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Remedial Action Report

Record of Preparation, Review, and Approval

Harbor Island Superfund Site

Lockheed Shipyard Sediment Operable Unit

Excavation and Containment of Contaminated Sediments

This report has been prepared in accordance with EPA OSWER Directive 9320.2-09A and will be used, along with the Construction Completion Report, as a basis for this report.

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REMEDIAL ACTION REPORT

LOCKHEED SHUIPYARD SEDIMENT OPERABLE UNIT
HARBOR ISLAND SUPERFUND SITE
SEATTLE WASHINGTON

EPA CERCLIS ID NUMBER

I. Introduction

Harbor Island is located approximately one mile southwest of downtown Seattle, in King County, Washington, and lies at the mouth of the Duwamish River on the southern edge of Elliott Bay (see Location Map - Figure 1). The island is man-made and has been used for industrial purposes since about 1912. The island is approximately 430 acres in size and is bordered by the East Waterway and West Waterway of the Duwamish River and by Elliott Bay to the north. Major features of Harbor Island, including the locations of the Todd and Lockheed shipyards, are shown in the Vicinity Map, Figure 2.

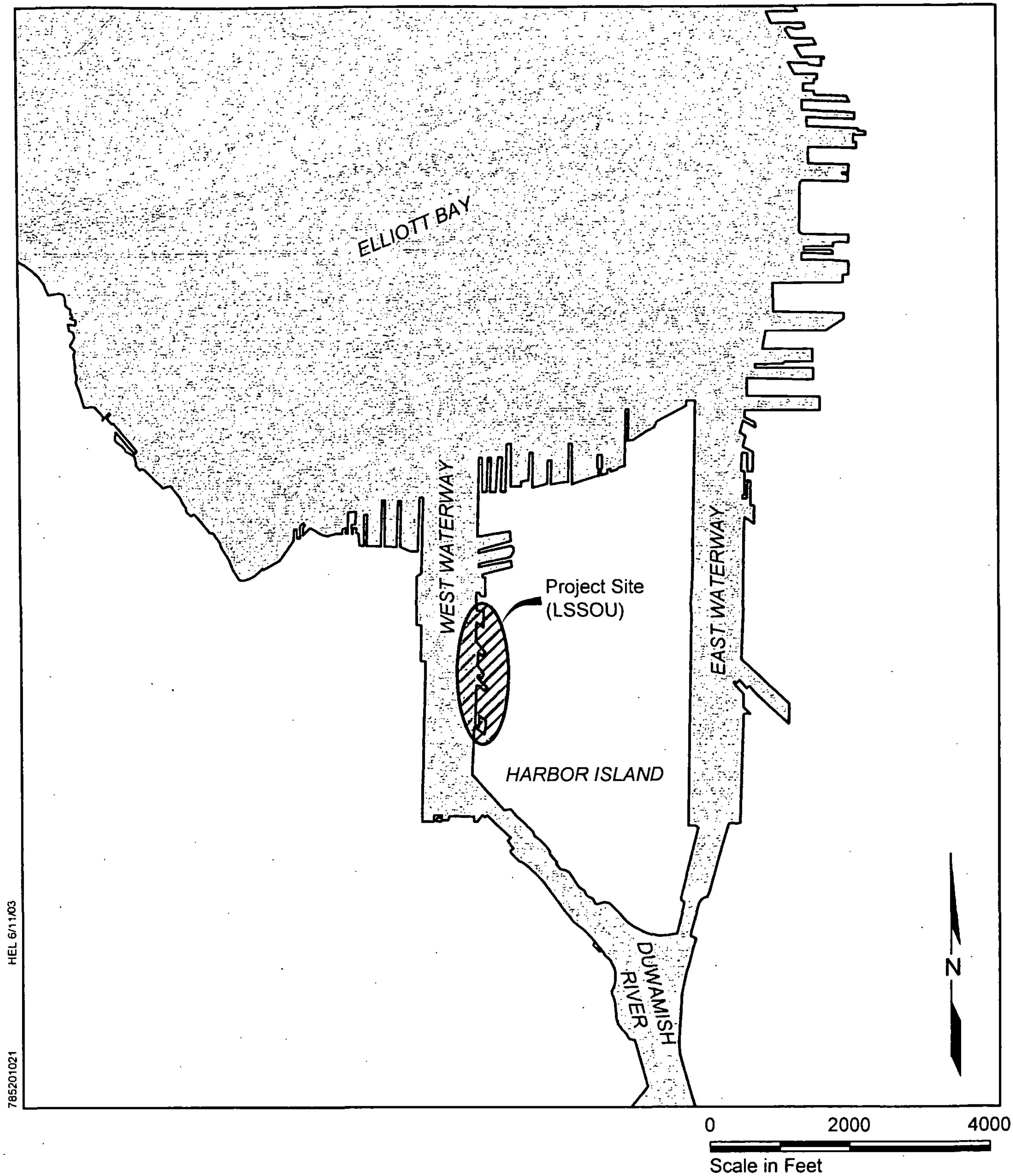
Prior to 1885, the area that is currently Harbor Island consisted of tideflats and a river mouth delta with some piling-supported structures. Initial construction of the island began between 1903 and 1905 when dredging of the East and West waterways and the main navigational channel of the Duwamish River occurred. Dredged sediment was spread across the present island area to form a fill 5 to 15 feet thick. This dredged sediment was later covered with soil and demolition debris from Seattle regrade projects.

Since its construction, the island has been used for commercial and industrial activities. Major activities have included ocean and rail transport operations, bulk petroleum storage and transfer, a secondary lead smelter, metal fabrication, and shipbuilding and repair. Warehouses, laboratories, and office buildings also have been located on the island. The Harbor Island Superfund Site was listed on the National Priorities List (NPL) in 1983, due to the release of lead from a secondary lead smelter on the island, as well as the release of other hazardous substances from other industrial operations on the island.

The Harbor Island Superfund Site is divided into seven operable units: (1) the petroleum storage tank facilities operable unit (OU), (2) the Soil/Groundwater OU, (3) the Lockheed Shipyard OU, (4) the Lockheed Shipyard Sediment Operable Unit (LSSOU)[1], (5) the Todd Shipyard Sediments Operable Unit (TSSOU), (6) the East Waterway Sediment OU, and (7) the West Waterway Sediment OU. The Lockheed Shipyard Sediment Operable Unit (LSSOU) includes nearshore sediments at Lockheed Shipyard out to the edge of the steep slope of the West Waterway, which occurs at approximately the minus

[1] At the time of the ROD, Todd and Lockheed Shipyard Sediment Operable Units were part of the Shipyards Sediments Operable Unit (SSOU). EPA created the Lockheed and Todd Shipyard Sediment Operable Units from the SSOU because they have different remedial issues that are better addressed as separate OUs.

Vicinity Map



Location Map

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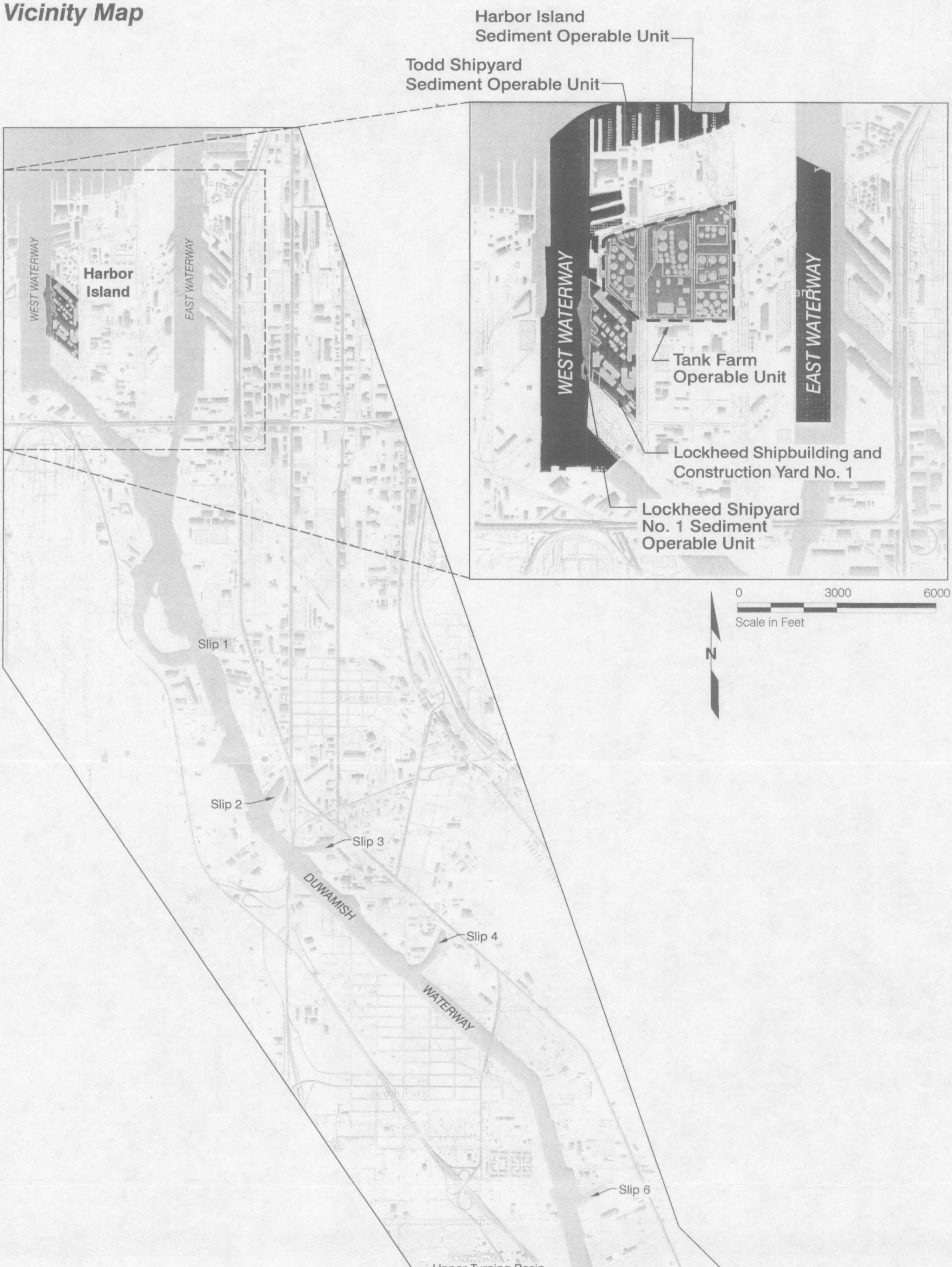
Figure 1 FDAR

Vicinity Map



Note: Base map prepared from USGS 7.5 minute quadrangle map of Seattle South, Washington, dated 1973.

