.

- It is noted that ingestion rates (excluding anadromous fish) estimated from **tribal** consumption studies performed outside of the Duwamish/Elliott Bay system range from approximately 30 to 80 g/day, while the King County data estimates that the **non-tribal** seafood ingestion rate for the Duwamish River is 3 g/day (it is noted that some believe that the King County survey is not a statistically valid survey and that King County methodologies for generating grams of fish consumed per day are not consistent with EPA's methodology). Thus, the RME is representative of a sensitive population with high exposure, but not necessarily of the Muckleshoot Tribe, as data are not available for that tribe.

- For the RME scenario, it was assumed that an individual fisher obtained all the Puget Sound caught seafood in their diet from the West Waterway OU for 30 years (i.e., it was assumed that all seafood consumed, except for seafood from restaurants and grocery stores and areas outside of Puget Sound, was caught <u>only</u> from the West Waterway OU and not from any other area, and that all seafood consumed had the equivalent of the maximum concentration measured in tissue). Given the small size of the West Waterway OU (particularly in comparison to the available harvest area), the absence of intertidal habitat within the West Waterway OU (see video documentation dated August 10, 1999), and the availability of more suitable habitat for resident fish and shellfish outside the West Waterway, the amount of seafood affected by contaminated sediments in the West Waterway OU and caught and consumed from the West Waterway OU is likely to be much lower than the value used in the risk assessment calculations.

- The risk assessment included the assumption that all types of shellfish live in and are available from the West Waterway OU. EPA believes that this assumption is extremely unlikely given that there is no intertidal habitat within the West Waterway OU, which restricts the occurrence and abundance of many types of shellfish (e.g., harvestable snails, oysters, clams). Further, the "shellfish" ingestion rate used in the risk assessment was based on consumption of numerous different types of shellfish, including clams, snails, scallops, squid, sea urchins, mussels, oysters, shrimp, crab and sea cucumbers. Because many of these shellfish are not present in and/or are not harvested from the West Waterway OU, the shellfish ingestion rate used in the assessment would overestimate actual shellfish consumption in West Waterway.

- The risk assessment included the assumption that all non-salmon seafood consumed from the West Waterway OU contained chemical concentrations that were equal to the *maximum* chemical concentration in tissue that was measured for the species tested. It also assumes that the "person" that consumes the 95th percentile (g/day) of shellfish also consumes the 95th percentile of benthic fish and the 95th percentile of pelagic fish. This is probably an overestimate of total seafood consumption.

- Consumption of salmon was excluded because bioaccumulation of contaminants in salmon is primarily attributable to dietary sources that salmon have outside the Superfund Site.

In Table 10, the initial risk calculation for the West Waterway OU is presented in the first row in Table 10. Alternative scenarios are also presented for comparison purposes in Table 10. These risk estimates are based on the application of various tribes' seafood ingestion patterns to reflect site-specific consumption for the Muckleshoot Tribe (for which no data are available).

Human Health Risk Assessment, Conclusion–

A human health risk assessment was conducted to identify potential current and future risks posed by chemicals (PCBs, TBT, mercury) detected in sediments or seafood (e.g., fish, shellfish) from the West Waterway OU. For sediment contact (ingestion and dermal), potential excess cancer risk was estimated at 10^{-5}. For seafood consumption, potential excess cancer risk was estimated at 10^{-4}. Based on these assessments, the cumulative site cancer risk (based on multiple chemicals) to an individual based on reasonable maximum exposure for both current and future use is 10^{-4}, and the most likely risk is less than 10^{-4} considering site-specific conditions and the protective nature of the risk assessment that was performed.

For potential non-cancer health effects due to sediment contact, HQ estimates were below 1 for multiple chemicals. For the seafood consumption pathway, HQ estimates for mercury and TBT were also below 1. These estimates indicate that non-cancer health effects are not expected from these pathways at the site. For seafood consumption, the HQ for PCBs was 6.5; however, considering site-specific conditions and the protective nature of the human health risk assessment, adverse health effects are not expected.

EPA believes that the sediments in the West Waterway OU do not pose unacceptable risks to human health and sediment cleanup is not warranted.

Overall Summary of Ecological and Human Health Risk Assessment Results –

For the sediments in the West Waterway OU, the baseline risk assessments conclude that under current and reasonably anticipated future uses of the waterway, site conditions pose no unacceptable risks to human health or the environment. EPA believes that a no action decision is appropriate because environmental investigations and site-specific risk assessments found that concentrations of chemicals (including PCBs, tributyltin, and mercury) in marine sediments within the West Waterway Operable Unit do not pose unacceptable risks to human health and the environment. Further, environmental investigations did not identify any "hot spots" of contaminated sediments that warranted cleanup. Finally, EPA believes that the majority of the contamination associated with the sediments along the western side of Harbor Island, including contamination that could have contributed to sediment problems in the West Waterway Operable Unit, is being addressed as part of the Lockheed and Todd Shipyard Sediment cleanups along the western portion of the West Waterway, upland soil and groundwater cleanups, and upland source cleanups implemented to reduce contaminant inputs into the marine environment. Future work remains to address sediments in the East Waterway adjacent to Harbor Island.

This OU does not exist in isolation from other areas of interest to EPA under Superfund and RCRA and the Washington Department of Ecology. A five-year review for the Harbor Island site will be performed for all OUs at the site (including the two shipyard OUs, West Waterway OU, East Waterway OU, and Soil/Groundwater OU) and will address all chemicals of concern as well. The primary purpose of a five-year review is to determine whether the selected remedy (or in the case of West Waterway OU, the no action decision) continues to be protective of human health and the environment. The five-year review includes: 1) identification of any issues that currently prevent the response action from being protective, or may do so in the future; 2) recommendations and follow-up actions to resolve those issues; and, 3) a determination of whether the response action is, or is expected to be, protective of human health and the environment. A key component of five-year reviews is to evaluate effects of significant changes in standards and assumptions that were used at the time of ROD determinations. As part of the five-year review process, EPA may require and/or conduct monitoring at the site to verify that sediment continues to pose no unacceptable risks to human health and the environment. Ecology will have an opportunity to participate in the five-year review process. Among the issues that will be evaluated for the Shipyard OUs will be the contaminants remaining above the State Sediment Management Standards. In particular, Ecology has expressed concern about the potential for mercury contamination to exist above the SMS in the West Waterway OU. If during the five-year review process, Ecology's evaluation of the site data indicates that mercury is still of concern to the State, EPA will conduct monitoring for mercury. Ecology also may independently require sediment monitoring under its authorities.

In addition, for the following reasons, EPA expressly determines that the No Action decision in the ROD with respect to PCBs will be revisited if information gathered from dioxin-like PCB congener analyses undertaken for the Lower Duwamish Waterway Superfund site indicate that similar analyses are warranted for the West Waterway OU to ensure protectiveness of human health and the environment. This determination is based on the following circumstances, and is in addition to EPA's normal capacity to re-open site decisions whenever new information suggests EPA should do so to ensure adequate protection of human health and the environment:

- The West Waterway OU is contiguous with and down river from the LDW site.
- EPA believes that sources of PCBs found in West Waterway OU may include the LDW site.
- All West Waterway OU PCB data utilized for this decision have been evaluated by the total PCB or Aroclor method.
- In the future, environmental samples from the LDW site will be analyzed for dioxin-like PCB congeners, as set forth in the December 20, 2000 LDW RI/FS AOC and attached SOW.

EPA commits to review West Waterway OU in light of LDW data and decisions and new scientific information or methodologies at a future time.

8. Documentation of Significant Changes

There are no significant changes from the original proposal in the Proposed Plan (November 1999).

PART 3: RESPONSIVENESS SUMMARY

Stakeholder Issues and Lead Agency Responses

EPA issued a Proposed Plan in November 1999 for the West Waterway OU. The Proposed Plan recommended No Action for marine sediments. Comment letters were received from the Washington State Department of Ecology (Trustee role), the National Oceanic and Atmospheric Administration (NOAA), the U.S. Fish and Wildlife Service (USFWS), the Muckleshoot Tribe, and the Agency for Toxic Substances and Disease Registry (ATSDR). A draft comment letter was received from the Washington State Department of Ecology Toxics Cleanup Program. No comments were received from the general public.

The three significant issues that were common among most commentors are addressed below (Number 1, 2, and 3), followed by individual comments. Specific comments requesting information on technical details (e.g., the location of specific sampling stations) contained in final reports for the West Waterway OU are not responded to below as the information is contained within the administrative record.

1. Stakeholders are concerned that the West Waterway OU decision will set a precedent for cleanup decisions at the LDW site, and that in some fashion, the West Waterway OU decision may be inconsistent with decisions made for the LDW site.

Response: Superfund believes that this is unlikely. There are many differences between the two sites (see below), and as a result, we believe that this West Waterway OU decision is not precedent setting for the LDW. Further, site-specific ecological and human health risk assessments will be completed for the LDW site prior to final cleanup decisions.

Differences between the LDW site and the West Waterway OU:

- West Waterway OU is approximately 1 mile in length, with about 70 acres of *only* subtidal sediments. West Waterway OU is a shipping channel that contains no natural shorelines.

  LDW is approximately 6 miles in length, with *both* intertidal and subtidal sediments. LDW is also a shipping channel but does contain some natural shoreline.

- The area surrounding West Waterway OU is heavy industrial/port use.

  The area surrounding LDW is a mix of residential, business, and heavy industrial/port use.

- West Waterway OU data show 1 of 58 stations exceeds the state's chemical CSL for PCBs.

  LDW data show 130 of 948 stations exceed the state's chemical CSL for PCBs.

- West Waterway OU is an older site (sediment studies were conducted in 1991 and 1995), and thus sediments were not analyzed for dioxin-like PCB congeners.

  LDW is a new site (listed in 2001), and some analyses for dioxin-like PCB congeners will be done in the Phase II RI.

- West Waterway OU does not have any "hot spots" of localized sediments with high contamination (including no PCB hot spots). "Hot spots" within the general West Waterway area are addressed by the Shipyard Sediment ROD and associated ESDs for Todd and Lockheed Shipyard Sediment OUs.

  LDW has "hot spots" of PCB-contaminated sediments, and early actions are proposed to address these "hot spots."

2. Stakeholders are concerned that Superfund may not re-evaluate the No Action decision for the West Waterway OU if new information, particularly for dioxin-like PCB congeners, suggests that the West Waterway OU may not be protective of human health or the environment.

Response: As required by the NCP, EPA will re-visit our decision, as necessary, to ensure protectiveness of human health and the environment. EPA has incorporated the following language into the No Action ROD for the West Waterway OU.

Excerpted from the ROD: For the following reasons, EPA expressly determines that the No Action decision in the ROD with respect to PCBs will be revisited if information gathered from dioxin-like PCB congener analyses undertaken for the Lower Duwamish Waterway (LDW) Superfund site indicate that similar analyses are warranted for the West Waterway OU to ensure protectiveness of human health and the environment. This determination is based on the following circumstances, and is in addition to EPA's normal capacity to re-open past site decisions whenever new information suggests EPA should do so to ensure adequate protection of human health and the environment:

- The West Waterway OU is contiguous with and down river from the LDW site.
- EPA believes that potential sources of PCBs found in West Waterway OU may include the LDW site.
- All West Waterway OU PCB data utilized for this decision have been evaluated by the total PCB or Aroclor method.
- In the future, environmental samples from the LDW site will be analyzed for dioxin-like PCB congeners, as set forth in the December 20, 2000 LDW RI/FS AOC and attached SOW.

EPA commits to review West Waterway OU in light of LDW decisions and new scientific information at a future time.

3. Stakeholders are concerned that Superfund should require a cleanup because the human health risk (seafood ingestion pathway) is 10^{-4}. The Muckleshoot tribe indicated that cleanups should be performed if seafood risks are greater than 10^{-6}, and Ecology indicated that cleanups should be performed if seafood risks are greater than 10^{-5}.

Response: As described in the ROD, EPA believes that the most likely risk is lower than 10^{-4}. There are many uncertainties in seafood risk assessments. For example, considering only the uncertainties regarding fish consumption rates, fraction from source, and exposure duration, excess risk estimates range from 10^{-6} to 10^{-4} (see Table 10). We believe that the assumptions used in our human health seafood risk assessments for the West Waterway OU are more likely to lead to an overestimation of risk, rather than an underestimation of risk. As set forth in *OSWER Directive 9355.0-30*, Superfund follows the following guidance:

> *"Generally, where the baseline risk assessment indicates that a cumulative site risk to an individual using RME assumptions for either current or future land use exceeds the 10-4 lifetime excess cancer risk end of the risk range, action under CERCLA is generally warranted at the site. For sites where the cumulative site risk to an individual based on reasonable maximum exposure for both current and future land use is less than 10-4, action generally is not warranted, but may be warranted if a chemical specific standard that defines acceptable risk is violated or unless there are noncarcinogenic effects or an adverse environmental impact that warrants action."*

These issues are more thoroughly discussed in the ROD.

4. Commentor requested that the seafood consumption data from the Suquamish Tribe be incorporated into the risk characterization.

Response: The Suquamish Tribe consumption data have been incorporated into the risk characterization, as the consumption data from the Suquamish Tribal Consumption Survey were used to generate a seafood ingestion rate for the West Waterway OU.

5. Commentor agrees that the true amount of seafood caught and consumed from the waterway is likely to be much lower than that estimated in the human health risk assessment, but from the broader perspective of protecting public health, it is difficult to look at a site in isolation.

Response: Comment noted. Superfund risk assessments must address *site-specific* risks.

6. Commentor stated that adequate information was not provided on which to determine whether areas of the West Waterway require remediation to protect human health.

Response: EPA disagrees. We believe that adequate information exists to assess human health risks for the West Waterway OU.

7. Commentor requested that alternative exposure durations for the human health risk assessments should be considered.

Response: EPA agrees. Alternative input parameters for the human health risk assessment were evaluated after the Proposed Plan and are provided in the ROD.

8. Commentor requested that human health risks for the Shipyard Sediment OU (Todd and Lockheed Shipyards) be addressed in the West Waterway ROD.

Response: Human health risks associated with the Todd and Lockheed Shipyard OUs are addressed in documentation (e.g., the ROD and Explanation of Significant Differences) for those sites.

9. Commentor requested that the cumulative effect of risks associated with Tribal fishing be performed.

Response: EPA evaluated cancer risks using a Reasonable Maximum Exposure (RME) scenario for a tribal net fisher scenario (ingestion and dermal exposure with sediment by tribal net fishers – multiple chemicals and multiple pathways) as well as a tribal RME seafood consumption scenario (ingestion of fish and shellfish – multiple chemicals). The sum of the cancer risk estimates for the netfishing and seafood consumption scenarios are the same as the cancer risk estimates for the seafood consumption scenario alone, because the estimates from the fish consumption scenario are so much higher than the estimates from the netfishing scenario (after rounding the sum to one significant figure and given the emphasis that is placed on order of magnitude risk (e.g., 10^{-4} or 10^{-5}) when characterizing risk.

Cumulative noncancer hazard indices calculated for the tribal net fisher scenario through ingestion and dermal contact with sediment were all below the benchmark of concern of 1.

10. Commentor requested that EPA consider a range of cleanup alternatives for public consideration.

Response: A feasibility study, including development of various cleanup alternatives, is not being performed for the West Waterway OU because a no action decision has been made.

11. Commentor requested that EPA perform additional studies to determine whether bioaccumulation of TBT poses a risk to fish and invertebrates – specific comments were provided regarding new test species and alternative test methods. Commentor requested that porewater TBT data be compared to PSDDA criteria.

Response: EPA does not agree that additional studies should be performed at this time for the West Waterway OU – the specific studies and target tissue levels that were established for TBT at this site were agreed to with broad input from numerous state and federal agencies. As documented in the Administrative Record for this OU, it is appropriate for EPA to make a determination of potential TBT risks based on the approach that was agreed to pursuant to our AOC, SOW, and other TBT-specific documents. EPA continues to evaluate the potential need for alternative species tests and alternative testing scenarios at other sites (e.g., the East Waterway OU).

12. Commentor noted that less protective TBT criteria were established based on the assumption that sensitive species were not present at the site.

Response: EPA disagrees. As documented in the Administrative Record, effects considered relevant for the development of a site-specific TBT level included mortality, reduced growth, and reproductive impairment. Some of the commonly reported sublethal effects such as bivalve shell thickening or *induction* of imposex or intersex in gastropod snails were not included in the evaluation for two reasons: 1) these endpoints are not population level effects – although the *onset* of imposex/intersex was not included as a relevant endpoint for this study, *sterilization* due to imposex/intersex was included as a relevant endpoint because it was considered a population level effect; and, 2) there is a lack of suitable habitat for the typically affected species (oysters and meso- and neogastropods). The West Waterway is a deep (-30 to -60 ft MLLW), heavily industrialized waterway within the Duwamish River estuary. Very little intertidal habitat is available because of extensive channelization and dredging of the waterway and no commercial or recreational shellfish beds occur. In addition, gastropods are typically not a large component of the Duwamish estuary benthic community and meso- and neogastropods make up only a small fraction of the total gastropod abundance.

13. Commentor requested that sediment cleanup areas should be identified based on a comparison of sediment PAH concentrations to the trustee restoration goal of 2,000 ppb dw PAHs rather than comparing data to the state Sediment Management Standards (SMS). Commentor also stated that the State SMS are generally not considered protective of trust resources for PAHs and PCBs, and that additional studies on bioaccumulative chemical and associated ecological risks should be performed.

Response: EPA believes that the comparison of surface sediment data (bulk sediment chemical PAH and PCB concentrations and co-located sediment toxicity test results) to Washington State Sediment Management Standards, and the literature survey of bioaccumulative chemical tissue residue effects for PCBs, is appropriate for estimating ecological risks from sediments in the West Waterway OU.

14. Four of five commentor disagreed with EPA's no action decision.

Response: Comment noted. Since the Proposed Plan was issued, EPA has completed additional technical memoranda and risk characterizations, as well as stakeholder presentations, in an effort to further evaluate EPA's decision. As documented in the ROD, EPA believes that a no action decision is appropriate for this OU.