Figure 2-1 3/98

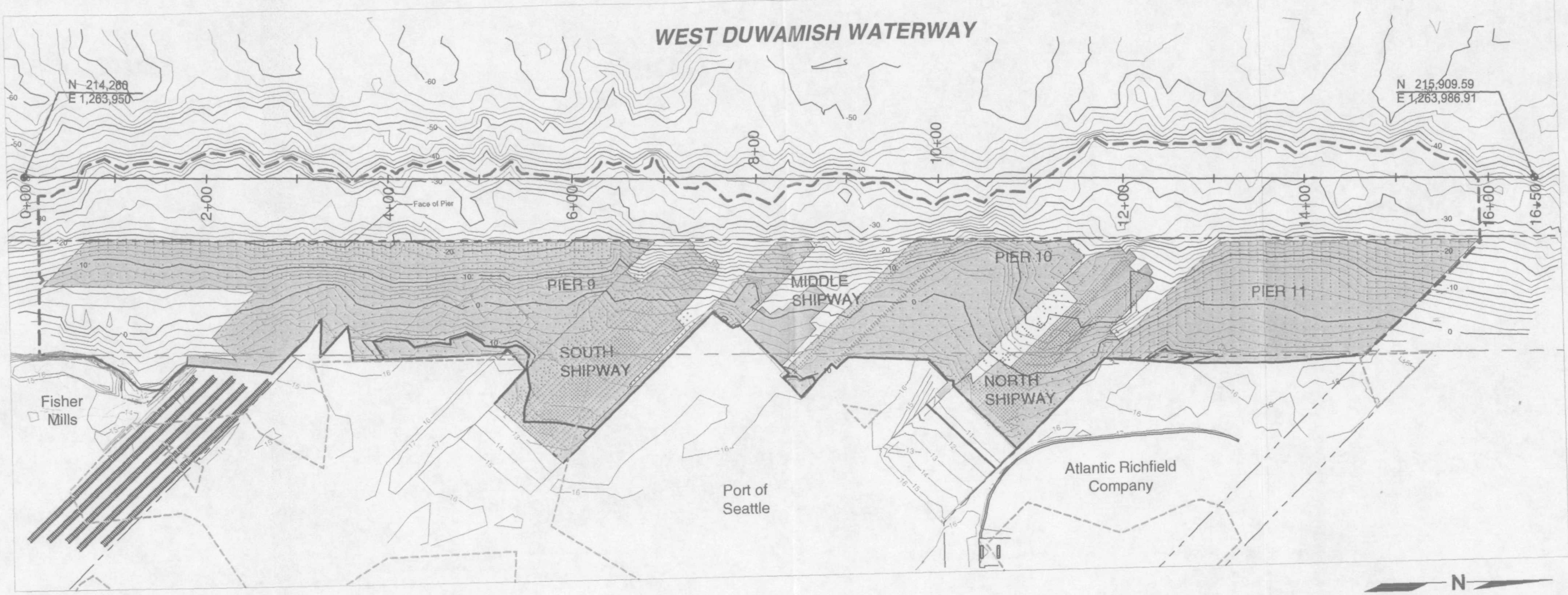
36 (-36) foot MLLW contour, as shown in the Features Map, Figure 3. These sediments are distinct from other contaminated sediments at Harbor Island because they are predominantly contaminated with hazardous substances and shipyard wastes (primarily abrasive grit blast (AGB)) released by shipbuilding and maintenance operations at Lockheed shipyards. Hazardous substances released from this shipyard include arsenic, copper, lead, mercury, and zinc, which were additives to marine paints used on ships. Other hazardous substances potentially associated with shipyard activities include polychorinated biphenyls (PCBs) and polycyclic aromatic hydrocarbons (PAHs).

An initial investigation of marine sediments around Harbor Island was completed by EPA in 1988 as part of the Elliott Bay Action Program. The nature and extent of contamination in Harbor Island sediments was characterized in a Remedial Investigation (RI) Report issued by EPA in September 1994. A Supplementary RI Report conducted by a group of Potentially Responsible Parties (PRPs) in 1995 further characterized the extent of chemical contamination in Harbor Island sediments and reported results of biological effects tests conducted on these sediments.

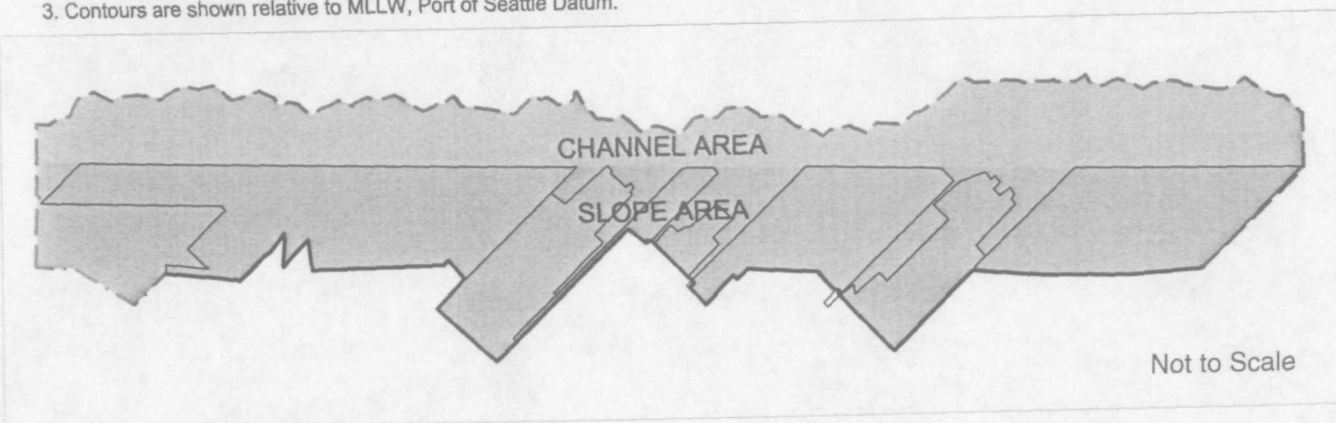
Evidence for adverse effects in benthic organisms due to contaminants in the LSSOU and the TSSOU have been demonstrated by exceedances of effects-based chemical thresholds, bioassays, and a mussel bioaccumulation study. The mussel study results further indicated that copper, lead, zinc, and TBT in the SSOU sediments are biologically available and bioaccumulate in mussels, causing adverse effects on these organisms.

The average risk from consumption of Elliott Bay fish was found to be 3 in 10,000 (3.0E-04) and high risk was found to be 4 in 1,000 (4.0E-03). Both of these risk levels exceed the acceptable excess cancer risk of 1 in 10,000 (1.0E-04) identified in the National Contingency Plan. The primary contaminant of concern for the human fish consumption risk is PCBs.

Site Features Map



Note:
1. Base map prepared from drawing provided by Hartman Consulting Corp. titled "Lockheed Yard", dated September 2, 1997.
2. Piling information based on drawing by Foster Wheeler Environmental Corporation titled "Piling Information" dated February 25, 1998.
3. Contours are shown relative to MLLW, Port of Seattle Datum.



Outer LSSOU Boundary (-36 Feet MLLW)

MHHW (11.35 Feet MLLW)

Approximate Location of Property Line

Bulkhead

Pierhead Line

Inner Harbor Line

Top of Bank

Upland Areas Requiring Long-Term Cap Monitoring and Maintenance (ICF Kaiser 1995)

Pier or Shipway Structure

Approximate Pile Locations

Approximate Location of Rail Spur

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Figure ~~1-2~~ 3 *FDAR*

II. Operable Unit Background

A Record of Decision for the Lockheed shipyard sediments and the Todd shipyard sediments was issued in November 1996. The chemicals of concern (COCs) for the sediments at each shipyard included arsenic, copper, lead, mercury, zinc, polychlorinated biphenyls, total low molecular weight polynuclear aromatic hydrocarbons, total high weight heavy polynuclear aromatic hydrocarbons and tributyltin. An Adminstrative Order on Consent (AOC) for Remedial Design was approved on July 16, 1997. Later, two Explanation of Significant Differences (ESDs) for the LSSOU were issued in February 2002 and March 2003, respectively, to amend the ROD.

The remedy described in the ROD for the LSSOU included:

(1) dredging to remove shipyard waste and contaminated sediments exceeding the cleanup screening level (CSL) of the State of Washington Sediment Management Standards (SMS);
(2) capping contaminated sediments exceeding the sediment quality standards (SQS) of the SMS;
(3) identification of acceptable disposal options;
(4) specification of design criteria for acceptable habitat and to prevent future recontamination; and
(5) institution of long-term monitoring and maintenance of the remedy.

The ROD also identified eight remedial design objectives which are to:

(1) identify sediment contamination exceeding the CSL and SQS;
(2) conduct confirmatory biological effects tests (optional);
(3) characterize dredged sediments;
(4) evaluate armoring of any caps;
(5) conduct habitat inventory;
(6) evaluate potential disposal sites;
(7) evaluate physical separation technologies for shipyard waste; and
(8) determine the extent of dredging under-pier sediments.

Additionally, the ROD notes that "(t)he extent of dredging of contaminated sediments and waste under piers at .... Lockheed Shipyard will be determined during remedial design based on cost, benefit and technical feasibility."

Subsequent to the ROD, pre-remedial design studies for the Lockheed Shipyard Sediment Operable Unit have better defined the nature and extent of contamination. This sediment characterization has been further used by EPA to determine the most technically feasible, cost-effective approach for implementing the dredge and cap remedy. During this pre-remedial design phase, EPA has also developed definitions for "shipyard waste", including definitions for AGB and shipyard debris. The more detailed description of the remedy and associated definitions were documented in an ESD, dated February 12, 2002.

Specifically, the ESD required the following remedial action:

1. In the Slope Area of the LSSOU (referred to as the under-pier, shipway, and enclosed areas in the ESD):

(a) *remove the shipway pier and decking; remove or modify pilings to* the maximum extent practicable so as not to compromise the stability of the existing bulkhead or existing slope but to permit dredging and capping as defined below;
(b) remove any shipyard debris that will impede dredging activities or compromise the integrity of the cap to be placed in these areas;
(c) dredge AGB to a sufficient depth to accommodate the cap without any loss of the present water column;
(d) dredge all sediments exceeding CSL to a depth sufficient depth to accommodate the cap without any loss of the present water column;
(e) cover all sediments exceeding SQS with a cap that shall physically and chemically contain and confine contaminants of concern; and
(f) dispose of contaminated dredged material at an appropriate upland landfill.

2. In the Channel Area of the LSSOU (referred to as the open-water areas in the ESD):
(a) remove any shipyard debris that will impede dredging activities or compromise the integrity of the cap to be placed in these areas;
(b) dredge all sediments exceeding SQS; and
(c) dispose of contaminated dredged material at an appropriate upland landfill.

A second ESD was issued on March 2, 2003. The primary purpose of the second ESD was to establish West Waterway confirmational numbers (WWCN) for some of the COCs. See Table 1 *for the* WWCN *by selected* COCs. *These numbers were used to* distinguish contaminants characteristic of the West Waterway from contamination associated shipyard operations at the point where the two operable units (OUs) met and could also be used in determining potential future recontamination. See Appendix A for an explanation of how these numbers were developed and were to be used. The WWCNs will be referred to henceforth as the West Waterway 90th percentile numbers (WW90N).

Table 1 -- West Waterway Confirmational Numbers

West Waterway Confirmational Numbers for Certain Chemicals of Concern			
Contaminant	**SQS (mg/kg)**	**CSL (mg/kg)**	**Confirmational Number**
PCBs	12 toc	65 toc	39 (mg/kg) toc 591 ug/kg dw
Tributyltin	not available	not available	76 (mg/kg) toc 1335 ug/kg dw
Mercury	0.41 dw	0.59 dw	1.34 (mg/kg) dw

III. Design Activities

In an Administrative Order on Consent (AOC) signed with EPA on July 16, 1997, Lockheed Martin agreed to perform the remedial design (RD) for implementing the remedy in conformance with the ROD as modified by the two ESDs. The RD was approved in parts. The RD for:

- demolition was approved on July 2, 2003
- First season dredging and capping was approved on October 25, 2003
- Second season dredging, capping and habitat enhancement on May 25, 2004.

To meet objectives of the ESD, the following criteria were utilized in the remedial design for the LSSOU:

- Replace the existing deteriorated bulkhead wall so the upland soils will remain stable during and after remedial activities, including the following:
  - Pier and timber bulkhead removal; and
  - Dredging adjacent to the bulkhead.
- Remove all existing pier structures including timber piling and portions of the existing shipway structures from aquatic areas of the site while maintaining the stability of the site.
- Dredge contaminated sediments from the channel and slope areas of the LSSOU while maintaining stable slopes and critical habitat elevations:
  - Design the dredge prisms and constructed slopes such that they will be constructible;
  - In the Channel Area, remove the depth of sediment exceeding SQS criteria and construct a berm to support the Slope Area and maintain critical habitat elevation;
  - Perform post-dredge sediment verification sampling and analysis to confirm achievement of SQS in the Channel Area; and
  - In the Slope Area, limit changes in the post-remediation of critical habitat elevations (i.e., between -4 to 8 feet MLLW) from that of the existing condition while accommodating a 5-foot-thick cap.
- Construct an on-site mitigation area:
  - Habitat losses resulting from the partial filling of the South Shipway will be mitigated by creation of intertidal habitat by excavation of the upland portion of Pier 10.
- Cap the Slope Area such that the cap will provide the following:
  - Isolation of the underlying contaminated sediments;
  - Protection of the isolation portion of the cap from bioturbation and erosional forces; and
  - A final cap surface that is habitat compatible.

IV. Construction Activities

A Consent Decree for remedial action was approved on July 23, 2003. Remedial Action was implemented in two phases. Phase 1 was completed on March 10, 2004 and Phase 2 was completed on February 4, 2005. The first phase of remedial construction efforts were focused on pier demolition and dredging of contaminated sediments. The second phase consisted of dredging contaminated sediments, capping and habitat enhancement.

PHASE I

Mobilization. Site mobilization began in early July 2003 with installation of temporary fencing, construction trailers, and associated infrastructure. Stockpile areas for treated wood debris from demolition were constructed. Debris booms were placed in the water to contain floating debris.

Demolition. Demolition began on July 18, 2003. All pier and shipway decking was removed concurrently with the removal of pilings using a vibratory hammer attached to a crane mounted on a barge or a crawler crane equipped with a vibratory hammer working from the shore to remove nearshore piling.

Wood debris was either placed on a barge which was unloaded on site into a stockpile area or transported by land-based equipment to the stockpile. In the stockpile, the debris was crushed to the maximum allowed size for eventual transportation via 48-foot steel containers to the Waste Management landfill in Arlington, Oregon.

Visual monitoring of water quality was conducted during demolition and sheet-pile bulkhead construction.

Demolition was essentially completed in 14 weeks. The debris stockpile area was dismantled the following week.

Bulkhead Construction. Construction of the sheet-pile bulkhead began immediately began immediately after demolition. Typically, demolition of the existing bulkhead was completed just ahead of the sheet-pile installation crew. Finishing the new sheet-pile bulkhead included forming and pouring a steel-reinforced concrete pile cap, which often took place well after the steel sheets were driven. All bulkhead construction work was completed in 22 weeks. Monitoring the new bulkhead for movement was conducted by surveys and no significant movement was detected.

Contingency Area Sampling. Sediment sampling was conducted along the perimeter of the OU to ensure that the OU boundaries were adequately defined. The sampling was accomplished on November 24 and 25, 2003. Based on the results of the sampling, EPA determined that the OU boundaries adequately defined the extent of contamination associated with the LSSOU.

First Season Dredging. Prior to beginning dredging, an uplands facility for offloading dredged sediment from materials barges, stockpiling it to promote dewatering, and loading the sediment on to rail cars (gondolas) was constructed. The following week excavation of sediments in the beach areas commenced using standard upland earthwork equipment. This work was done at low tides. Dredged (excavated) debris and sediments were transported by truck to the dewatering and stockpile area in the former South Shipway. These materials were transported and loaded into the gondolas using front-end loaders. Dredging using upland equipment continued periodically. Dredging was undertaken using a shallow to deep pattern in order to capture any material that would become unstable and slide down the slope.

The presence of hard material, debris, and broken off or buried piling made the use of a closed environmental bucket infeasible. A 3.5-cubic-yard digging bucket was therefore used. Upland separation was used to segregate much of the debris from the sediment waste stream. The debris became a separate waste stream which was shipped out by truck. The degree to which the sediments would dewater varied over the course of the project and was impacted by rainfall. On some occasions the dredged materials were very dark and granular and dewatered well. However, in many cases the sediments were finer-grained and did not dewater enough to allow effective handling and shipping. In those instances, diatomaceous earth was added directly to the gondolas to control water.

On January 29, 2004, sediment grab samples were taken in accordance with the Field Sampling Plan in three of the 17 sediment management units (SMUs) in the Open Channel Area. Observations were made of redeposited material in the grab samples and exceedances of many of the COCs at levels of up to five times the SQS where measured. Based on these unfavorable initial results, additional samples were obtained on February 6 and 11 using shallow core tubes to better understand the initial failure to meet SQS. Both redeposited material from dredging and in-place material that was of shipyard origin proved to have elevated levels of specific COCs compared to the required SQS for the COCs. Consequently, the Open Channel Area did not meet the requirements of the ROD and ESDs and further dredging during the second dredge season was required.

Table 3 summarizes the total tons of material disposed as a result of demolition and dredging activities. Approximately 74,000 tons of the 1197,064 total tons disposed were from dredged sediments and debris only.

.Hydrographic single-beam and multibeam surveys were conducted before, during, and following dredging. These surveys documented the volume of material removed, provided a general idea of the depth of the interim cap and served as the basis for additional dredge design in the second construction season.

Interim Cap. Following the termination of dredging, a thin layer (approximately 4 inches) of coarse sand was placed over the entire LSSOU. This material amounted to approximately 8,290 tons. The material was intended to limit any movement of contaminated fine materials as well as to protect marine life from any harm due to exposure to COCs until dredging could resume after the end of the in-water work closure window. Work window closures define the construction season for in-water work and generally preclude work from February 15 to August 15, depending on the area and nature of construction. A diver survey was conducted to document the thickness and coverage of the interim cap. Overall coverage from 2 to over 4 inches of interim cap was confirmed. Cap materials were sampled for chemistry to assure they would not contribute to any COCs as well as for grain size. Any work conducted after February 14 was subject to a requirement that the LSSOU be periodically checked for the presence of protected juvenile salmon using approved beach-seining methods. In the event more than a certain number of protected fish were observed, all in-water work would be stopped. A few protected species were observed and no interruption to operations was necessary.

Focused Feasibility Study. Before, the start of the second season of dredging a Focused Feasibility Study was conducted to evaluate the dredging methodologies used the first dredging season and to evaluate other methodologies that could be used more successfully during the second dredging season. Many options for second season dredging in the Open Channel Area were evaluated and compared in the Focused Feasibility Study. Alternative 3, Mechanical Dredging with Optional Enhanced Natural Recovery (ENR), was recommended as the best remedial alternative. ENR is the application of a relatively thin layer, usually approximately 10 cm. of sand or other fine grained material to the top surface of a contaminated surface. ENR is an acceptable remedy when information shows that the top 10 cm of surface will meet the SQS within 10 years of application through bioturbation of the clean and contaminated layers. As additional sediment is deposited on the mixture through natural processes, the exposure to marine organisms is further reduced.

PHASE II

Second Season Dredging. To reduce to an absolute minimum the potential for redeposition of dredged materials, a three-step operational approach was adopted. First, any identified debris areas would be dredged to clear the debris using a standard digging bucket. Second, an initial dredge pass using the same bucket would be made over the entire operable unit to remove the bulk of the contaminated material and any remaining debris, leaving behind a final layer less than one-foot thick. The final pass would use an environmental bucket to dredge the final, relatively thin layer and any redeposited material from the initial debris clearing and first-pass dredging. The final pass would be dredged to the native material because analytical data from cores indicated that contamination extended to native material and that the native material was clean. At times, scrapping the top of the native material with the environmental bucket was necessary to remove residual contaminated material left behind after the final pass.

The dredging contractor proceeded to dredge the first pass utilizing a 5-cubic yard digging bucket. This operation took place in a southern to northern pattern with the first pass beginning on October 19, 2004 and being completed on October 28, 2004. The materials were brought to the surface, held just above the surface in order to allow the water to drain from the bucket, and placed in a materials barge equipped to dewater the sediments. The barge typically was filled within two to three days. It was left moored over the work area to allow for farther drainage overnight. The following morning the barge was towed over to Terminal 25 for unloading and shipment to an upland disposal facility. Straw bales were placed around the open end of the barges to filter the escaping water from the sediments and a filter liner was installed on the inside perimeter wooden bulkhead. Any damage to the fabric was repaired immediately to ensure continuous compliance with the BMPs.

Water quality monitoring was accomplished through both visual observation and testing for turbidity, temperature, dissolved oxygen, total suspended solids and COCs. No exceedances of compliance criteria were noted throughout the operation.

Progress surveys were taken by the contracted survey group on October 20, 22, 25, 27, and 29. The primary purpose was not only to determine the depths being achieved but also to determine whether any "sloughing" had occurred. In general, the depths observed during dredging were identical with those measured by the progress survey and no significant sloughing was identified.

The second dredging pass utilized a 6-cubic-yard closed environment bucket and, once again, the work began at the southern end of the project and proceeded northward. This effort began on October 30, 2004 and was initially completed on November 12, 2004. During Weeks 3 and 4, qualitative sediment sampling was conducted with a small grab-sampling device. The results indicated in nearly all cases that native materials were encountered, indicating redeposition was not likely to be a problem.

At various times during the second-pass operations, sediment samples were taken using composite cores to determine whether the second-pass dredging operations were adequate in the removal of undesirable sediments. These progress samples were taken on November 4,10 and 11. It was determined from further analytical testing of individual progress sample cores that several areas were in need of further dredging in order to reach the required SQS. These areas were targeted in consultation with the EPA and dredged to a predetermined depth based on results of cores, or refusal, which ever came first. Refusal was targeted as the underlying native sand which was clean (based on analytical chemistry) and relatively hard, assuring a clean surface. This work took place on November 13, 16, 18, 19, and 21.

A final round of progress samples were taken using a van Veen grab sampler at various locations on November 22 to document the condition of the sediments following final dredging in the targeted areas. The chemical results were analyzed. EPA made the determination that a best effort had been made to dredge to the SQS and that further dredging probably would not result in removing the material causing exceedances of the SQS in the few areas that it existed.

A total of eight sediment samples were collected from the post-dredge surface of the channel area (SMAs 1-7) to evaluate compliance with the design criteria. All analytical results were compared to the SQS chemical criteria to evaluate compliance. Out of 248 chemical analytical results, from eight samples, three samples exceeded the SQS for PCBs only. Three other samples out of eight or 30 analytical results out of 248, exceeded the SQS for a combination of COCs. Therefore, a total of 33 of 243 analytical results failed the SQS. The following table summarizes the nature and locations of exceedances and the corresponding remedial action.