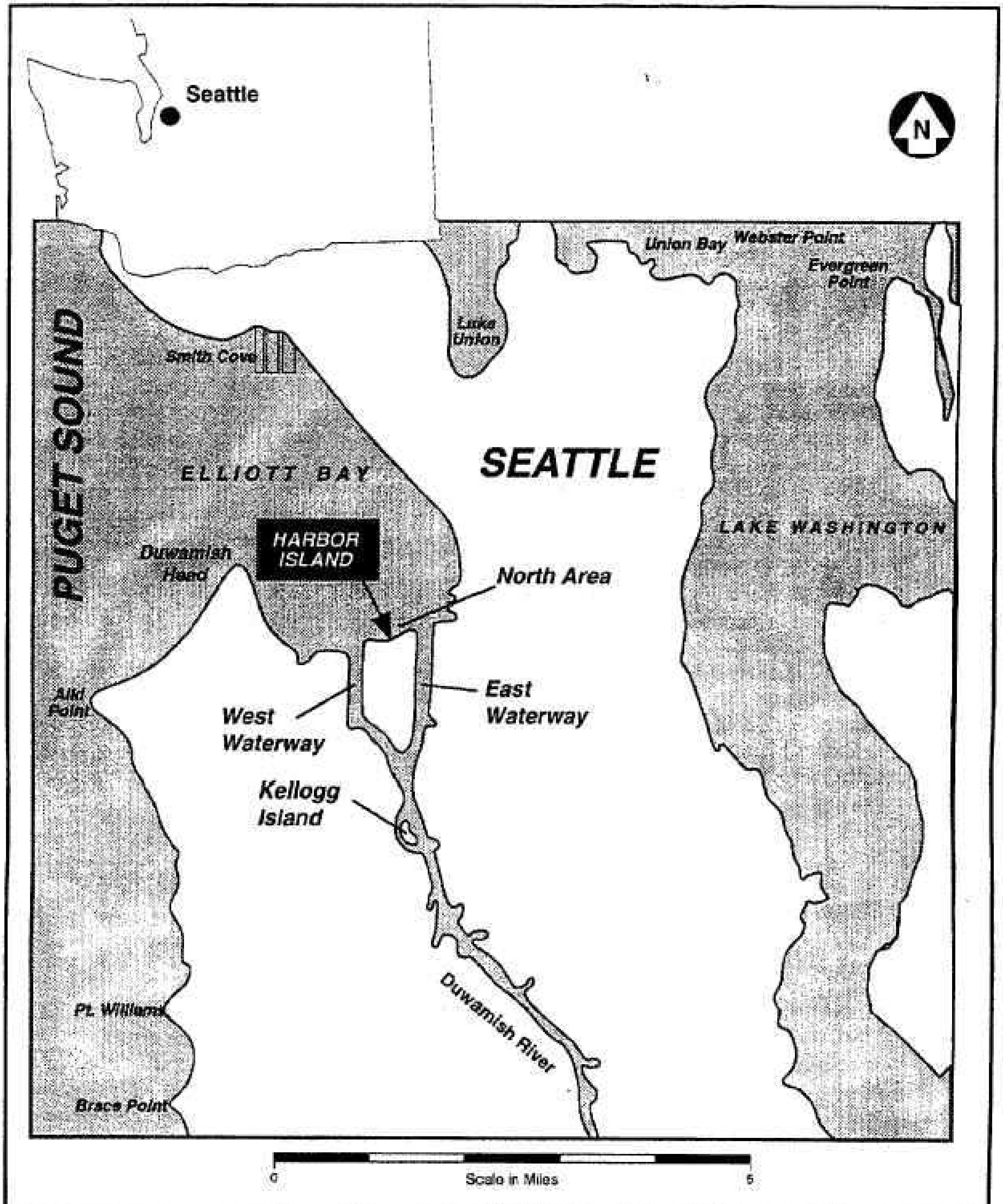


Figure 1. Vicinity Map

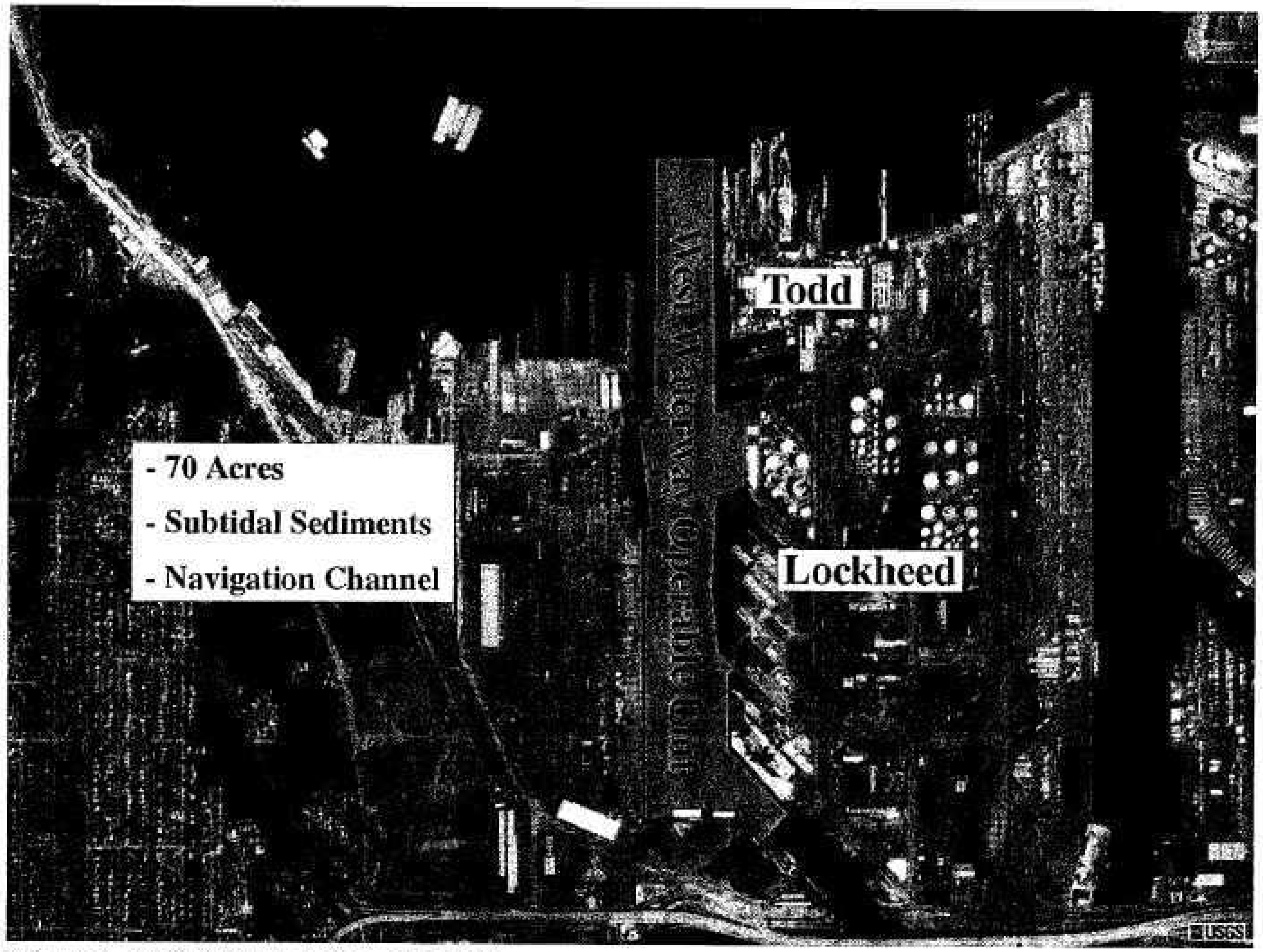


Figure 2. West Waterway Operable Unit

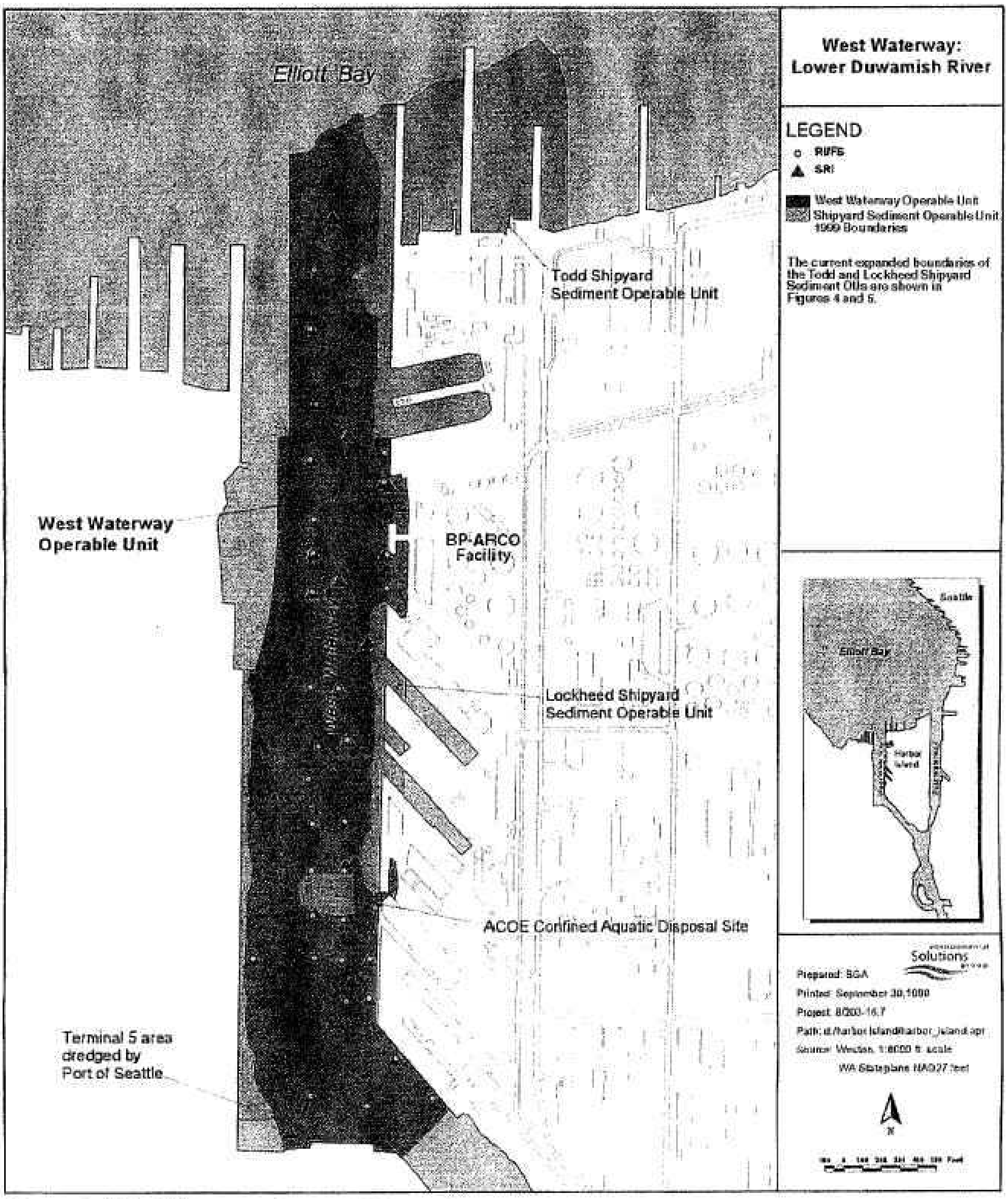


Figure 3. West Waterway Operable Unit and Sediment Station Locations

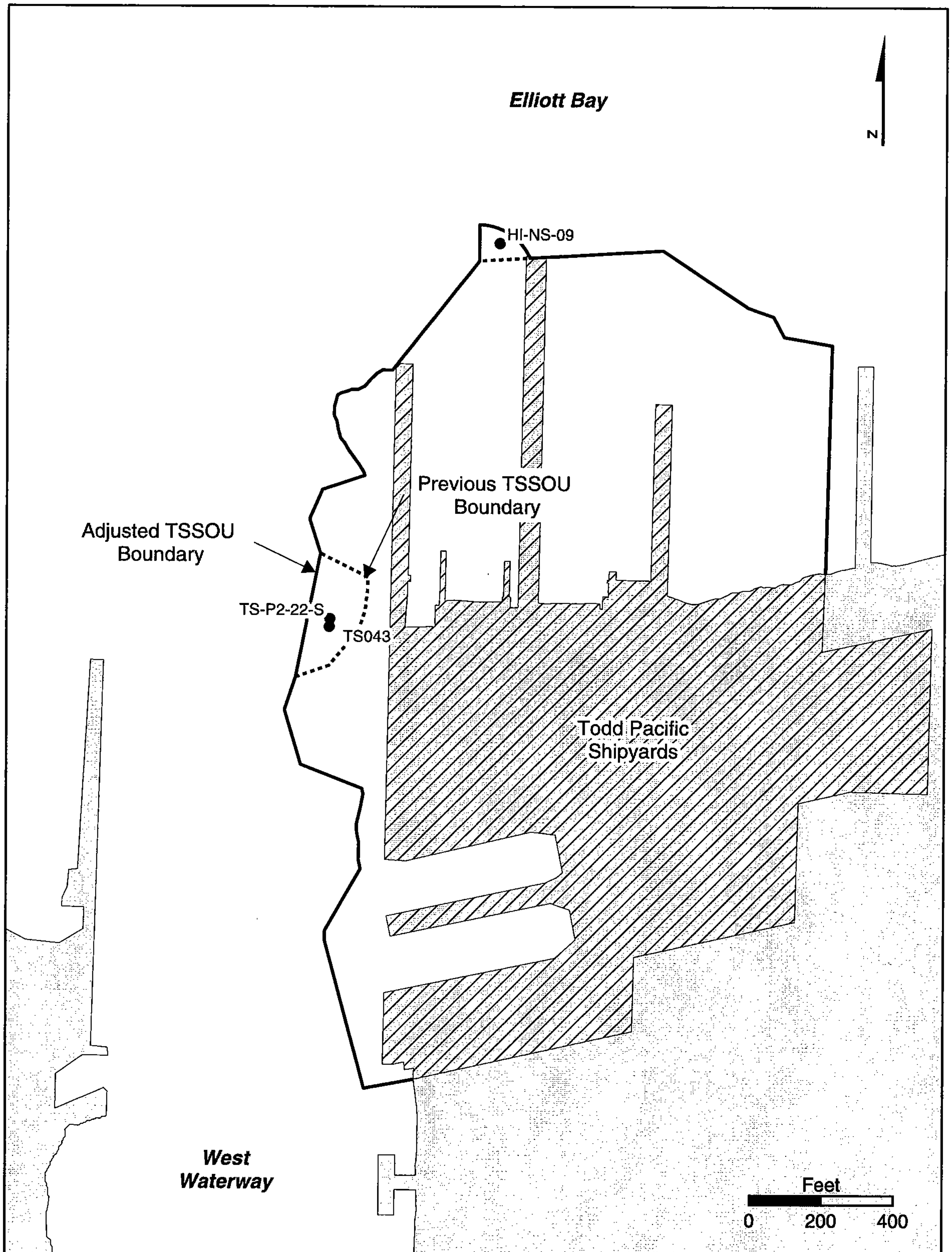


Figure 4.
Todd Shipyard Sediment OU Boundaries, Excerpted from the 2003 ESD

Explanation of Significant Differences to the Harbor Island - Shipyard Sediment Operable Unit Todd Shipyard Sediments Seattle, Washington