Table 2 – Nature and Locations of Exceedances and the Corresponding Remedial Action

Sampling Locations	SQS Compliance Criteria	Sampling Results	Remedial Decision
SED-200	PCBs – 12 mg/kg toc	13 mg/kg toc	pass
SED-201	PCBs – 130 ug/kg dw	146.5 ug/kg dw	ENR
SED-202		no exceedances	pass
SED-203	As – 57 mg/kg toc LPAH – 370 mg/kg toc	As – 73.4 mg/kg toc LPAH – 1620 mg/kg toc	ENR

	HPAH - 960 mg/kg toc PCB - 12 mg/kg toc	HPAH - 1937 mg/kg toc PCB - 21 mg/kg toc	
SED-204	As - 57 mg/kg toc Cu - 370 mg/kg toc Zn - 960 mg/kg toc Hg - 0.41 mg/kg dw PCB - 12 mg/kg toc	As - 127 mg/kg toc Cu - 829 mg/kg toc Zn - 585 mg/kg toc Hg - 0.618 mg/kg dw PCB - 20 mg/kg toc	ENR
SED-205		no exceedances	pass
SED-206	PCB - 12 mg/kg toc	PCB - 18 mg/kg toc	pass
SED-207	As - 57 mg/kg toc Cu - 370 mg/kg toc Zn - 960 mg/kg toc Hg - 0.41 mg/kg dw LPAH - 370 mg/kg toc	As - 139 mg/kg toc Cu - 553 mg/kg toc Zn - 912 mg/kg toc Hg - 1.32 mg/kg dw LPAH - 1341 mg/kg toc	ENR

The remedial action for portions of the channel area, represented by samples SED 201, 203, 204 and 207, that failed to meet the clean up numbers was the addition of 4 to 6 inches of sand to the sediment surface, namely Enhanced Natural Recovery. Areas where there was an exceedance of PCBs only, no action was taken because the exceedances were minor and were below the 95th percentile WWCN for PCBs.

A final multibeam survey for the entire site was taken on November 22, which was used as the baseline survey for the capping effort. Results indicated that targeted dredge depths were met or exceeded. The final quantity of dredged sediment, soil and debris delivered to the two upland disposal facilities was 106,320.50 tons. Table 3 summarizes by material type and quantity all material disposed at upland disposal facilities.

Table 3 - Total Tons of Demolition and Dredged Sediments and Debris by Disposal Route

Dredging and Disposal Events	Weight in Tons	Notes
First Construction Season		
Dredge and Debris Disposal by Rail	85,096	864 Rail Cars
Soil and Dredge Disposal by Truck	1,118	
Creosote Treated Wood Disposal by Bins	10,660	442 Bins
Wood Salvage for Reuse	205	
Concrete Recycle	121	
Concrete w/Rebar Recycle	1,113	
Steel Recycle	36	

Subtotal	98,349	
Second Construction Season		
Dredge and Debris Disposal by Barge	21,107	15 Barges
Rock and Soil Disposal by Truck	586	
Creosote Treated Wood Disposal by Bins	21	1 Bin
Sample Disposal by Bin	1	1 Roll Off
Subtotal	**21715**	
Total	**119,064**	

Waterway Capping-- Employing Marine Equipment. The waterway capping effort in the areas deeper that approximate elevation 0 feet MLLW commenced on November 23, 2004 and was completed on February 3, 2005. Initially a toe buttress of riprap was placed from south to north along the western boundary of the slope area of the project. This material was Glacier Product #7360 and was placed from November 23 to December 1, 2004 with the exception of Station 14+17 to 15+9.1, which was placed on December 21, 2004. After the buttress was in place, the first layer of attenuation material consisting of gravely sand, Glacier Product #7180, was placed at approximately 1 -foot thickness. Due to an agreement with the EPA, the entire site was not done at once, but rather in 2 sections, in order to help provide erosion of the attenuation layer by currents for a long period of time. This effort commenced on December 2, 2004 and was completed on December 4, 2004. A diver survey on December 5 was conducted to check for uniform coverage and stability of the material on the slope with favorable findings of at least one-foot of a relatively uniform thickness. No indications of sliding or other accumulation were noted. Final quantities utilized are shown in Table 5 of this report.

The second lift of gravely sand attenuation material was then placed to achieve the desired 2-foot-minimum thickness. This operation began on December 6, 2004 and was completed on December 9, 2004. The second layer was also targeted to construct the designed 2:1 slope. To accomplish this slope, additional material was applied in specific areas. Multibeam progress surveys were completed on November 27 and 29 as well as December 1, 5, and 8 to document the placement of gravely sand attenuation material. Survey results indicated that application rates and methods were effectively meeting design grades and thicknesses.

The rig then moved back to Station 0+16 at the southern project boundary and began application of the required minimum of 1-foot of angular filter rock. This material was Titan Rock Product #5QS 1A. This application began on December 10, 2004 and was completed on December 11, 2004. A multibeam progress survey was completed on December 12 to document the filter placement, which was indicated to be uniform and of the intended one-foot thickness.

Again, the rig returned to Station 0+16 and began placement of the required 2-foot minimum of armor rock (riprap) on top of the filter rock. This operation began on December 14, 2004 and was completed on December 22, 2004. Except for the top layer of habitat mix, which was scheduled to be applied at the end of the project, this riprap layer completed the cap construction using waterway equipment for the south half of the project.

By late December the cap application in the shallow areas, using upland equipment was completed (less habitat enhancement materials) for the southern half of the project.

The northern half of the cap installation, using marine equipment, began on December 24, 2004 with the installation of the first 1-foot-thick pass of attenuation layer material. This was completed on December 29. A multibeam progress survey on December 30 tracked attenuation material placement in the north as well as the recently-completed southern riprap layer. On January 2, a diver survey was conducted to check for uniform coverage and stability of the first pass. The sand was found to be uniformly distributed with the appropriate thickness and showed no signs of stuffing or raveling on the slope.

The second-pass layer of attenuation material was then installed from December 30 through January 6,2005. This pass completed the minimum 2-foot layer thickness target and provided the necessary 2:1 slope through the application of additional material in selected areas. As previous, a multibeam progress survey on January 6 documented this effort. Application of the northern half of the filter layer commenced on January 10 and concluded on January 12, 2005. On January 6, a multibeam progress survey documented northern filter placement. The placement of the armor rock (riprap) over the filter layer in the northern half of the site began on January 13, 2005 and was completed on January 24, 2005 as documented in a multibeam progress survey that day. The approved habitat mix, Glacier Product #7123, was tested for appropriate chemical parameters and placement of the product began on January 25, 2005. The material was placed in variable thicknesses based on depth as per approved plans over the entire cap area recently placed by the marine equipment. In addition, in the Pier 11 area the material was placed on the beach area since this area was not readily accessible by upland equipment. The habitat mix application was completed on the February 2.

A final multibeam survey of the completed cap, including habitat mix as placed by marine equipment, was completed on February 8, 2005.

Waterway Capping -- Employing Upland Equipment and Methods. The beach portion of the waterway cap in the elevations shallower than approximately 0 feet MLLW commenced on December 8, 2004 and was completed on January 14, 2005. The majority of the work was accomplished during two low-tide cycles at night (December 8 through 17 and January 6 through 14). The cap was placed utilizing upland equipment and methods (i.e., loaders, dozers, and a Telebelt mobile conveyor system which placed the attenuation layer) with BMPs strictly enforced. The cap in this area utilized the alternative cap design on slopes of 5H:1V. This alternative design consisted of 2 feet of attenuation material overlain by 3 feet of cobbles to serve as a geotechnical/armor layer. All slopes steeper than 5H:1 V were constructed using the standard cap design. These areas included all the slopes immediately adjacent to the bulkhead. Final quantities utilized are shown in Table 5 of this report.

The attenuation material consisting of gravely sand, approved Glacier Product #7180 was placed from approximate Stationing 0+16 to 7+50 (south to north) from December 8 through December 14 and from 15+50 to 7+50 (north to south) between January 5 and January 10, 2005. This material was placed to the full height required to meet a minimum of 2 feet. A relatively simple system was employed to ensure the material met the 2-foot thickness requirement. Prior to placing material, a series of grade stakes were driven into the beach and flagging was tied 2' 4" above the existing grade. The Telebelt operator was stationed on the beach to observe placement of the material and was able to move the belt using remote control to place the required material to bury the flagging. The 3-foot-thick geotechnical/armor layer, consisting of a rounded gravel/cobble mix, Washington Rock Product #040B, was then applied while the latter stages of the attenuation material were still being applied further up the beach. This effort began on December 11 and was completed on December 16, 2004 at Stationing 0+16 to 7+50 (south to north) and on January 8 through January 14, 2005 for Stationing 15+50 through 7+50 from north to south. A system similar to the attenuation material was employed to insure the 3-foot-thickness geotechnical/armor layer was placed. Grade stakes were driven into the existing attenuation layer and flagging attached 3 feet above existing grade. A small bulldozer then graded the material from the supply point near the bulkhead or upland supply area down the beach to cover the flagging at each grade stake. The southern portion of the boundary rock (riprap) was placed on December 13 followed by the sheet-pile wall armor rock (riprap) from December 14 through December 17, 2004 from south to north. Simple measurements of area covered and intended height provided confirmation that riprap was placed according to plans. These were confirmed by tracking delivered versus used quantities.

The northern portion of the boundary rock was placed on January 11, 2005 followed by the sheet-pile armor rock (riprap) being installed from January 11 to January 15, 2005 and again installed from north to south.

Quality-assurance topographic surveys, using standard upland survey equipment and methods, were taken for the first portion of the placement on December 6,9,11, and 14. Topographic surveys were taken for the second portion on January 7,9,11, and 14. A final survey was taken over the entire beach portion of the waterway on February 28 during a low-tide period. The final survey figures indicate that within the uncertainties of the surveys and construction methods employed, cap construction met the design parameters.

Approved habitat-mix materials were then applied using upland equipment during low tides to elevations -3 feet MLLW and shallower in the beach application. In addition to the originally-specified habitat mix, the two additional habitat mix materials were used, Glacier's #7180 (same as the attenuation layer) and Washington Rock's Pit Run Product #020. These were applied in a 1 -foot thick layer over the top of the geotechnical layer material. Grade stakes were driven into the geotechnical/armor layer and flagging was attached one foot above existing grade. The appropriate habitat mix for each area of the site was then placed by a small bulldozer from the supply point next to the shoreline down the beach to cover the flagging on the graded stakes. In addition, the required 1 cubic foot per lineal foot "feeder" berms were installed. This effort, for the entire site, was accomplished from south to north between January 13 and February 3, 2005. Final waterway capping material placement quantities can be seen in Table 5.

Table 5 – Tonnage of Capping Material Placed by Type

Capping Event	Weight in Tons	Notes
Phase 1 Construction Season		
Interim Cap	8,290	covered entire OU
Subtotal	**8,290**	
Phase 2 Construction Season - Applied by Marine Equipment		
Toe Buttress Riprap	4,854	
Armor Riprap	13,501	
Sand Attenuation Cap Layer	21,479	
Filter Layer	5,951	
Rounded Filter/Armor Layer	1,451	one barge load
Fish Mix	8,667	
Subtotal	**55,903**	
Phase 2 Construction Season - Applied by Upland Equipment		
Armor Riprap	2,446	
Sand Attenuation Cap Layer	13,052	includes habitat mix in some areas
Rounded Filter/Armor Layer	17,018	
Fish Mix - Pit Run	3,001	
Subtotal	35,517	
Total	**99,710 Tons**	

Mitigation Area Construction. The mitigation area construction took place during both low-tide cycles and non-low-tide cycles. All work was done with upland placement equipment. Similar to the previously-described beach areas, a 5-foot-thick cap was installed (2-foot chemical attenuation layer with a 3-foot rounded rock geotechnical layer on top) from elevation +2 feet MLLW to approximate elevation +10 feet MLLW. This was followed by placement of armor cap material (riprap) between elevations +10 upward to approximately +16 at a slope ratio of 2:1. Habitat mix was applied to the area on February 3,2005 with the required feeder berm installed on the 16th.