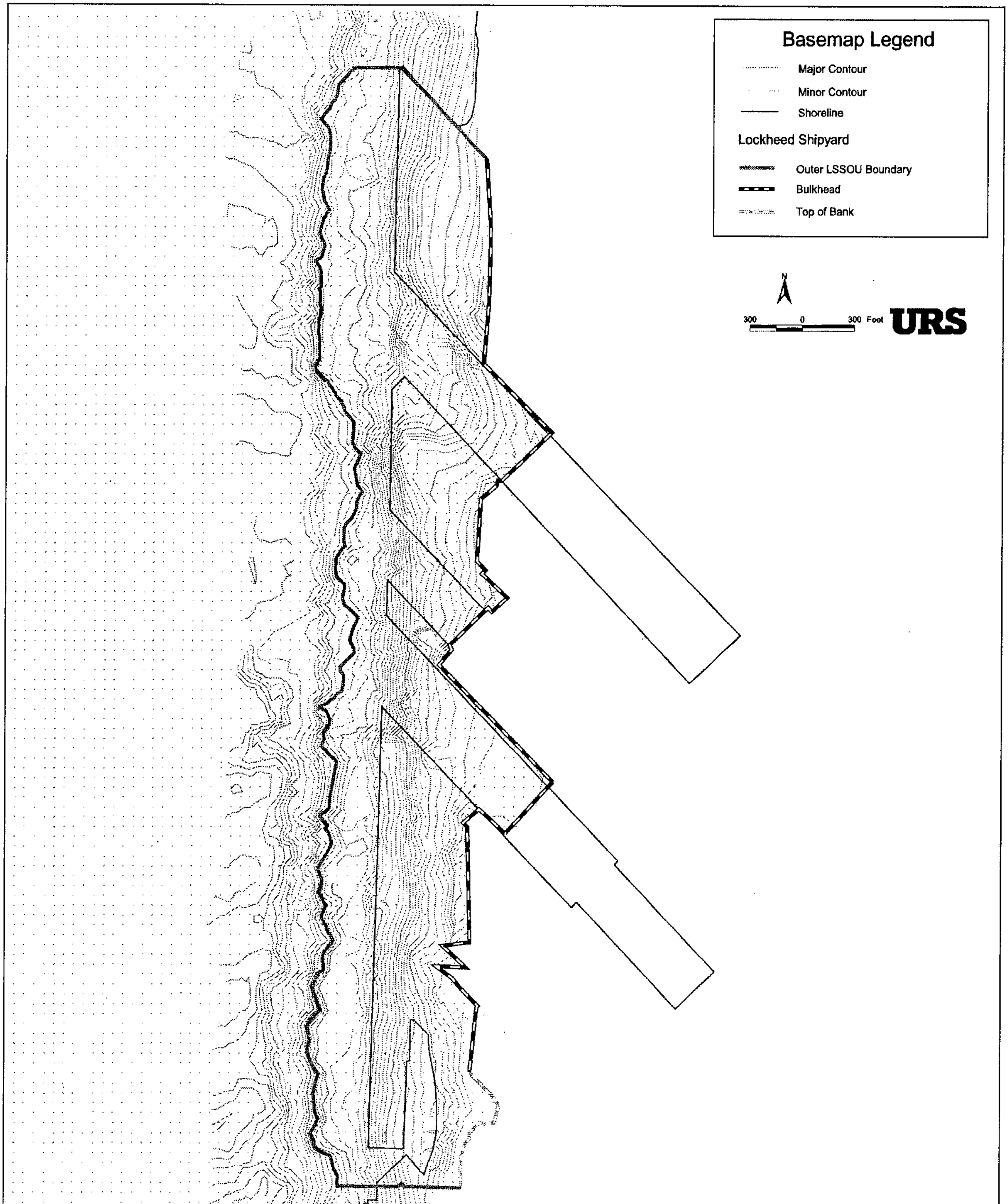
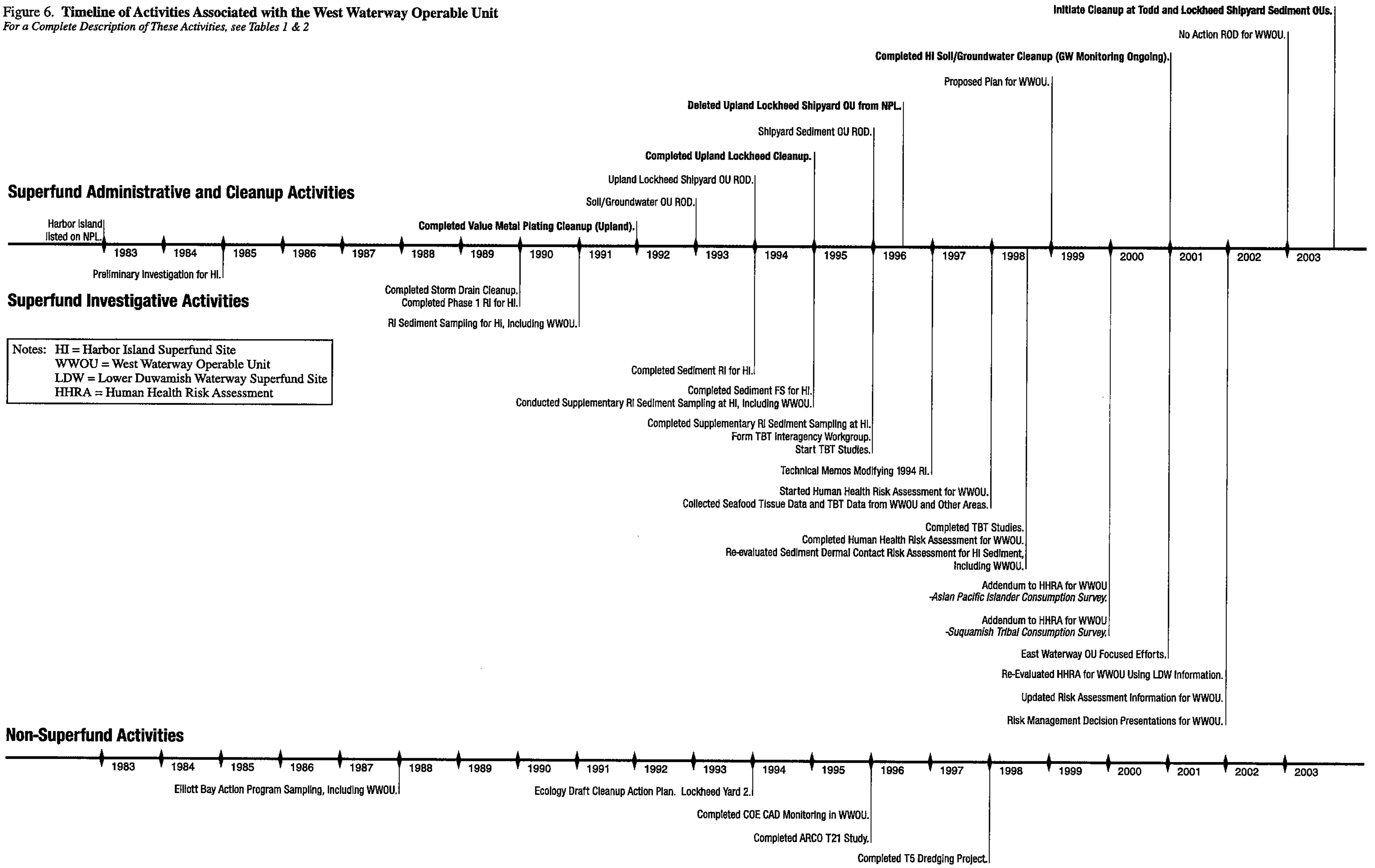


Figure 5. Lockheed Shipyard Sediment OU Boundaries, Excerpted from the 2003 ESD.

Figure 6. **Timeline of Activities Associated with the West Waterway Operable Unit**
For a Complete Description of These Activities, see Tables 1 & 2



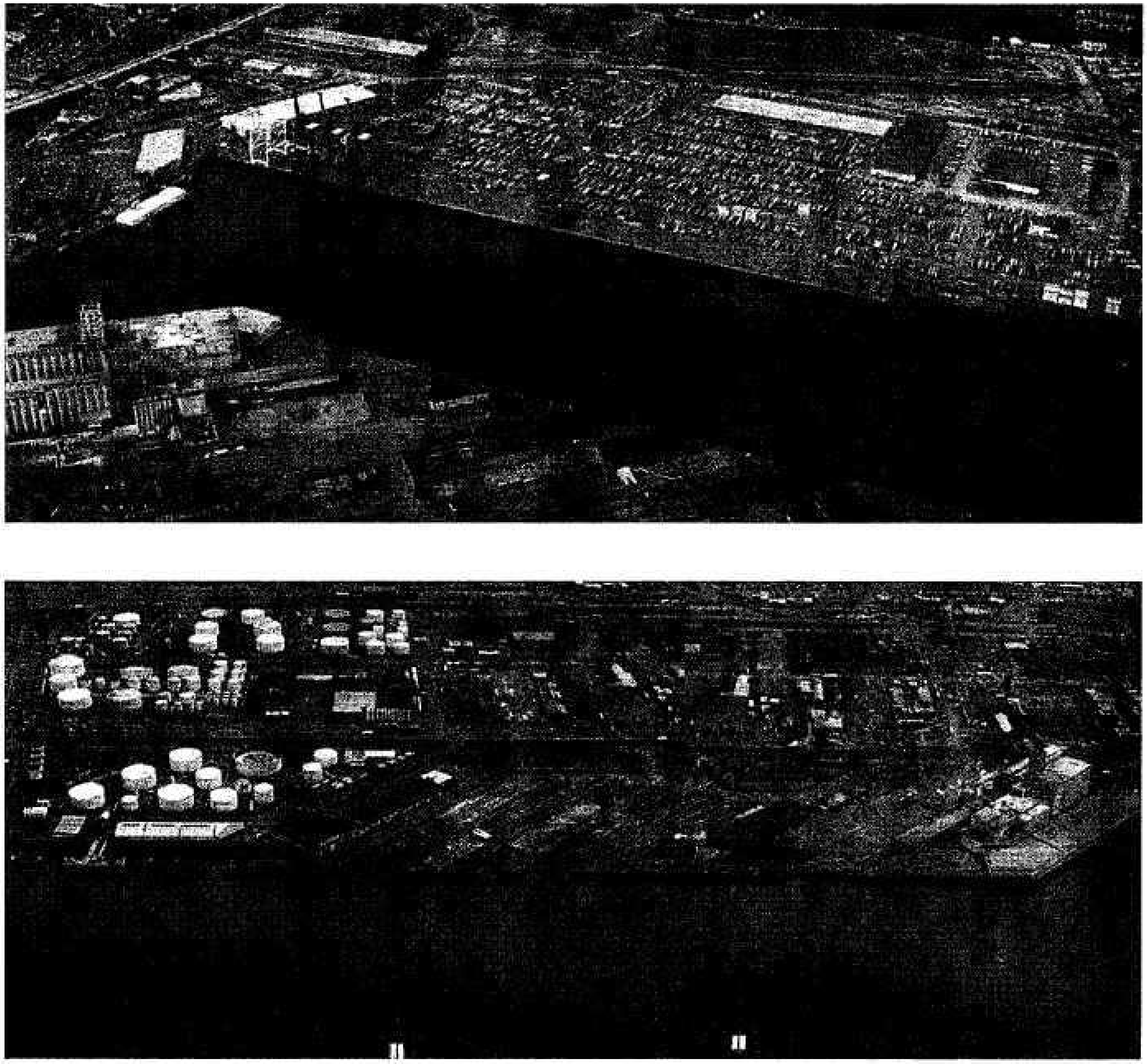


Figure 7. Aerial Photographs of the West Waterway Operable Unit

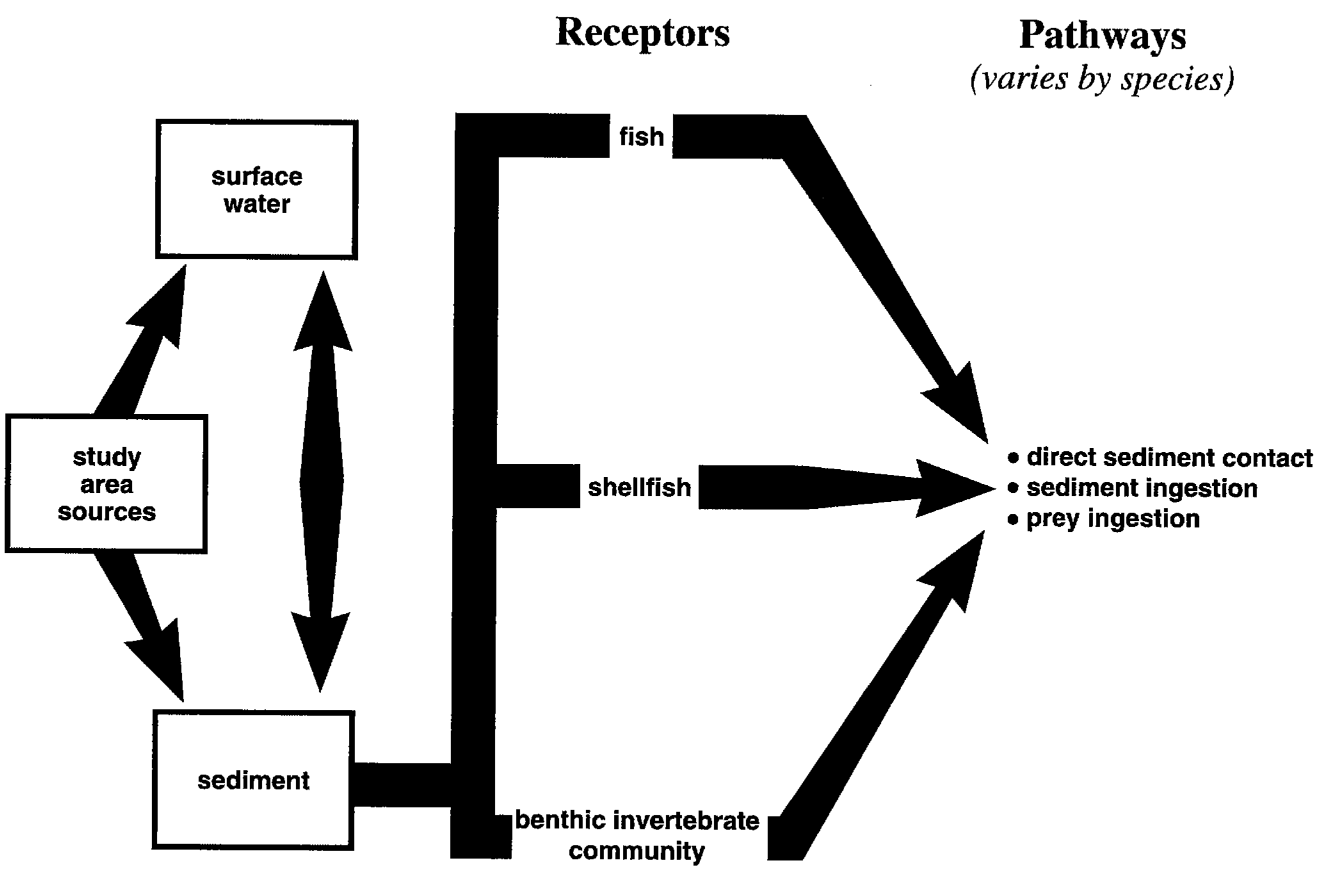


Figure 8. Conceptual Site Model for Fish, Shellfish, and Benthic Invertebrate Community.

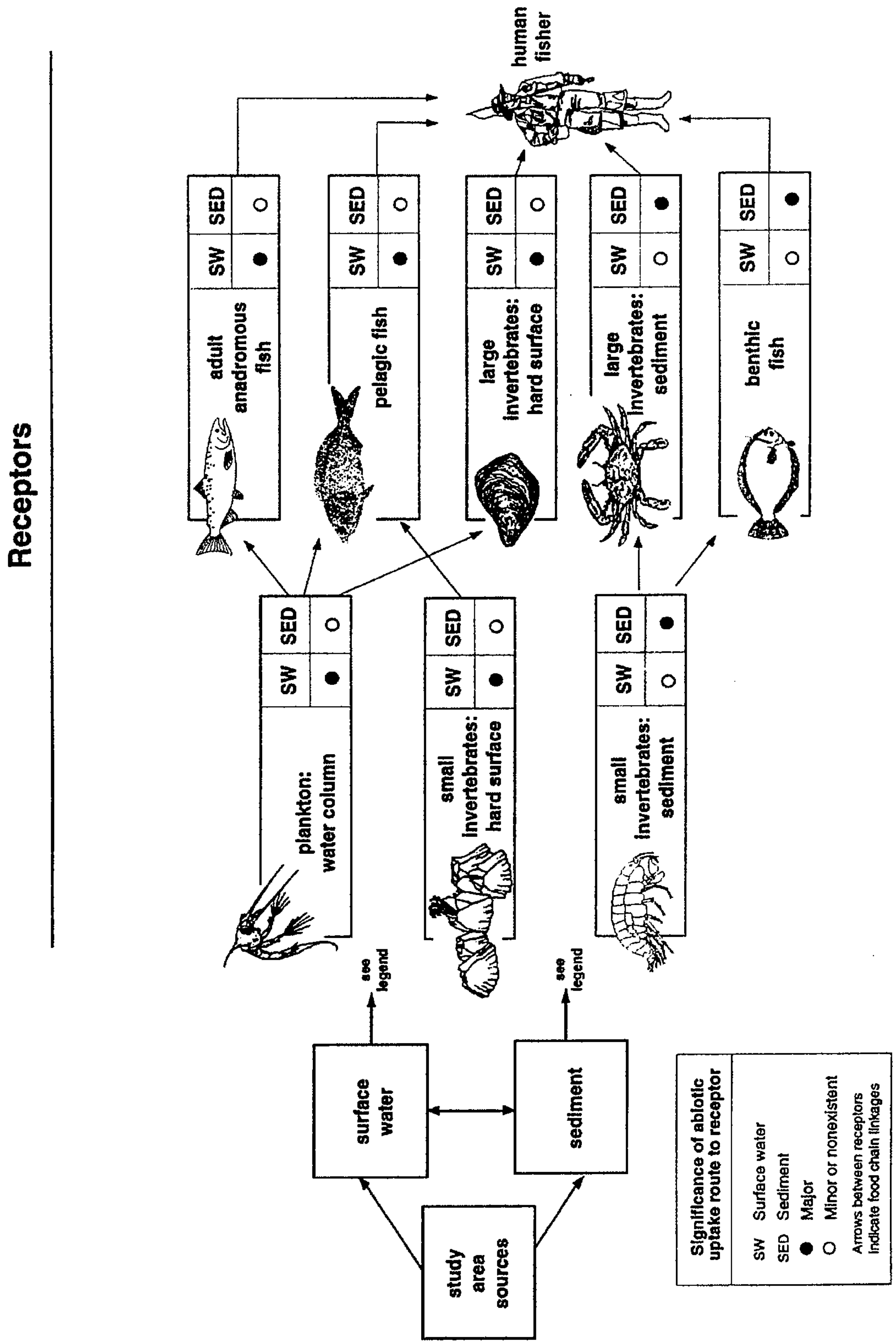
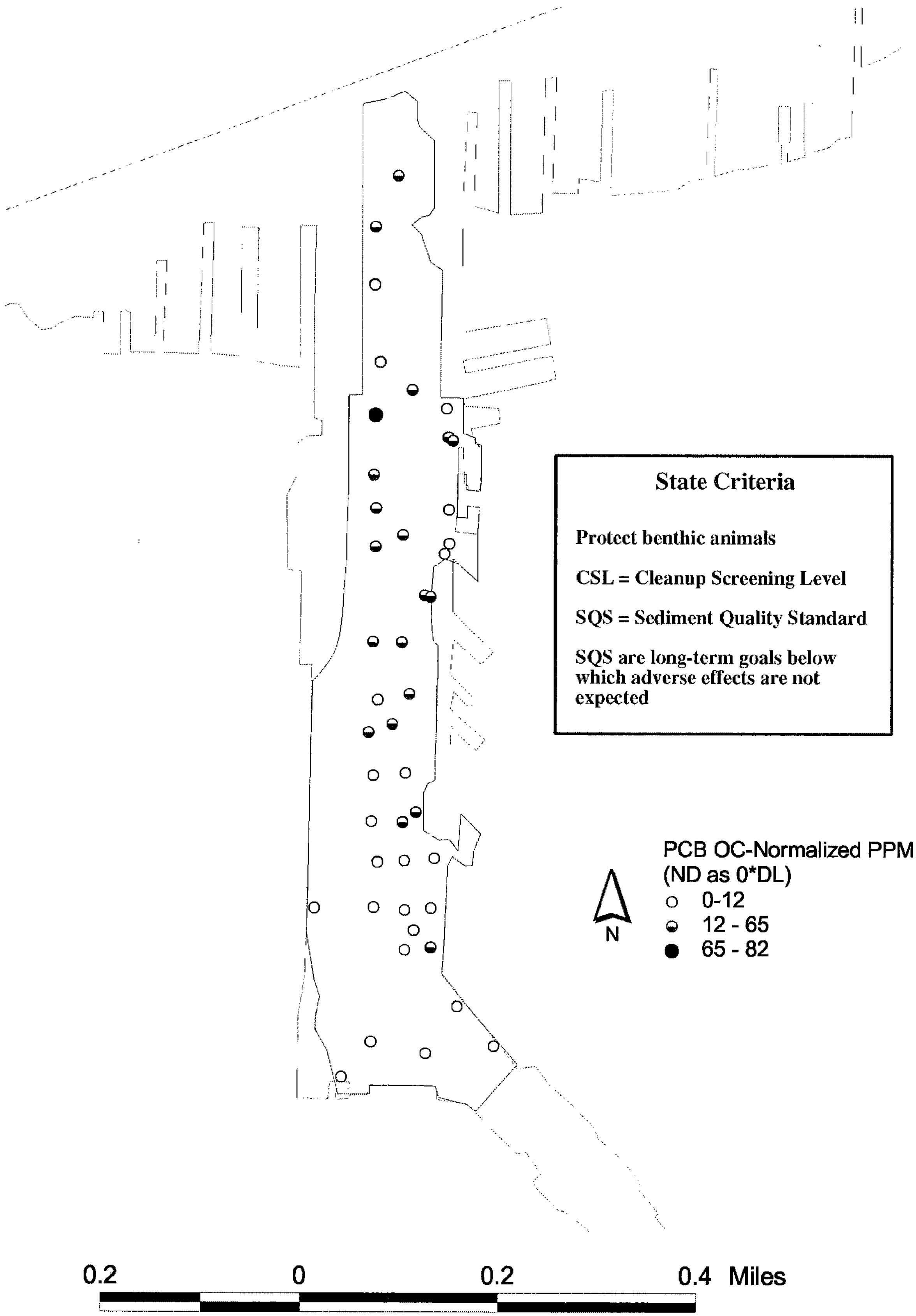


Figure 9. Conceptual Site Food Web Model for Assessing Human Consumption of Seafood, Excerpted from the Human Health Risk Assessment.