Douglas fir logs, per the plans, were then attached to the top of the armor rock at the grade break between the upland planting area and the beach/mitigation area. Geotextile fabric was spread along the upland side of the armor material and on top of a base layer of rounded rock in the planting area to preclude the loss of material from the planting area. This work was completed on February 10 and 11, 2005.

Following completion of the earthwork, the remainder of the Mitigation Area (the planting area) was constructed per the Habitat Mitigation Plan. Woody debris obtained from the US Army Corps of Engineers was placed and secured in the upper beach area. Topsoil material (50/50 garden mix from Palmer Coking Coal Co.) was brought in for the planting area and placed on February 15 and 18. Planting mix (Steerco from Sawdust Supply Co.) was brought in on February 18 and installed. Plantings were completed on February 22, 2005.

IV. Chronology of Events

Date	Event
November 27, 1996	Record of Decision
July 16, 1997	Administrative Order on Consent for Remedial Design
April 2, 1999	Remedial Design Investigation Study
January 15, 2002	Basis of Design Report
February 22, 2002	Explanation of Significant Difference (ESD)
March 31, 2003	Explanation of Significant Difference (ESD)
May 1, 2003	Consent Decree (CD)
July 31, 2003	Remedial Design - Demolition and Bulkhead Construction
July 7, 2003	Demolition and Bulkhead Const. Begins, Season 1 (2003/2004)
October 2003	Remedial Design - Dredging and Capping
November 22, 2003	Dredging Begins, Season 1 (2003/2004)
November 23 and 24, 2003	Contingency Area Sampling
January 29, 2004 February 6 and 11, 2004	Confirmatory Sampling, Season 1 (2003/2004)
March 10, 2004	Dredging Season Ends, Season 1 (2003-2004)
May 6, 2004	Video Survey
May 19-28, 2004	Sampling Open Channel Area
July 13, 2004	Diver Survey
August 11, 2004	Focused Remedial Investigation/Feasibility Study
November 30, 2004	Remedial Design - Dredging and Capping

October 22, 2004	Proposed Slope Cap Design Modification Tech. Memo
October 22, 2004	Dredging Begins, Season 2 (2004/2005)
November 10,11,22,2004	Confirmatory Sampling, Season 2 (2004/2005)
December 3, 2004	Toe of Slope Sampling and Analysis Plan
December 1-3,2004	Toe of Slope Core Samples Taken
November 23, 2004	Capping Begins, Season 2 (2004/2005)
February 4, 2005	Capping Completed, Season 2 (2004/2005)
March 7, 2005	Final Remedial Action Inspection
April 1,2005	Demobilization Completed
September 8, 2005	Construction Completion Report
September 28,2006	Operation, Maintenance and Monitoring Plan

V. Performance Standards and Construction Quality Control

Table 6 below summarizes remediation objectives or cleanup goals and describes how these objectives or goals were met.

Table 6 -- Remedial Objectives and Results

Remediation Objectives/Cleanup Goals	Performance Results
In the under-pier area	
• dredge all sediments exceeding CSL to a depth sufficient depth to accommodate the cap without any loss of the present water column	Bathymetric and topographic surveys conducted post-dredging verify that the design depth for dredging was obtained.
• cover all sediments exceeding SQS with a cap that shall physically and chemically contain and confine contaminants of concern	A cap was designed to contain COCs. The designed cap was five feet thick. Bathymetric and topographic survey data verify that the cap design specifications were obtained. Long-term monitoring of the cap will verify whether containment has been obtained.
In the open water area	
• dredge all sediments exceeding SQS	Confirmational sampling data demonstrate that the cleanup goal, the SQS, was obtained with a couple exceptions. Where EPA determined that it was not feasible to obtain the cleanup goal, a thin layer of sand was added to promote natural recovery.
Dispose of contaminated dredged material at an appropriate upland landfill.	Dredged material and debris were disposed at Columbia Ridge Disposal Facility operated by Waste Management during the first operational season. The second season the sediments were taken to the Roosevelt Regional Landfill operated by Regional Disposal Company.
Restore habitat to the extent possible.	The top foot of the cap was made entirely of materials that were compatible developing and sustaining a marine benthic community and were stable.

Dredging and Capping. Inspection, verification, and monitoring were to be performed to confirm compliance with the project plan and specifications. Key activities for this element of the work included the contractor monitoring the location being dredged and the depth of dredge for that location (using specialized equipment on the dredge), and establishing horizontal and elevation survey control systems that are acceptable to EPA (i.e., meet the performance requirements designated in the Project Specifications). The horizontal survey was to be used to verify that sediment dredging and capping had been completed over the intertidal and subtidal areas of the site according to the Project Plans and Specifications. The vertical survey was to be used to verify that required dredging depths and capping thickness for each capping layer were achieved.

Survey reference points and base stations were to be staked and maintained by the contractor until dredging and capping have been completed. Permanent survey markers were to be left in place for the purposes of long-term monitoring of the slope area cap and sedimentation in the channel excavation area. Both land-based and hydrographic survey methods were used. The methods and performance standards for surveys are described in detail in the Project Specifications. Further information is provided in the contractors Hydrographic and Survey Plan provided as an attachment to the Remedial Action Work Plan. A key goal of the Construction and Quality Assurance Plan was to assure that the surveys adequately verify compliance with the design and specifications.

Confirmational monitoring for the dredging also included collection and analysis of sediment samples in the open channel area to confirm attainment of cleanup numbers, the SQS. See Section IV, Second Dredging Season for more information.

Inspection and monitoring of off-site transport of materials being disposed was to include confirmation that any containers loaded at the site were closed and protected from spilling or leaking, counts of the containers leaving the site, and measurement of the weight or volume of material disposed at the landfill. When an off-site transloading facility was used, some of these responsibilities will be the transloading facility operators. Waste management is further discussed in Section 5.4 of the Remedial Action Work Plan.

There was also confirmatory sampling performed to verify chemical levels in the capping materials. This sampling and the performance standards are discussed in Chapter 6.0 of the Remedial Action Work Plan. Data validation was performed on selected data as per the Remedial Action Work Plan.

A summary of dredging quality-control and project progress records for Phases I and II are shown in Tables 7 and 8, respectively. In general, the records indicate that improvements in dredging equipment and methods employed during the second construction season were instrumental in largely achieving the SQS in the Open Channel Area. Redeposition was likely eliminated as an issue due to the use of debris clearing, two-pass dredging, and an environmental bucket for the second pass. The concurrent use of upland and marine equipment allowed the schedule to be met and provided for a simple and reliable method of constructing a multi-layered cap. Water quality exceedances beyond background conditions were minimal during both construction seasons.

Water Quality Monitoring and Management. Water quality monitoring was to be conducted for the following major construction phases:

- Bulkhead replacement
- Pier demolition
- Dredging
- Capping
- Barge dewatering
- Upland sediment dewatering

This monitoring effort was to provide information and document the potential effects of the construction activities on the environment in accordance with the Water Quality Certification. Visual monitoring was to be combined by monitoring with instruments. Monitoring stations including reference stations, mixing zones, and points of compliance were established for each activity. A tiered monitoring schedule of intensive, routine, and discontinued monitoring was established based on the length of time the construction had been ongoing without an exceedance of the compliance criteria. Temperature, dissolved oxygen, turbidity, salinity, and total suspended solids were standard monitoring parameters. COCs were periodically sampled and analyzed based on the monitoring schedule. Reporting and notification procedures were established for routine and non-routine operational situations.

BMPs were specified for each construction operation and included visual monitoring of any plumes along with BMP inspection and documentation. In-water BMPs included prohibition of work during work-closure periods; inspections to preclude the introduction of foreign materials to the waterway; the use of certain types of demolition, dredging, and capping equipment; the use of booms and silt curtains to contain debris and suspended material; and specifications for dewatering sediments.

The results of water quality monitoring were, with very limited exceptions, within the compliance criteria. On a few occasions, analytical chemistry results indicated exceedances of the ambient water quality standard for copper. When compared to reference values obtained outside the area of operations, the copper values were nearly identical, indicating no contribution from the construction activities. On one occasion, when an exceedance for turbidity was noted for upland sediment dewatering, it was attributed to nearby dredging that was well within the dredging mixing zone. On one occasion, very low levels of dissolved oxygen were measured which were shown to be an equipment malfunction which was repaired. Daily water quality reports were prepared and weekly summary reports were completed and included in the weekly construction activity reports.

Disposal. The contractor was to conduct regular inspections of all liners, stockpile covers, and other containment structures to ensure adequate containment, protection from erosion, and use of BMPs (including upland operations during Phase I). Any deficiencies in the containment barrier integrity were to be noted along with the corrective actions taken to repair or replace the liner. A Contingency Plan was developed as part of the RAWP to describe procedures to control and report spills or releases of contaminated materials, fuels, and other chemical products in use at the site. The dredging contractor, waste management contractor, and/or T-25 facility operator were to provide written documentation for all materials shipped for off-site landfill disposal. Truck weight tickets or barge displacement calculations indicating tonnage received and weekly reports were to be provided. Written documentation was to also include a complete accounting of the reuse, recycling, or disposal of all other materials removed during construction and demobilization. A summary of disposal quality control and project progress records for Phases I and II are shown in Tables 7 and 8, respectively.

Table 7 -- Summary of Phase 1 QA/QC Activities

page 1	TABLE 10 - QA/QC AND PROJECT PROGRESS REFERENCE TABLE	Demolition	Bulkhead Construction	Dredge Open Channel Area	Dredge Slope Area	Cap Slope Area Waterway Equip.	Cap Slope Area Upland Equip.
Phase II							
Appendix A	Daily QA/QC Documentation						
A.1	Upland Daily Diaries	X	X	X	X	X	X
A.2	Waterway Daily Diaries	X		X	X	X	X
A.3	Upland Compaction Testing		X				
Appendix B	Project Photographs						
B.1	Photographic Log	X	X	X	X	X	X
B.2	Photographs	X	X	X	X	X	X
Appendix C	Deviation from Original Plans/Specs.						
C.1	Cap Design Memo of 10/22/2004					X	X
Appendix D	Analytical Test Data						
D.1	Imported Material and Other Test Results		X			X	X
D.2	May 2004 Contingency Area Test Results						
D.3	Open Channel Composite Cores Results			X			
D.4	Post Dredge Added Core Analyses			X			
D.5	Redredge Grab Samples			X			
D.6	Post Dredge Samples (Summary of D.3-D.5)			X			
D.7	Slope Toe Composite Core Results			X			
D.8	Confirmation Sample Results			X			
D.9	Data Validation Report			X			
Appendix E	Air Quality Monitoring						
E.1	Hart Crowser Monitoring Results			X	X		
E.2	TRC Badge Results			X	X		
Appendix F	Water Quality Monitoring						
F.1	MCS Environmental Monitoring Results			X	X	X	X
Appendix G	EPA Oversight						
G.1	Weekly Summary Reports	X	X	X	X	X	X
G.2	Weekly Meeting Minutes	X	X	X	X	X	X
Appendix H	Activity Implementation Plans						
H.1	Sediment Dredging and Materials Handling			X	X		
H.2	Diving Plan					X	
H.3	Remaining Piling Removal Plan	X				X	X
H.4	Waterway Capping Plan					X	
H.5	Upland Capping Plan						X