Figure 10. Sediment PCB Concentrations in the West Waterway Operable Unit



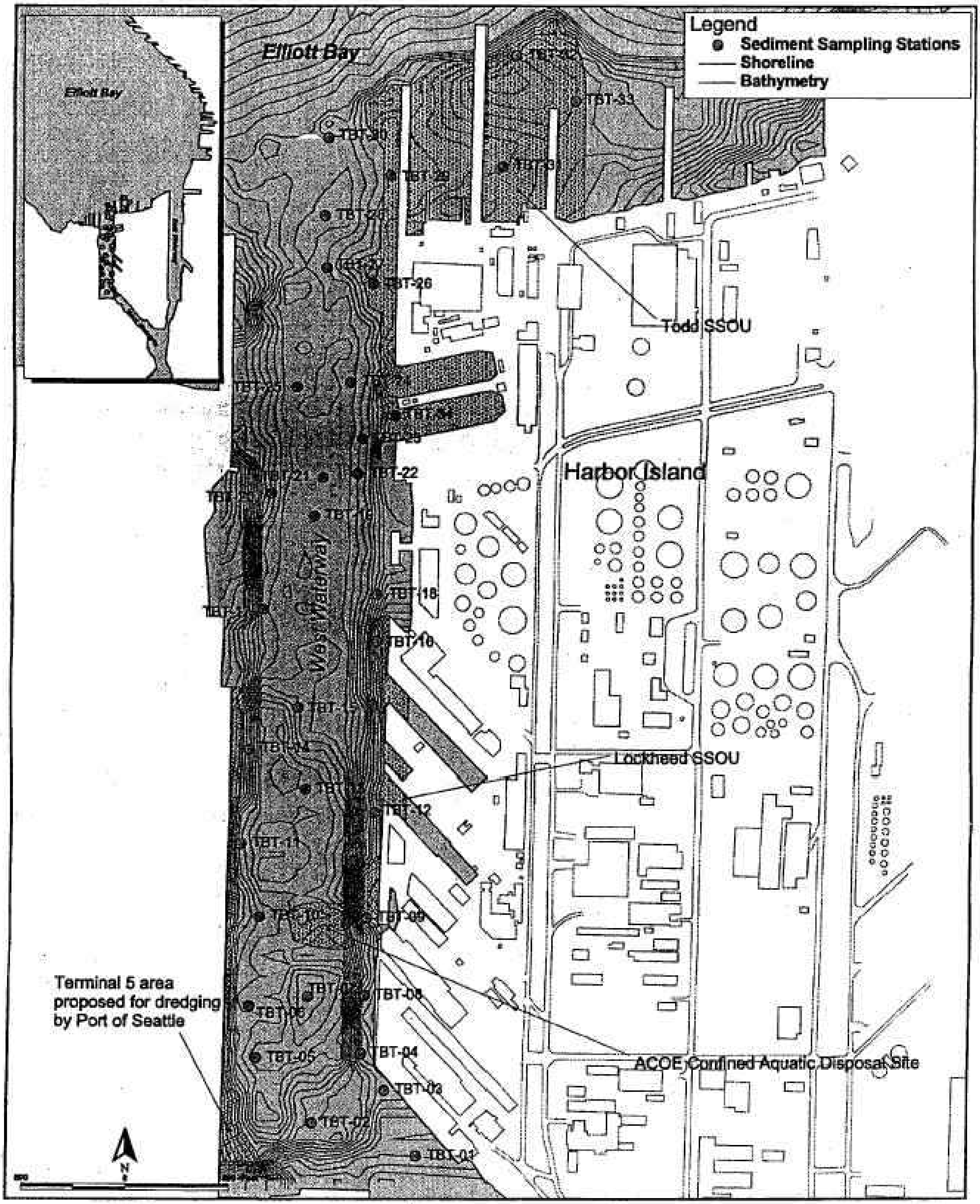


Figure 11. Station Locations for Sediment Collection and TBT Analysis

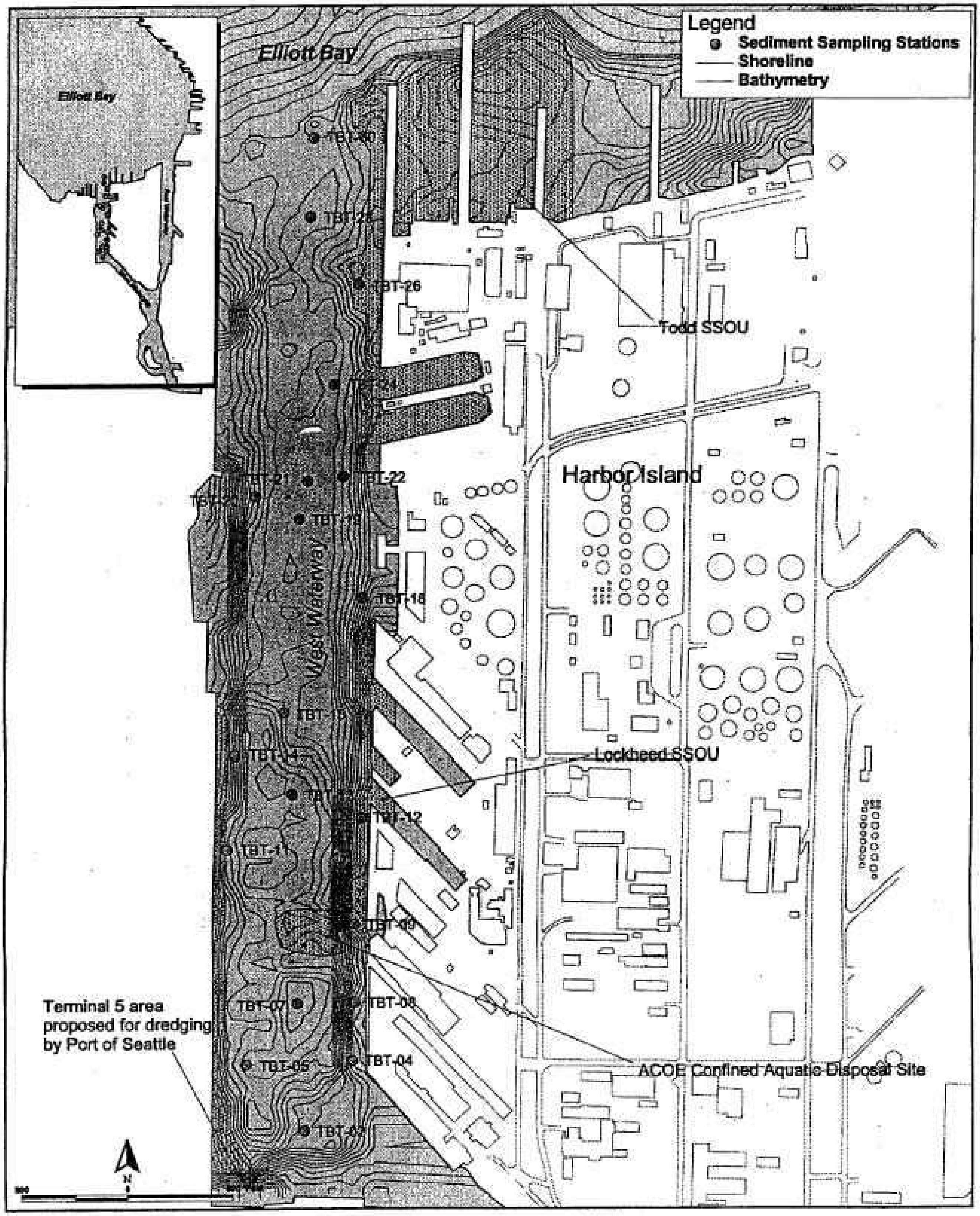


Figure 12. Station Locations for Sediment Bioaccumulation testing for TBT.

Table 1. Summary of environmental investigations associated with marine sediments at the Harbor Island Superfund site and the West Waterway OU

1985 Preliminary Investigation - Phase 1	Black and Veatch 1985	Lower Duwamish Waterway East and West Waterways Elliott Bay	The Preliminary Investigation (PI) summarized existing literature regarding past site activities, the extent of sediment contamination around Harbor Island, and the potential need for additional data collection. The PI examined existing data to determine the nature and extent of sediment contamination; potential upland sources; ecological effects including toxicity, bioaccumulation, pathology, and benthic community structure; and potential concerns for human health. The PI did not identify any formal ecological risk assessments for the Harbor Island area, and no benthic data were identified for the West Waterway. However, the report summarized several area-wide studies that investigated ecological risk factors beyond sediment toxicity and bioaccumulation potential. None of the studies independently evaluated the West Waterway as a distinct location within the Duwamish River estuary. Given the age of the data, and lack of site-specific information, information from this report was not used for the risk management decisions for the West Waterway OU.
1988 Elliott Bay Action Program (EBAP)	PTI and Tetra Tech 1988	Lower Duwamish Waterway East and West Waterways Elliott Bay	In 1985, PTI and Tetra Tech collected environmental contamination and effects data within Elliott Bay and the lower Duwamish River to support the following EBAP objectives: to protect the marine and estuarine ecosystems from further degradation from anthropogenic inputs, identify degraded areas for remedial action, and protect recreational users. Sediments were collected at nineteen locations throughout Elliott Bay and the Duwamish River for chemical analysis, toxicity testing, and evaluation of benthic abundance. Fish were also collected for analysis of tissue chemistry. For the West Waterway, the EBAP study reported results for six amphipod (*Rhepoxynius abronius*) acute sediment toxicity bioassays within the area that is now defined as the West Waterway OU. None of the bioassays exceeded the CSL biological criterion for the amphipod bioassay. One of the bioassays exceeded the SQS biological criterion for the amphipod bioassay. The EBAP data were collected prior to promulgation of the Washington State Department of Ecology's Sediment Management Standards (SMS). Consequently, chemical and biological data are not sufficient to determine compliance with the SMS in the West Waterway. Additionally, 1985 data are generally considered outdated for use in making sediment risk management decisions.

1995 Harbor Island RI/FS, Part 2-Sediment *Fund-lead*	Weston 1994, 1995	Lower Duwamish Waterway East and West Waterways North Harbor Island (Elliott Bay)	In 1990, the EPA's Phase 1 remedial investigation for the Harbor Island Superfund site (Ebasco 1990) did not include studies on marine sediments adjacent to Harbor Island. Subsequently, EPA initiated a sediment remedial investigation for the Harbor Island site. In 1991, surface and subsurface sediment samples were collected and analyzed for chemistry and an *in situ* bioaccumulation study using caged mussels was performed. No biological toxicity testing was performed for the RI/FS. In 1995, the sediment RI/FS was completed. The RI/FS report summarized background information, characterized the nature and extent of sediment contamination, summarized the fate and transport of contaminants, estimated risk to human health and the environment, identified and prioritized areas for cleanup, and developed and evaluated cleanup alternatives. Preliminary clean-up goals were based on Washington State Sediment Management Standards (Chapter 173-204 WAC) sediment quality standards (SQS) and cleanup screening levels (CSL). Related technical memorandum: 1997 EPA Memorandum: Update on Activities related to Marine Sediments at the Harbor Island Superfund site 1997 EPA Memorandum: Errata and Modifications to the EPA RI/FS for sediments at the Harbor Island Superfund site
1995, 1996 Two Supplementary RI Studies *Pursuant to Administrative Order on Consent, dated February 13, 1995, No. 10-95-0130-CERCLA*	EVS and Hart Crowser 1995; EVS 1996	West and East Waterways North Harbor Island (Elliott Bay)	In 1995, additional sediment investigations were performed as part of the Harbor Island Supplementary Remedial Investigation (SRI) field sampling effort. This effort was conducted under a legal agreement between the EPA and several potentially responsible parties (PRPs). Additional sediment data were required primarily because the Harbor Island RI/FS did not adequately define the extent of surface sediments that may potentially warrant cleanup based on SMS chemical and biological criteria. For the SRI, surface and subsurface chemical data and surface sediment toxicity bioassay data were collected around Harbor Island, with 33 surface sediment stations located in the West Waterway.

1996 U.S. Army Corps of Engineers' Confined Aquatic Disposal (CAD) Site Study	SAIC 1996	West Waterway	The U.S. Army Corps of Engineers Seattle District created a CAD site in the Duwamish Waterway in 1984. Dredged sediments contaminated with PCBs were placed in a depression in the West Waterway and then capped, in part to demonstrate the feasibility of CAD technology. In 1995, an 11th-year monitoring survey was conducted to assess any potential cap degradation and the biological health of the re-colonized cap. The monitoring study included collecting 3 vibracore samples and 36 images as part of a sediment vertical profiling system (SVPS) survey. Results suggest that the CAD site provides a fair to moderate sediment quality for benthic infauna and that contaminants are not migrating through the cap.
1996 ARCO Environmental Study, Terminal 21T	Geraghty & Miller 1996	West Waterway	In 1995 and 1996, surface sediment sampling was conducted between the ARCO T-dock and the shoreline riprap in the West Waterway to evaluate potential sediment impacts from municipal outfalls located near the facility. Five locations were sampled during September 1995 and three locations during May of 1996. Samples were analyzed for metals, HPAHs, LPAHs, selected SVOCs, TPH compounds, and PCBs. No biological data were collected. The chemical data were evaluated in accordance with state Sediment Management Standards. PCBs were not detected in any outfall sediment sample, and PAHs and 6 metals were not found at concentrations above state SQS. Ecology determined that sediments are not impacted above levels that would cause adverse effects to aquatic life and that no additional sampling was necessary.
1996 Recommendations for Screening Values for Tributyltin in Sediments at Superfund Sites in Puget Sound, Washington	Weston 1996		An interagency workgroup comprised of EPA, Ecology, State Department of Natural Resources, U.S. Army Corps of Engineers, NOAA, EVS consultants, and Weston (EPA contractor) was formed to identify and evaluate various approaches to derive a marine sediment effects-based screening value or cleanup level for TBT in the absence of a federal or state regulatory standard. The effort was initiated to assist EPA in selecting sediment screening values and recommending a cleanup approach for assessing risks associated with TBT-contaminated sediments at Superfund sites in Puget Sound, WA.

1998, 1999 Human Health Risk Assessment and Studies on Tributyltin in Marine Sediments and Bioaccumulation of Tributyltin in Tissues of Marine Organisms *Pursuant to Administrative Order on Consent, dated May 4, 1998, No. 10-98-0087-CERCLA*	Various authors	Lower Duwamish Waterway West and East Waterways	These studies were undertaken to address potential concerns associated with three bioaccumulative compounds -- PCBs, TBT, and mercury -- previously detected at the site. In large part, these studies were conducted because: 1) there is no state sediment standard for TBT; and, 2) although sediments in the West Waterway OU "passed" the state SMS, those standards do not consider human health or bioaccumulative risks. The three major components of the study included: 1) performing a literature of tissue residue effects data for PCBs, TBT, and mercury in marine organisms; 2) assessing the potential ecological impacts associated with exposure to TBT in sediments; and, 3) performing a human health risk assessment (HHRA) to estimate potential risk associated with PCBs, TBT, and mercury that may have bioaccumulated from site sediments to fish and shellfish consumed from the West Waterway OU by people. The specific tasks undertaken included reviewing existing literature on tissue residue ecological effects data for the three contaminants of concern; chemical analysis (sediment and porewater) and bioaccumulation testing of West Waterway sediments for TBT; determination of a site-specific tissue trigger level for TBT; a review of seafood consumption surveys and relevant historical tissue data for PCBs, TBT, and mercury; collection of seafood tissue data and analysis for PCBs, TBT, and mercury; and, development of a conceptual site model and subsequent HHRA (seafood pathway). A re-evaluation of potential dermal risks to tribal net fishers was also performed. Specific reports include: 1998 Conceptual Site Model and Exposure Assessment - Assessing Human Health Risks from the Consumption of Seafood 1998 Sampling and Analysis plan for TBT Study 1998 Sampling and Analysis Plan - Assessing Human Health Risks from the Consumption of Seafood 1999 Review of Tissue Residue Effects Data for Tributyltin, Mercury, and Polychlorinated Biphenyls 1999 Tributyltin in Marine Sediments and Bioaccumulation of Tributyltin: Combined Data Report 1999 Human Health Risk Assessment - Assessing Human Health Risks from the Consumption of Seafood 1999 EPA Technical Memorandum - Topics Related to the TBT Field Study at the Harbor Island Superfund Site 1999 EPA Letter - Tribal Net Fisher Scenario, Human Health Risk Assessment, Harbor Island Superfund Site

2002 Updated Risk Assessment Information for the West Waterway Operable Unit of the Harbor Island Superfund Site, Seattle, Washington	EPA 2002	West Waterway	EPA completed a technical memorandum that provided a status of ongoing actions at the Harbor Island Superfund site; summarized existing data and risk characterization results for the West Waterway OU; incorporated additional human health risk assessment characterization based on Suquamish Tribe consumption survey ingestion rates and risk assessment assumptions from the Phase 1 risk assessment of the Lower Duwamish Waterway Superfund site; presented a range of risks for the consumption of seafood; and, provided responses to concerns raised by stakeholders.

Table 2. Completed and ongoing cleanup actions at the Harbor Island Superfund site and surrounding areas

Harbor Island Soil/Groundwater OU (1993 EPA Record of Decision)

- Completed excavation and offsite disposal of PCB-contaminated soils (Seattle Iron and Metals) and other "hot spots" of contaminated soils.
- Completed capping of exposed soils exceeding cleanup goals.
- Ongoing excavation and onsite treatment of "hot spots" of petroleum-contaminated soils at Todd Shipyards.
- Ongoing removal and treatment of floating petroleum product and contaminated groundwater at Todd Shipyards.
- Determination that contaminated groundwater at the site, with the exception of Todd Shipyards and the Petroleum Tank Farms (see below), is an insignificant source to sediments.

Harbor Island Upland Lockheed Shipyard OU (1994 EPA Record of Decision)

- Excavation of "hot spots" of petroleum-contaminated soils; capping of soil; and long-term monitoring of groundwater. Deleted from Superfund list in 1996.

Harbor Island - Other Source Control (in accordance with Superfund authorities)

- Removal of all sediments in Harbor Island public storm drain system; identification and correction of illegal connections; determination that storm drains no longer considered to be a significant source of contamination to sediments (completed 1990).
- Value Metal Plating cleanup (completed 1992).
- Determination that private storm drains on Harbor Island were not considered to be significant sources of contamination to sediments (completed 1993).

Harbor Island - Petroleum Tank Farms OU, State Lead (in accordance with State of Washington cleanup authorities)

-Under a Memorandum of Agreement between EPA and Ecology, EPA designated Ecology the lead agency for the tank farms because petroleum is the primary contaminant of concern. Petroleum is excluded from Superfund regulations, but is regulated as a hazardous substance under the State of Washington Model Toxics Control Act.
-Tank farms include: Shell (formerly Equilon and Texaco); BP-ARCO; and Kinder Morgan (formerly GATX and Shell Oil).
-For Shell, an Ecology cleanup action plan and consent decree were finalized in April 1999. The cleanup plan includes contaminated soil excavation, groundwater cleanup and soil vapor extraction, and long-term monitoring. To date, excavation and removal of TPH-contaminated soil (and some lead and arsenic-contaminated soil) has been partially completed. Operation of the remedial system, monitoring, and data collection are ongoing.

-For Kinder Morgan, an Ecology cleanup action plan and consent decree were finalized in April 2000. The cleanup plan includes free product recovery and installation of a barrier to prevent migration, air sparging, excavation of accessible TPH, lead, and arsenic-contaminated soil, and long-term monitoring. To date, the free product recovery and air sparging systems have been constructed and are now in operation. All accessible contaminated soil has been excavated and removed in the B and C yards. Monitoring and data collection are ongoing. GATX is not located near the shoreline.
-For BP-ARCO, an Ecology cleanup action plan and consent decree were finalized in March 2000. The cleanup plan includes expanding a product recovery system at the terminal bulkhead and adding soil vapor extraction and air sparging, excavation of accessible TPH-contaminated soil, and long-term monitoring. All accessible contaminated soil has been excavated and removed. Monitoring and data collection are ongoing.

Lockheed and Todd Shipyard Sediment OUs (1996 EPA Record of Decision; 2002 and 2003 Lockheed ESDs; 1999 and 2003 Todd ESD)

- Contaminated sediments Ecological risk drivers are arsenic, copper, lead, mercury, zinc, and TBT.
- Todd and former Lockheed Shipyards. For the Lockheed Shipyard Sediment OU, cleanup will begin in 2003 and will include removal of 6,000 pilings, dredging of an estimated 130,000 cy of sediments, capping of an estimated 4 acres, and partial filling of a shipway and associated mitigation. For the Todd Shipyard Sediment OU, cleanup will include removal of 2,000 pilings, dredging of an estimated 200,000 cy sediments, pier reconfiguration, and capping under pier structures that remain in place.

Harbor Island East Waterway OU

- EPA is currently planning how best to implement East Waterway remediation under Superfund authorities in coordination with the Port of Seattle's proposal to dredge the East Waterway for navigational purposes.

Pacific Sound Resources Superfund Site (1999 ROD)

- PAH-contaminated sediments over approximately 50 acres. Cleanup will begin in 2003. Human health risk (seafood consumption) is not a driver. Post-cleanup residual human health risk estimated to be 1×10^{-5}.

Lower Duwamish Waterway (LDW) Superfund Site

- Study area includes approximately 6 miles of the lower Duwamish Waterway. Estimates for the scoping phase RI to be completed in early 2003, with early cleanup work initiated in 2003. Baseline risk assessments planned for 2004, with a ROD planned for 2004 or 2005 for the LDW.

Table 3. Total PCBs, Total Mercury, and TBT (Ion) Concentrations for Proposed Target Fish and Shellfish Species Collected During Previous Studies from 1990 to 1998, Excerpted from the Human Health Risk Assessment.

	Concentration Statistics - Mean (Max, Min, SD, N)[a]				
	Total PCBs (µg/kg wet weight)				
Species	**Lower Duwamish**	**West Waterway**	**East Waterway**	**Elliott Bay**	**Reference**[b]
Chinook salmon	**56** (161, 18, 28, 31)[c]	na	na	na	**48** (212, 5.0, 33, 117)[c]
Coho salmon	**26** (46, 9.0, 9.0, 24)[c]	na	na	na	**25** (126, 4.7, 20, 115)[c]
Shiner perch	**500** (620, 356, 134, 3)[c,d]	na	na	**200** (262, 138, 62, 3)[c,d]	**70** (102, 53, 27, 3)[c,d]
English sole	**192** (365, 81, 83,12)[c]	**336** (462, 262, 110, 3)[c]	**560** (643, 412, 128, 3)[c]	**71** (447, 6.3, 80, 73)[c]	**12** (76, 2.3, 11, 198)[c]
Dungeness crab	**157** (177, 138, –, 2)[c]	na	na	**118** (278, 12, 115, 4)[c]	**8.0** (8.0, 8.0, 0, 3)[c]

	Total Mercury (µg/kg wet weight)				
Species	**Lower Duwamish**	**West Waterway**	**East Waterway**	**Elliott Bay**	**Reference**
Chinook salmon	**102** (150, 59, 27, 18)	na	na	na	**90** (160, 51, 25, 82)
Coho salmon	**41** (53, 25, 8, 18)	na	na	na	**50** (110, 26, 17, 88)
Shiner perch	**78** (88, 71, 9, 3)[d]	na	na	**29** (30, 27, 1.6, 3)[d]	**70** (106, 41, 33, 3)[d]
English sole	**53** (83, 20, 23, 12)	**23** (29, 20, 5.3, 3)	**30** (34, 26, 4.2, 3)	**69** (129, 24, 28, 72)[c]	**51** (130, 17, 19, 191)
Dungeness crab	**100** (111, 90, –, 2)	na	na	**87** (128, 58, 34, 4)	**63** (69, 53, 8.5, 3)

	TBT (ion) (µg/kg wet weight)				
Species	**Lower Duwamish**	**West Waterway**	**East Waterway**	**Elliott Bay**	**Reference**
Chinook salmon	na	na	na	na	na
Coho salmon	na	na	na	na	na
Shiner perch	**153** (179, 118, 31, 3)[d]	na	na	**126** (174, 102, 41, 3)[d]	**32** (46, 16, 15, 3)[d]
English sole	**2.6** (5.7, 0.37, 2.5, 6)[c]	**1.4** (2.1, 0.34, 0.93, 3)[c]	**1.3** (1.9, 0.34, 0.82, 3)[c]	**0.40** (2.0, 0.06, 0.64, 12)[c]	**0.32** (0.36, 0.27, 0.04, 3)
Dungeness crab	**64** (82, 47, –, 2)	na	na	**32** (79, 1.6, 40, 5)	**2.5** (3.0, 2.2, 0.45, 3)

SOURCES: King County Department of Natural Resources (1999); O'Neill pers. comm. (1998); Weston (1998); Port of Seattle unpublished data collected in 1996

NOTE: All fish samples were composites of skinless filets unless otherwise noted; all shellfish samples were edible muscle meat; all samples uncooked
All concentrations (including total PCBs) calculated assuming one-half detection limit for non-detect samples
No data available for Upper Duwamish study area section (not shown on table)
All total PCB concentrations include at least one detected Aroclor
na - not available

a Number in bold is mean concentration; numbers in parentheses are, in order, maximum concentration (Max), minimum concentration (Min), standard deviation (SD), and number of samples analyzed (N).

b Reference areas are shown in Appendix B (Figure B-1).

c Summary statistics include one or more non-detect values.

d Shiner perch samples were whole-body.