Table 7 -- Summary of Phase 1 QA/QC Activities -- continued

	PROGRESS REFERENCE TABLE	Demolition	Bulkhead Construction	Dredge Open Channel Area	Dredge Slope Area	Cap Slope Area Waterway Equip.	Cap Slope Area Upland Equip.
Phase I							
Appendix J	Final Construction Schedule	X	X	X	X	X	
Appendix K	Project Surveys						
K.1	Multibeam Survey of Oct. 2003			X	X		
K.2	Multibeam Survey of Feb. 2004			X	X		
K.3	Interim Cap Diver Survey					X	
K.4	Fish Monitoring					X	
Appendix L	WISHA Incident						
L.1	Assessment Results			X	X		
L.2	Citation and Notice of Appeal			X	X		
L.3	Appeal Request			X	X		
L.4	Appeal Denial			X	X		
Appendix M	Plans and Specifications						
M.1	Phase I Specifications	X	X	X	X	X	
M.2	Phase I Plans-Demolition and Bulkhead	X	X				
M.3	Phase I Plans-Dredging and Capping			X	X	X	
Table 1	Dredged Sediments Disposal Recap			X	X		
Table 2	Creosote Treated Wood Disposal Recap	X					
Table 3	Salvaged Wood Disposal Recap	X					
Table 4	Salvaged Materials Quantities Recap	X					
Table 5	Upland Excavated Soil Removal Recap	X					
Table 6	Import DMOA Road Material Recap			X	X		
Table 7	Import DMOA Pit Material Recap			X	X		
Table 8	Import Bulkhead Backfill Material Recap						
Table 9	Import Capping Concrete Material Recap						
Table 10	Import Diatomaceous Material Recap			X	X		
Table 11	QA/QC and Project Progress Reference	X	X	X	X	X	X
Figure 1.1	Site Location Map	X		X	X		
Figure 1.2	General Site Plan	X		X	X		
Figure 1.3	Dredged Material Handling Area Layout			X	X		

Table 8 -- Summary of Phase II QA/QC Activities

	PROGRESS REFERENCE TABLE	Demolition	Bulkhead Construction	Dredge Open Channel Area	Dredge Slope Area	Cap Slope Area Waterway Equip.	Cap Slope Area Upland Equip.
Phase II							
Appendix A	Daily QA/QC Documentation						
A.1	Upland Daily Diaries	X	X	X	X	X	X
A.2	Waterway Daily Diaries	X		X	X	X	X
A.3	Upland Compaction Testing		X				
Appendix B	Project Photographs						
B.1	Photographic Log	X	X	X	X	X	X
B.2	Photographs	X	X	X	X	X	X
Appendix C	Deviation from Original Plans/Specs						
C.1	Cap Design Memo of 10/22/2004					X	X
Appendix D	Analytical Test Data						
D.1	Imported Material and Other Test Results		X			X	X
D.2	May 2004 Contingency Area Test Results						
D.3	Open Channel Composite Cores Results			X			
D.4	Post Dredge Added Core Analyses			X			
D.5	Redredge Grab Samples			X			
D.6	Post Dredge Samples (Summary of D.3-D.5)			X			
D.7	Slope Toe Composite Core Results			X			
D.8	Confirmation Sample Results			X			
D.9	Data Validation Report			X			
Appendix E	Air Quality Monitoring						
E.1	Hart Crowser Monitoring Results			X	X		
E.2	TRC Badge Results			X	X		
Appendix F	Water Quality Monitoring						
F.1	MCS Environmental Monitoring Results			X	X	X	X
Appendix G	EPA Oversight						
G.1	Weekly Summary Reports	X	X	X	X	X	X
G.2	Weekly Meeting Minutes	X	X	X	X	X	X
Appendix H	Activity Implementation Plans						
H.1	Sediment Dredging and Materials Handling			X	X		
H.2	Diving Plan					X	
H.3	Remaining Piling Removal Plan	X				X	X
H.4	Waterway Capping Plan					X	
H.5	Upland Capping Plan						X
Appendix I	Final Construction Schedule	X	X	X	X	X	X
Appendix J	Project Surveys						
J.1	Project Survey Report			X	X	X	X
J.2	Project Cross Sections			X	X	X	X
J.3	Project Final Topography					X	X
J.4	Project Final Isopach Drawing					X	X
Appendix K	State of Washington Use Authorization					X	

Table 8 -- Summary of Phase II QA/QC Activities -- continued

	PROGRESS REFERENCE TABLE	Demolition	Bulkhead Construction	Dredge Open Channel Area	Dredge Slope Area	Cap Slope Area Waterway Equip.	Cap Slope Area Upland Equip.
Phase II							
Appendix L	Plans and Specifications						
L.1	Phase II Specifications			X	X	X	
L.2	Phase II Drawings			X	X	X	
Appendix M	Diver Surveys and Inspections						
M.1	Diver Debris Survey			X	X		
M.2	Diver Initial Cap Layer Inspections					X	X
Table 1	LSSOU Capping Summary - Ph I and Ph II					X	X
Table 2	LSSOU Disposal and Recycle - Ph I and II	X	X	X	X		
Table 3	Waterway Material Placement Summary					X	
Table 4	Dredging Material Quantitative Summary			X	X		
Table 5	Waterway Capping Quantitative Summary					X	
Table 6	Upland Capping Quantitative Summary						X
Table 7	Glacier Upland Material Delivery Summary						X
Table 8	WA Rock Upland Material Delivery Summary						X
Table 9	Disposal Summary and Certificates			X	X		
Table 10	QA/QC and Project Progress Reference	X	X	X	X	X	X
Table 11	Project Cost Estimate vs. Actual Costs						
Table 12	Summary of Personnel Responsibilities						
Table 13	Chronology of Events						
Figure 1.1	Progress Sampling Summary			X			
Figure 1.2	Organization Chart						

VI. Final Inspections and Certifications

Remedial activities were conducted as planned and cleanup goals were obtained for the remedial action. EPA conducted a final inspection on March 7, 2005. The final inspection concluded that construction had been completed in accordance with the remedial design plans and specifications and did not result in the development of a punch list for the remedial action.

VII. Operation and Maintenance Activities

The remedial activities for the LSSOU that are subject to this OMMP are:

- Dredging of contaminated sediments in the 3.2 acre Open Channel Area;
- Placement of Enhanced Natural Recovery (ENR) material in about 1.2 acres of the Open Channel Area;
  - Construction of the Under-Pier Area permanent-cap consisting of two areas:
    - Slope Area from the rock buttress at about -30- to -4-feet Mean Lower Low Water (MLLW; 3 acres); and
    - Beach Area from about -4- to +12-feet MLLW (2 acres);
  - Construction of the Mitigation Area (0.25 acres outside the LSSOU);
  - Construction of the Riparian Area (2,500 square feet outside the LSSOU).

The goals of the OMMP are to ensure that the remedial actions continue to be protective of human health and the environment. The specific goals of the OMMP are to ensure that:

- The sediment cap continues to isolate toxic concentrations of previously identified chemicals of concern (COCs) in the underlaying sediments from marine biota and other biological receptors; and
- The sediment cap and the previously dredged open channel area do not become recontaminated with COCs from the underlying sediments or from the uplands adjacent to the LSSOU.

Integrity of the capped areas is fundamental to achieving these objectives. Cap integrity depends on maintaining the designed cap thickness to avoid potential contaminant releases, and to attain the specific performance standards discussed below. To ensure cap integrity, the OMMP includes the following:

- **Physical Integrity Monitoring.** Physical integrity monitoring will ensure that erosion is not occurring to the extent that it would compromise the ability of the cap to physically isolate contaminated sediments from environmental receptors. Hydrographic and topographic monitoring are planned to detect erosion.

- **Surface Sediment Quality Monitoring.** Sediment quality monitoring will be conducted to confirm that toxic concentrations of contaminants are not moving upward to the top of the cap via groundwater or other transport mechanisms and that previously dredged sediments are not being contaminated. Sediment sampling of the top 10 cm of sediment is planned.

Verification that upland source control is in place and functioning according to specified standards and that the cap is functioning as designed are also vital to accomplishing the goals of the OMMP water. To ensure these, the OMMP includes the following:

- **Upland Groundwater Monitoring.** Data from the Lockheed Martin Yard 2 Upland Groundwater Monitoring Program will be provided by Lockheed Martin for inclusion in the annual OMMP Reports. This data will provide information about groundwater quality along the shoreline relative to the established RAOs for the Upland OU monitoring program and to support the certification for the LSSOU remedy that adequate upland source control efforts have been achieved such that sediment recontamination will not occur.

Monitoring results will be used to determine whether project objectives are being met, or when contingency measures are needed to address deficiencies noted. See 9 for a summary of monitoring tasks for the LSSOU.

Table 9 -- Summary of Monitoring in Each Remedial Area

	Visual and Photographic	Hydrographic	Topographic	Sediment Samples and Chemistry	Groundwater Monitoring and Chemistry
Open Channel Area		X		X	
Cap - Slope Area		X		X	
Cap - Beach Area	X		X	X	
Cap - Mitigation Area	X		X		
Riparian Area	X				
Upland Groundwater Monitoring					X

VIII. Summary of Project Costs

As shown in Table 10, actual project costs were about $20 million versus estimated costs of approximately $12 million for Strategy 18C in the ESD. The ROD cost estimate was only $4.5 million, but was based on only addressing the Open Channel Area. Direct comparisons by line item are difficult because the ESD estimating system and the actual project cost accounting system did not use all of the same elements. This is not unusual; for instance, an estimate would typically contain a contingency item while project spending does not provide for procurement of anything but goods and services. The ESD estimate has a line item for contractor overhead and profit of $1.23 million, which is apportioned among the various contractor items in the project accounting system.

There was a nearly $2 million difference between the ESD estimate and the actual bulkhead construction cost. The ESD assumed the wood bulkhead would be repaired while the entire bulkhead required demolition and replacement. Similarly the ESD estimate for demolition is less than the actual by $1.6 million. Significantly more demolition was required for the wood bulkhead and additional pilings that were encountered, which increased the cost. While dredge volumes were approximately 20 percent or more above those anticipated, this does not account for the 176 percent increase of actual above estimate. The presence of extensive amounts of debris as well as areas of extremely hard digging conditions due to shipyard wastes having been consolidated or fused with corrosion products combined to reduce dredging production by half for a significant portion of the project. The unit rates in the estimate were typically significantly less than actual rates. Two mobilizations to the project were required as well. Disposal costs were $4.6 million as compared to an estimate of $2.85 million. There was no provision for disposal of treated wood in the ESD estimate, which accounted for $0.6 million of this difference. Unit disposal costs in the ESD were $42 per cubic yard while actual costs were approximately 50 percent greater due to the difficulty of handling and dewatering these materials.

Actual capping costs were $2.4 million versus the estimated $0.89 million for approximately the same amount of material. Direct cost comparisons are complicated by the use of upland delivery and application methods for a portion of the cap in addition to the introduction of cap materials such as pit run, filter material, and cobbles that were not anticipated in the ESD. Unit rates for actual costs were about 30 percent above the estimated values. Costs for construction management and administration were about $2 million more than estimated in the ESD. This was a larger and more complicated project than originally envisioned when the ESD estimate was prepared. With the addition of a completely new bulkhead, the construction management was much more intense and was complicated by the failure of the old sheet-pile bulkhead. Nearly every project component was complicated by unanticipated field condition which required additional management and administrate efforts. The length of the project was likely longer than anticipated so the greater level of effort was also maintained over a longer time period.