Table 4. Sediment ingestion (exposure factors), excerpted from the RI.

$$CDI_{ingestion} = C_{sediment} \times \frac{IR \times CF \times FI \times EF \times ED}{BW \times AT}$$

Parameters	Exposure Factor	Value
$C_{sediment}$	**Concentration of Contaminant in Sediment (mg/kg)** Upper 95% confidence limit of the arithmetic mean.	Site-specific
IR	**Ingestion Rate (mg/day)** The ingestion rate of 75 mg/day assumes that people fishing work double shifts during half of the 7-month season and single shifts the other half. (Best professional judgement, based on the EPA default ingestion rate for industrial workers of 50 mg/day.)	75
CF	**Conversion Factor (kg/mg)**	1.0E-06
FI	**Fraction Ingested from Contaminated Source (unitless)** The fraction assumes all exposure is received at work.	1.0
EF	**Exposure Frequency (days/year)** The exposure frequency assumes people work every day for the extended season of 7 months (210 days).	210
ED	**Exposure Duration (years)** The exposure duration is 25 years, the EPA standard industrial default.[a]	25
BW	**Body Weight (kg)** The adult body weight is the EPA standard default of 70 kg.[a]	70
AT	**Averaging Time (days)** The averaging time for noncancer risk is 25 years x 365 days/year. The averaging time for cancer risk is 70 years x 365 days/year.[a]	9,125[b] 25,550[c]
Noncarcinogenic Incidental Sediment Ingestion Summary Intake Factor[d]		6.2E-07
Carcinogenic Incidental Sediment Ingestion Summary Intake Factor[d]		2.2E-07

Note: $CDI_{ingestion}$ represents the chronic daily intake of ingested sediment.

[a] *EPA. 1991. Supplemental Risk Assessment Guidance for Superfund,* U.S. Environmental Protection Agency, Region X, Seattle, Washington. 16 August 1991.

[b] Noncancer risk.

[c] Cancer risk.

[d] Chronic daily intake estimate assuming contaminant concentration in sediment of 1 mg/kg (units of mg/kg-day).

Table 5. Dermal contact with sediment (exposure factors), excerpted from Appendix D of the RI.

$$\text{Absorbed Dose} = C_{sediment} \times \frac{ABS \times CF \times SA \times AF \times FC \times EF \times ED}{BW \times AT}$$

Parameters	Exposure Factor	Value
$C_{sediment}$	**Concentration of Contaminant in Sediment (mg/kg)** Upper 95% confidence limit of the arithmetic mean.	Site-specific
ABS	**Percutaneous Absorption Factor (unitless ratio)**	Contaminant-specific[a]
CF	**Conversion Factor (kg/mg)**	1.0E-06
SA	**Surface Area Available for Contact (cm^2)** An exposed surface area of 3160 cm^2 was based on the head, hands, and forearms, which assumes that workers wear full rain gear but no gloves.[b]	3,160
AF	**Soil to Skin Adherence Factor (mg/cm^2)** The soil to skin adherence factor is 1.0 mg/cm^2, the EPA-recommended reasonable upper value.[c]	1.0
FC	**Fraction Contacted from Contaminated Source (unitless)** All contact is assumed to occur while fishing.	1.0
EF	**Exposure Frequency (days/year)** The exposure frequency assumes people are working every day for the extended season of 7 months (210 days).	210
ED	**Exposure Duration (years)** The exposure duration is 25 years, the EPA standard industrial default value.[d]	25
BW	**Body Weight (kg)** The adult body weight is the EPA standard default of 70 kg.[d]	70
AT	**Averaging Time (days)** The averaging time for noncancer risk is 25 years x 365 days/year. The averaging time for cancer risk is 70 years x 365 days/year.[d]	9,125[e] 25,550[f]
Noncarcinogenic Dermal Contact Intake Factor[g]		2.6E-05 x ABS
Carcinogenic Dermal Contact Intake Factor[g]		9.3E-06 x ABS

[a] Table 6-7—Fractional Percutaneous Absorption for Dermal Exposure.
[b] *Exposure Factors Handbook (EPA 1989c).*
[c] *Dermal Exposure Assessment: Principles and Applications* (EPA 1992a).
[d] *Supplemental Risk Assessment Guidance for Superfund* (EPA 1991b).
[e] Noncancer risk.
[f] Cancer risk.
[g] Absorbed dose estimate assuming a contaminant concentration in sediment of 1 mg/kg (units in mg/kg-day).

Table 6. Excess cancer risk characterization due to sediment contact for West Waterway.

Contaminant	Cancer Risk		
	Incidental Ingestion	Dermal Contact	Total Risk (across both pathways)
Bis(2-ethylhexyl)phthalate	1.4E-08	3.4E-08	4.8E-08
PAHs[a]	3.2E-06	NA	3.2E-06
Heptachlor	2.2E-09	5.5E-09	7.7E-09
PCBs[b]	2.8E-07	3.6E-07	6.5E-07
Arsenic	7.9E-06	NA	7.9E-06
Beryllium	1.5E-07	NA	1.5E-07
Total Risk	1.2E-05	4.0E-07	1.2E-05

NA Not applicable for this pathway.

[a] Sum of all carcinogenic PAHs using the TEF approach discussed in Section 3.1 of Appendix D. PAHs included in the total are benzo(a)pyrene, benz(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(k)fluoranthene, indeno(1,2,3-cd)pyrene, and dibenz(a,h)anthracene. Risks associated with individual carcinogenic PAHs presented in the risk calculation spreadsheets (Appendix D).

[b] Sum of PCBs detected in sediment: Aroclor-1248, Aroclor-1254, and Aroclor-1260.

Table 7. Noncancer risk characterization due to sediment contact for West Waterway.

Contaminant	Hazard Quotients		Total Hazard Index (across all pathways)
	Incidental Ingestion	Dermal Contact	
Bis(2-ethylhexyl)phthalate	0.00014	0.00034	0.00048
Heptachlor	0.0000027	0.0000069	0.0000096
Arsenic	0.041	NA	0.041
Beryllium	0.000020	NA	0.000020
TBT	0.053	0.14	0.19
Total Hazard Index	0.095	0.14	0.23

NA Not applicable for this pathway.

Table 8. Values used for daily intake calculations for fish and shellfish consumption pathway.

Scenario Timeframe: Current/future
Medium: Sediment
Exposure Medium: Animal tissue

Exposure Point: Fish and shellfish
Receptor Population: Fisher
Receptor Age: Adult

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	CT Value	CT Rationale/ Reference	Intake Equation/ Model Name
Ingestion	EPC	Exposure point concentration in fish or shellfish	µg/kg	Table 4-3	–	Table 4-3	–	Chronic Daily Intake (CDI) (mg/kg-day) =
	IR-F	Ingestion rate - fish[a]	g/day	105[b]	Toy et al. 1996	31	Ecology 1999, based on Landolt et al. 1985	EPC x IR x FI x FR x EF x ED x CF1 x CF2 x 1/BW x 1/AT
	IR-S	Ingestion rate - shellfish[a]	g/day	61[c]	Toy et al. 1996	5[d]	Toy et al. 1996	
	FI	Fraction ingested (by species)	unitless	Table 4-2	see text	Table 4-2	see text	
	FR	Fraction ingested from site	unitless	1	see text	1	see text	
	EF	Exposure frequency	days/year	365	see text	365	see text	
	ED	Exposure duration	years	30	USEPA 1991a	9	USEPA 1991b	
	CF1	Conversion factor	kg/g	0.001	–	0.001	–	
	CF2	Conversion factor	mg/µg	0.001	–	0.001	–	
	BW	Body weight	kg	70	USEPA 1991a	70	USEPA 1991a	
	AT-C	Averaging time - cancer	days	25,550	USEPA 1989	25,550	USEPA 1989	
	AT-N	Averaging time - noncancer	days	10,950	USEPA 1989	3,285	USEPA 1989	

SOURCE: Standard Table 4 in USEPA (1998a)

NOTE: CT - central tendency
RME - reasonable maximum exposure

[a] Consumption rates based on wet weights as consumed prior to cooking; preparation methods differ between individuals; see Appendix A and source documents for more information.

[b] 95th percentile total finfish consumption rate for both tribes combined from Toy et al. (1996, Table 3) adjusted to account for fishing within Puget Sound only (multiplied by fraction of 0.687; see Appendix Table F-1)

[c] 95th percentile shellfish consumption rate for both tribes combined from Toy et al. (1996, Table 3) adjusted to account for fishing within Puget Sound only (multiplied by fraction of 0.669; see Appendix Table F-1).

[d] Median shellfish consumption rate for both tribes combined from Toy et al. (1996, Table 3) adjusted to account for fishing within Puget Sound only (multiplied by fraction of 0.669; see Appendix Table F-1).

Table 9. Total PCB concentrations measured from stations located within the West Waterway OU

Study	Sample Depth	Stations in West Waterway OU	Minimum	Median	Maximum	# exceeding SQS (12 mg/kg OC)	# exceeding CSL (65 mg/kg OC)
RI/FS (Weston 1995)	0 to 2 cm	33	0.0 (mg/kg OC) 0.0 (µg/kg dw)	5.2 (mg/kg OC) 92 (µg/kg dw)	34.2 (mg/kg OC) 467 (µg/kg dw)	9	0
SRI (EVS and Hart Crowser 1996)	0 to 10 cm	25	6 (mg/kg OC) 91 (µg/kg dw)	14.4 (mg/kg OC) 290 (µg/kg dw)	81.1 (mg/kg OC) 1460 (µg/kg dw)	21	1

Note: Total PCBs were summed using a value of zero for undetected individual Aroclor values, which is the approach recommended by Washington State and the Puget Sound Dredged Disposal Analysis program. Maximum values are less when the outlier is deleted (e.g., for the supplementary RI, the next highest value is 43.9 ppm-oc total PCBs (compared to the maximum of 81 ppm-oc total PCBs).

Table 10. Final risk estimates for the seafood ingestion pathway for the West Waterway OU (first row) and comparison risk estimates using alternative input parameters

	Percent Seafood Consumed from West Waterway OU	Exposure Duration	Ingestion Rate	Excess Cancer Risk[13]
Risk Estimates Based on Tulalip/Squaxin Study Ingestion Rates (from Proposed Plan)	10% to 100% (The final risk assessment for the West Waterway OU assumed 100% of all Puget Sound caught seafood was consumed from the West Waterway OU = 1 x 10^{-4}).	30 yr	76.5 g/day	1 x 10^{-5} to 1 x 10^{-4}
Comparison 1				
Risk Estimates Based on the Suquamish Study Ingestion Rates	10% to 100% (An addendum to the final risk assessment for the West Waterway OU assumed 100% of all Puget Sound caught seafood was consumed from the West Waterway OU).	30 yr	33.9 g/day	5 x 10^{-6} to 5 x 10^{-5}
Comparison 2				
Risk Estimates Based on Suquamish Study Ingestion Rates used for the LDW Scoping Phase	100%	30 yr (used for WWOU) to 55 yr (used for LDW)	84 g/day	2 x 10^{-4} to 3 x 10^{-4}

Note: These ingestion rates are based on tribal consumption surveys. The tribal ingestion rates exclude anadromous fish, such as salmon, and excludes seafood consumed at restaurants, from the grocery store, and from areas outside of Puget Sound. King County data estimate a non-tribal seafood ingestion rate for the Duwamish River at approximately 3 g/day.

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13. Given the uncertainties inherent in the risk assessment process, emphasis is placed on order of magnitude risk (e.g., 10^{-4} or 10^{-5}) when determining whether action is warranted under Superfund. EPA guidance indicates that the upper boundary of the risk range is not a discrete line at 1 x 10^{-4}, and given site-specific conditions, EPA can consider risk estimates slightly greater than 1 x 10^{-4} to be protective. Therefore, given site-specific conditions for the West Waterway OU, the risk estimates of 2 x 10^{-4} and 3 x 10^{-4} are within Superfund's acceptable risk range of 10^{-4} to 10^{-6} and action is not warranted under CERCLA.