Table 10 -- Summary of Estimated Cost Estimate vs Actual Project Costs

COSTS (IN $ MILLION)	ACTUAL	ROD (AIL 4) See Note	ESD (2002) Strategy 16C	Notes
Mobilize/Demobilize	0.00	0.00	0.06	
Demolition	3.30	0.00	1.66	Nearly 2,000 additional piling actual vs ESD estimate
Bulkhead Construction	2.40	0.00	0.45	ESD assumed existing wood bulkhead would be repaired
Dredging	2.70	0.81	0.98	ROD estimate is 18,000 cy while ESD is 57,725 cy including debris. Actual dredging was over 70,000 cy
Disposal	4.50	2.24	2.85	ESD estimate does not include disposal of treated wood
Capping	2.40	0.52	0.89	ROD estimate is 11,000 cy (about 17,000 tons) cap while ESD is 107,000 tons. Actual placement was about 100,000 tons including about 7,000 tons for the Interim cap
Contractor Overhead & Profit	0.00	0.99	1.23	ESD assumes 18% contractor overhead and profit
Const. Mgmt./Admin.	3.00	0.00	0.93	
Engineering	1.40	0.53	1.24	
Permitting	0.10	0.00	0.00	
Contingency	0.00	0.38	1.72	
TOTAL	19.90	4.45	11.68	

General Notes:
ROD estimate was for Open Channel Area Only.
No adjustment is made for inflation or time value of money.
ESD called for dredging 3.5 feet in underpier, slipway and enclosed water SMUs while actual was closer to 5 feet of dredging in these areas

IX. Observations and Lessons Learned

Demolition and Bulkhead Construction. During demolition and bulkhead construction, problems were encountered with piling removal creating relatively localized instability. Vibratory removal of piling, especially in very dense arrays typical of shipways, produces a large amount of energy which liquefies sediments to some extent. In addition, removal of piling creates voids, further reducing stability. In the shipways, the piling were often driven touching one another and several instances of pulling two or even three piling were noted when the jaws of the vibratory hammer were closed.

When this removal activity was conducted near existing structures such as sheet-pile bulkheads, they were subject to movement or leaning. In the case of the old sheet-pile bulkhead, about 50 feet of the bulkhead failed through leaning several feet. This structure was extremely corroded, especially at the mudline, and had lost essentially all the wall thickness from corrosion, spalling of corrosion products, and subsequent additional corrosion of the newly-exposed surfaces. In addition, the tie backs were made of steel which had corroded through in two cases.

This structure was marginally stable prior to demolition of the immediately-adjacent north shipway, so it is not surprising that the bulkhead failed. Another, less-dramatic, example occurring in the south shipway. In this case, the new bulkhead was driven but the concrete pile cap was not constructed prior to demolition in the adjacent south shipway. Some deflection of the new bulkhead was noted, at which point demolition was stopped until the situation could be addressed. For structures that were in place, it was recommended that no piling removal be conducted within 50 feet and that monitoring for movement be undertaken. For the remainder of the bulkhead, the recommendation was to alter the demolition/construction sequence so the demolition would be completed ahead of the bulkhead construction. This method did raise an issue with erosion since the previous sequence provided for the sheets to be driven prior to removing the remnant existing bulkhead. To address this potential, a temporary wall of large interlocking concrete "Ecology Blocks" was constructed to protect the shoreline between when the old bulkhead was removed until the steel sheets could be driven.

Dredge Design and Operations. Several problems became apparent during Phase I dredging which contributed to an initial failure to achieve SQS in the Open Channel Area. All manner of debris such as pipe, hoses, cables, concrete, and steel was mixed in with the target sediments, making dredging more disturbing to the sediment bed than anticipated. Debris caused resuspension of sediment and/or loss of sediments from the bucket due to failure to fully close and the large number of cycles required to remove debris. This situation was likely made worse by the presence of very hard, consolidated sandblast grit or fused metallic wastes in several areas. In addition, pile tips were encountered that had been historically broken off at or near the mudline and buried by subsequent waste deposition. These often were present on the slope area and were either worn away by repeated bucket closures or pulled in their entirety. This process complicated dredging to desired grades and greatly disturbed these areas, with the resulting resuspension of material which may have moved down slope into the Open Channel Area to some extent. The initial approach to dealing with debris was to conduct a debris clearing pass using a digging bucket deployed to just scrape the surface of the sediment bed. While a large quantity of debris was removed, this operation assumed that all debris was present at or within a foot or two of the bed surface. An examination of the physical deposition process of shipyard wastes would argue with this assumption, in fact debris would be expected to either be present throughout the dredge cut or be even more prevalent at deeper cut depths due to its relatively higher density compared to sediments. Two critical decisions were made early in the Phase I dredging process that made prompt resolution of the debris problem more difficult; an environmental bucket would not be up to the mechanical rigors of the dredging environment and a relatively small, 3.5-cubic-yard standard bucket would be used. A larger digging bucket would weigh considerable more and thus provide a more aggressive digging action with relatively fewer cycles required to clear debris or achieve desired cut depths. If this larger bucket were used to nearly achieve depths, the final cut would have relatively less large debris and would be able to be addressed with an environmental (closed) bucket. This set of equipment and associated operational practices was employed during the second season in the Open Channel Area with much better results. A series of test dredge cuts prior to decisions about dredge and cap design and equipment selection may have provided an early warning of this problem.

In a related item, the interface of the Slope and Open Channel Areas was approximately at the pierhead line and was designated as the border between sediments that were required to meet SQS in the Open Channel Area and sediments that were to be capped in the Slope Area. A significant amount of dredging was done in this area with mixed results relative to meeting SQS as this area was the most likely to receive redeposition material and/or material moving downslope. Short of cutting back the entire Slope Area and substantially reducing the post-cap desired habitat elevations, the area was subject to capping at the toe of the slope. During both dredging and capping, the accuracy and usefulness of hydro graphic surveys was an issue. Much of the work subject to survey took place on a relatively steep slope and single-beam surveys were not as useful as multibeam surveys due to relatively small errors in single-beam hydrographic methods being magnified by the slope. Multibeam surveys provided more accurate and reproducible data and were used exclusively for nearly the entire second season. The only exception to their relative utility was in the case of riprap surfaces, which were a problem due to their uneven nature. With the application offish mix which filled the void spaces and provided a smoother top surface the multibeam surveys were once again accurate and reproducible.

Capping. Refinements to the original cap design were possible due to taking a closer look at armor rock requirements. It turns out that riprap was not required on gentler beach slopes, which greatly reduced the need for large quantities of riprap and allowed upland construction equipment and methods to be employed in the beach area. Substitution of a 3-foot-thick cobble/gravel mix for the one-foot of geotechnical filter layer supporting an additional 2 feet of riprap allowed for adequate armoring and did not reduce the environmental efficacy of the cap. Simultaneous cap construction using marine and land equipment was possible with independent and parallel material supply. This reduced costs and greatly reduced the required schedule which allowed the timely completion of the project well within the in-water construction window.

X. Operable Unit Contact Information

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APPENDIX A

SELECTION OF CONFIRMATIONAL CHEMICAL CRITERIA FOR USE AT THE HARBOR ISLAND SUPERFUND SITE SHIPYARDS OPERABLE UNIT

The following memorandum describes how EPA derived chemical decision criteria, referred to as confirmation numbers, used to distinguish between the contamination associated with Todd or Lockheed Shipyards Sediment Operable Unit (TSSOU and LSSOU, respectively) and contamination characteristic of the adjacent West Waterway Operable Unit. The criteria will be applied as part of a post-remedial action compliance evaluation and long-term monitoring program.

The TSSOU and LSSOU are two separate parcels located along the eastern shore of the West Waterway (the waterway comprises a separate OU). The West Waterway is characterized by a wide variety of contaminants reflecting the diverse sources within the lower Duwamish River. However, contamination located near the Todd Shipyards and Lockheed Shipyard was greatly elevated and included more chemicals of concern than the West Waterway. Based on information available at the time of the ROD, EPA decided that the top of the channel slope (defined by different bathymetric contours for each parcel) would most likely define the extent of the contamination and debris associated with the shipyards that could act as a source to the waterway. Remedial design sampling conducted at the Lockheed Shipyard appeared to support the assumption that the –36 foot MLLW contour [Port of Seattle (POS) datum] adequately defined the extent of shipyard contamination. Sampling conducted in support of remedial design for Todd Shipyards suggested that the operable unit boundary likely extended beyond the administrative boundary [-42 foot MLLW contour; POS datum], due to exceedances of the Sediment Management Standards (SMS) and elevated tributyltin (TBT) concentrations at the outermost stations sampled. Additional sampling was conducted to further evaluate modifications to the TSSOU boundary. A decision was made to modify the boundary based on those results and is documented in the TSSOU Explanation of Significant Difference (March 1999).

As part of the re-evaluation of the TSSOU boundary, EPA developed screening levels for mercury, TBT and polychlorinated biphenyls (PCBs). Screening levels were necessary because the state standards for mercury and PCBs in sediments do not address bioaccumulative effects and no sediment standard exists for TBT. EPA developed these screening levels based on work that was conducted as part of the remedial investigation for the West Waterway OU.

An extensive literature review was conducted on the bioaccumulative effects of these three contaminants as part of the West Waterway OU investigations (EVS 1999). A tissue screening level for TBT was derived from literature values for use in site-specific bioaccumulation tests. Laboratory bioassays were then conducted to evaluate the bioaccumulation of TBT in benthic invertebrates (EVS, 1999). In addition, fish and shellfish samples were collected from the Duwamish Waterway for tissue analysis to support a human health and ecological risk assessment (EVS, 1999). Only limited bioaccumulation was observed in the laboratory studies and organism tissues did not exceed the tissue screening level associated with deleterious effects (i.e., mortality, reduced growth, or impaired reproduction) derived from the literature. Further, the results of the risk assessment suggested that sediment concentrations in the West Waterway represent minimal threat to human health from ingestion of seafood that may be exposed to West Waterway contaminants.

The ROD clearly states that the SQS be achieved within the OU in the open water surface sediments (and to the extent practicable in the under pier and shipway surface sediments); however, EPA was concerned that strict application of the SQS at the boundary may lead to remediation of the West Waterway (or Elliott Bay) sediments in the vicinity of the shipyards that are characterized by chemicals at concentrations above the SQS, but not necessarily related to shipyard sources. In addition, no sediment standard exists for TBT; thus determining the extent of contamination is more difficult.

To better understand the distribution of contaminants in light of the remedies under development at each of the shipyard operable units, EPA used interpolation technology to "map" concentrations of all chemicals of concern throughout the West Waterway, the TSSOU and the LSSOU. The resulting maps show a pattern of contamination throughout the area that shows that shipyard contamination is generally confined within the existing OU boundaries. However, there were some exceptions where possible contamination outside but contiguous with TSSOU or LSSOU boundaries was indicated. EPA recognizes that this mapping technique does not identify exact locations or magnitude of contamination; however, the trends indicated that the administrative boundary chosen for the site may not entirely encompass site-related contamination and a few data points associated with recent investigations further support this contention. The maps are attached.

In order to confirm that shipyard-related contamination has been addressed with the implementation of the remedies for each parcel, EPA has elected to use a combination of the SMS chemical criteria and chemical concentrations that are characteristic of West Waterway conditions to differentiate between contamination characteristic of the West Waterway and contamination associated with the shipyard.

EPA retained the screening levels for the three bioaccumulants: mercury, TBT, and PCBs, described above, as criteria to be used to distinguish between the contamination associated with Todd or Lockheed shipyards as a source of contamination and contamination characteristic of West Waterway. These screening levels are based on a non-parametric metric (percentiles) because chemical data are not normally distributed (an assumption that needs to be met for creating arithmetic means or upper confidence limits). The Supplemental Remedial Investigation, the West Waterway TBT study, and the TSSOU Phase 1B samples located outside the OU boundary) were used to calculate the 90th percentile for the Shipyards OU contaminants of concern (COCs), which include arsenic, copper, mercury, lead, zinc, low molecular weight polycyclic aromatic hydrocarbons (LPAHs) and high molecular weight PAHs (HPAHs), polychlorinated biphenyls (PCBs) and TBT. Only those stations that were located in the West Waterway, but are not part of the SSOUs were included. These values were then compared to the SMS cleanup screening levels (CSLs) for the purpose of selecting values that could be used for post-RA confirmational sampling (Table 1).

For the majority of the COCs (all metals except mercury, and LPAHs and HPAHs) the associated 90th percentile value is well below the CSL, suggesting that if the CSL was exceeded at the Shipyards OU boundary for a given COC, then that chemical would more likely be representative of Shipyards OU sediments. Mercury is elevated well above the CSL throughout the West Waterway, such that the state standard would not be able to distinguish between Shipyards OU and West Waterway OU sediments. However, the West Waterway conditions may be more indicative of an acceptable risk to humans and ecological receptors, based on the risk assessment results given that the state standard does not address bioaccumulative effects. PCBs within the West Waterway are generally below their respective CSL. No standard exists for TBT; therefore the 90th percentile of the West Waterway data set was considered the most effective criterion for distinguishing between shipyard and waterway sediments. In addition, the West Waterway risk assessment suggests that risks related to TBT exposure are within an acceptable range.

The values listed in Table 1 represent the confirmation numbers that will be applied as part of the post-RA compliance evaluation and as part of long-term monitoring. The evaluation process (how these numbers will be used and what decisions they may trigger) will be documented in a separate memorandum.

Table 1. Post RA Confirmational Numbers by Chemical of Concern			
Chemical	**West Waterway 90th percentile**	**SMS Cleanup Screening Level**	**Shipyards OU Confirmation Criteria**
Arsenic	27 mg/kg dw	97 mg/kg dw	97 mg/kg dw
Copper	230 mg/kg dw	390 mg/kg dw	390 mg/kg dw
Lead	255 mg/kg dw	530 mg/kg dw	530 mg/kg dw
Zinc	355 mg/kg dw	960 mg/kg dw	960 mg/kg dw
LPAHs*	102 mg/kg tocn	780 mg/kg tocn	780 mg/kg tocn (13 mg/kg dw)
HPAHs**	806 mg/kg tocn	5300 mg/kg tocn	5300 mg/kg tocn (69 mg/kg dw)
For Bioaccumulants			
PCBs	35 mg/kg tocn (500 ug/kg dw)	65 mg/kg tocn (1,000 ug/kg dw)	35 mg/kg tocn (500 ug/kg dw)
Tributyltin	76 mg/kg tocn (1335 ug/kg dw)	not available	76 mg/kg tocn (1335 ug/kg dw)
Mercury	1.34 mg/kg dw	0.59 dw	1.34 mg/kg dw

dw = dry weight
tocn = total organic carbon normalized
* low molecular weight polynuclear aromatic hydrocarbons
** high molecular weight polynuclear aromatic hydrocarbons

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Calculation of West Waterway Screening Levels

Station	Arsenic	Copper	Lead	Mercury	Zinc	PCBS	PCBs	TBT	TBT	LPAHs	HPAHs	TOC
	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	ug/kg DW	mg/kg TOCN	ug/kg DW	mg/kg TOCN	mg/kg TOCN	mg/kg TOCN	percent
Todd	Pre-Remedial Design Investigations — Phase 1B Report											
TS-36	19	166	149	0.8	466	307	12.5	780	31.7	40	328	
TS-37	15	126	107	0.4	164	375	22.2	840	49.7	60.7	496	
TS-38	12	143	81	0.8	186	324	20.9	750	48.4	72.1	496	
TS-43	12	173	82	0.9	166	247	21.3	1600	137.9	66.4	477	
WW	TBT Bioaccum Study											
TBT-01	NA	NA	NA	NA	NA	NA	NA	31	5.3	NA	NA	
TBT-02	NA	NA	NA	NA	NA	NA	NA	730	34.9	NA	NA	
TBT-03	NA	NA	NA	NA	NA	NA	NA	540	26.9	NA	NA	
TBT-04	NA	NA	NA	NA	NA	NA	NA	330	30.0	NA	NA	
TBT-05	NA	NA	NA	NA	NA	NA	NA	680	37.2	NA	NA	
TBT-06	NA	NA	NA	NA	NA	NA	NA	660	36.5	NA	NA	
TBT-07	NA	NA	NA	NA	NA	NA	NA	670	40.4	NA	NA	
TBT-08	NA	NA	NA	NA	NA	NA	NA	400	12.3	NA	NA	
TBT-10	NA	NA	NA	NA	NA	NA	NA	8	1.6	NA	NA	
TBT-11	NA	NA	NA	NA	NA	NA	NA	130	17.3	NA	NA	
TBT-13	NA	NA	NA	NA	NA	NA	NA	1100	84.0	NA	NA	
TBT-14	NA	NA	NA	NA	NA	NA	NA	1100	106.8	NA	NA	
TBT-15	NA	NA	NA	NA	NA	NA	NA	530	39.3	NA	NA	
TBT-17	NA	NA	NA	NA	NA	NA	NA	560	65.1	NA	NA	
TBT-18	NA	NA	NA	NA	NA	NA	NA	210	18.3	NA	NA	
TBT-19	NA	NA	NA	NA	NA	NA	NA	450	36.9	NA	NA	
TBT-20	NA	NA	NA	NA	NA	NA	NA	3500	218.8	NA	NA	
TBT-21	NA	NA	NA	NA	NA	NA	NA	610	49.6	NA	NA	
TBT-22	NA	NA	NA	NA	NA	NA	NA	350	37.2	NA	NA	
TBT-23	NA	NA	NA	NA	NA	NA	NA	510	54.8	NA	NA	
TBT-24	NA	NA	NA	NA	NA	NA	NA	570	44.9	NA	NA	
TBT-25	NA	NA	NA	NA	NA	NA	NA	310	27.7	NA	NA	
TBT-27	NA	NA	NA	NA	NA	NA	NA	730	60.3	NA	NA	
TBT-28	NA	NA	NA	NA	NA	NA	NA	690	47.6	NA	NA	
TBT-30	NA	NA	NA	NA	NA	NA	NA	310	25.4	NA	NA	
SRI	Supplemental Remedial Investigation											
WW-01	10	77	59	0.26	145	244	9.4	320	12.3	602.5	805.8	2.6
WW-02	12.2	126	92	0.36	175	205	9.8	1246	59.3	62.8	375.2	2.1
WW-03	13.1	124	86	0.38	157	126	6.0	641	30.5	49.3	303.8	2.1
WW-04	27	208	235	1.47	350	400	18.2	543	24.7	120.0	1267.7	2.2
WW-05	14.6	149	109	0.61	185	229	9.2	623	24.9	91.6	420.0	2.5
WW-06	15.4	165	197	0.56	392	182	7.0	721	27.7	66.7	426.9	2.6
WW-07	14	214	68	0.37	171	161	7.3	810	36.8	33.0	194.8	2.2
WW-08	9.3	86	52	0.18	121	179	9.9	792	44.0	48.9	274.3	
WW-09	14.3	144	102	0.65	190	230	13.5	890	52.4	62.7	416.5	
WW-10	25	186	245	0.82	278	332	20.8	890	55.6	60.2	479.4	
WW-11	17.3	230	161	0.69	220	502	17.9	445	15.9	26.7	188.9	2.8

Calculation of West Waterway Screening Levels

Station	Arsenic	Copper	Lead	Mercury	Zinc	PCBS	PCBs	TBT	TBT	LPAHs	HPAHs	TOC
	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	ug/kg DW	mg/kg TOCN	ug/kg DW	mg/kg TOCN	mg/kg TOCN	mg/kg TOCN	percent
WW-14	16.4	163	206	0.45	211	290	15.3	1424	74.9	64.8	353.2	
WW-15	27	207	294	1.09	366	556	30.9	1335	74.2	82.8	433.2	
WW-16	20	156	168	0.52	204	466	27.4	1157	68.1	60.0	332.6	
WW-17	14.9	96	72	0.37	122	190	13.6	1335	95.4	67.7	321.4	1.4
WW-18	99	275	651	1.93	1160	494	20.6	1335	55.6	98.1	407.1	
WW-18D	79	394	400	2.23	1050	500	35.7	1068	76.3	93.7	783.6	
WW-19	27	183	124	1.34	328	600	35.3	249	14.7	48.1	289.5	1.7
WW-20	23	177	163	0.84	251	615	43.9	979	69.9	70.0	504.3	
WW-21	20.9	298	336	0.87	253	290	11.6	1513	60.5	102.3	468.4	
WW-22	19	111	82	0.85	167	294	19.6	285	19.0	51.5	257.1	1.5
WW-25	35	169	121	1.03	233	1460	81.1	890	49.4	77.9	463.3	1.8
WW-27	18	177	121	0.87	226	172	12.3	1424	101.7	60.0	427.1	
WW-28	17.2	116	317	1.23	157	166	10.4	979	61.2	52.8	305.0	1.6
WW-29	10.2	64.8	56	0.31	83	91	10.2	365	41.0	21.6	257.4	
WW-31	20	231	155	1.37	242	440	40.0	1780	161.8	160.2	842.7	1.1
WW-32	52	357	191	1.14	804	330	30.0	819	74.4	94.5	1307.3	
Characteristic West Waterway Values												
25th	14.2	126.0	84.0	0.43	166.5	197.5	10.3	448.8	27.7	52.1	313.2	
50th	17.3	166.0	124.0	0.80	211.0	294.0	17.9	705.5	44.4	64.8	420.0	
75th	24.0	207.5	201.5	1.06	303.0	453.0	24.8	1001.3	62.2	87.2	487.7	
IQR	9.9	81.5	117.5	0.64	136.5	255.5	14.5	552.5	34.5	35.1	174.5	
1.5*IQR	14.8	122.3	176.3	0.95	204.8	383.3	21.8	828.8	51.7	52.6	261.7	
Outliers>	38.8	329.8	377.8	2.01	507.8	836.3	46.6	1830.0	113.9	139.8	749.4	
Number of outliers	3	2	2	1	3	1	1	1	3	2	5	
90th (no outliers)	*27*	*230*	*255*	*1.34*	*355*	*507*	*35*	*1335*	*76*	*95*	*488*	
90th(all)	*35*	*275*	*317*	*1.37*	*466*	*556*	*36*	*1380*	*90*	*102*	*806*	
Replace SL with CSL	*Yes*	*Yes*	*Yes*	*No*	*Yes*	*No*	*No*	*No*	*No*	*Yes*	*Yes*	
CSL	*93*	*390*	*530*	*0.59*	*960*	*1,000*	*65*	*NA*	*NA*	*780*	*5,300*	