DESIGN ANALYSIS REPORT
(PREFINAL 60 PERCENT DESIGN DELIVERABLE)

TERMINAL 4 EARLY ACTION
PORT OF PORTLAND, PORTLAND OREGON

DRAFT DOCUMENT: DO NOT QUOTE OR CITE
This document has not been reviewed or approved by USEPA and its federal, state and tribal partners and is subject to change in whole or in part

Prepared for
Port of Portland
Portland, Oregon

Prepared by
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In Association with
Berger/ABAM Engineers, Inc.
NewFields
Ash Creek Associates, Inc.
Dr. Stephen Dickenson

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PREFACE

The Terminal 4 project has several major engineering components that comprise the Removal Action. As the design process evolves, some of these components are more straightforward and advance further in the design process, while others require further testing and/or analysis to address issues that arise during design. Table 1 summarizes the major elements of design and their status at the time of the Prefinal (60 percent) Design.

Table 1
Outstanding 60% Design Issues and Associated Path Forward for Resolution

Slip 3 Dredging	The dredge prism is well defined in the majority of the slip. The one outstanding issue that needs to be addressed is the approach to dredging along the sheetpile wall in front of Berths 410 and 411. The basis of this issue is that the depth of contamination is undefined immediately in front of the face of the sheetpile wall and that the design of the sheetpile wall limits the amount of material that can be safely removed without jeopardizing its integrity.	An additional sediment core sampling event will be implemented in December to get more definitive information on the depth of contamination. This will be used to finalize the dredging approach directly in front of the sheetpile wall. If the contaminated material is "shallow" enough such that it can be removed without jeopardizing the wall, then that is the preferred path forward. If the contamination persists too deep, then options that will be evaluated include dredge and cap back or a modified staggered dredging approach, which will protect the wall while removing the contamination. The new data will be available in sufficient time to resolve this issue for 100 percent design.
Capping	No outstanding issues remain for the cap design in the following areas: behind berth 401, Wheeler Bay, and Slip 3 behind the sheetpile wall at Berths 410 and 411. The one outstanding issue is related to the capping activity along the Pier 5 shoreline. In this area, there are no outstanding issues with extent of chemical contamination and cap coverage. Rather, the outstanding issue is related to physical constraints. Along Pier 5, the upper extent of the cap needs to be balanced between two factors: protecting the existing wooden bulkhead structures and making sure the cap integrity is maintained as it is extended on to the shoreline face.	As part of the final design, the conditions of the existing bulkheads will be evaluated to determine the appropriate height of the cap on the slope.

Design Component	Current Status	Path forward for resolving outstanding issues in 100 percent design
CDF Berm	No outstanding design issues remain for the berm footprint and construction approach. The approach for the training terraces size and construction material has also been finalized, and has been modified since the Conceptual (30 percent) Design based on contractor input. The one outstanding issue for the berm is construction materials as they relate to berm permeability and seismic stability.	Available sources of berm material were inventoried in the local market. The grain size distribution of these materials was compared against seismic and permeability factors with the goal being to maintain a seismic safety factor of 1.1 or greater, while minimizing permeability as much as possible. In addition, a geofabric material was evaluated for the inner berm face as a mechanism for trapping suspended sediment, and this material was compared against the effectiveness of just the berm width itself (in excess of 200 feet) for trapping fines. Details of the results of this evaluation are provided in Section 7.5.3
CDF Settlement Monitoring Plan	The estimated amount of settlement of the CDF is presented in the document. However, a detailed plan to monitor the settlement amount and time rate is not fully developed.	A detailed settlement monitoring plan will be developed as part of the 100 percent design to confirm the predicted amount of settlement and the rate of settlement.
Berth structures and IRM	The IRM reroute is currently at a 30 percent design level due to the delay in finding a suitable location. The replacement berth is currently at the 60 percent design level, however value engineering is being completed to reduce costs.	The IRM relocation should be at a 60 percent design level by early January and at 100 percent design level with the Final 100 percent submittal. Value engineering is being completed on the replacement berth design to make it more cost effective. The replacement berth design will be finalized as part of the 100 percent design.
Stormwater re-route	The final conveyance route has been selected and is reflected in the Prefinal (60 percent) Design. Some of the conveyance has been shifted to the north side of the CDF, which is different than how it was depicted in the Conceptual (30 percent) Design. The potential outstanding design issue is whether additional structural controls/treatment is needed for the northern route. Following the completion of the rail yard improvements (which included new treatment systems), water quality for stormwater runoff at Terminal 4 will improve. That improvement needs to be quantified to determine if any additional structural controls/treatment is necessary.	Additional stormwater sampling will be implemented and the new data will be used to calibrate the current situation and help determine if additional structural controls/treatment is necessary.

Design Component	Current Status	Path forward for resolving outstanding issues in 100 percent design
Habitat Mitigation	Design of the on-site habitat mitigation actions, including construction of a habitat bench in the CDF berm, removal of treated wood piling in Wheeler Bay and Slip 3, placement of sand and gravel material over the armor layer of the cap in Wheeler Bay, and placement of cottonwood poles and willow livestakes for slope stability in Wheeler Bay, are presented in this document. The design of the off-site mitigation action at Ramsey Refugia, Phase II will be conducted by the City of Portland and is not presented in this document.	The Port and the City of Portland are working on developing an agreement for the Port to fund approximately 2.5 acres of the Ramsey Refugia, Phase II project.

1 INTRODUCTION

1.1 Background

In 2000, the U.S. Environmental Protection Agency (USEPA) added the Portland Harbor Superfund Site to the National Priorities List. The Port of Portland (Port) is one of ten potentially responsible parties that entered into an Administrative Order on Consent with USEPA for a Remedial Investigation/Feasibility Study (RI/FS) of the Superfund Site in fall 2001. The Administrative Order on Consent allows Early Actions to be conducted to address known contamination at specific locations within the Superfund Site. Contaminants found in Terminal 4 sediment samples during a remedial investigation directed by the Oregon Department of Environmental Quality (DEQ) led to a determination that a Removal Action at Terminal 4 is warranted. Accordingly, the Port is conducting a Non-Time-Critical Removal Action (NTCRA) under an Administrative Order of Consent for Removal Action (the AOC) executed by the Port and USEPA in October 2003. Figure 1 shows the Removal Action boundary at Terminal 4.

The AOC sets forth the general legal requirements that govern the execution of the Early Action. Appendix A to the AOC is the statement of work (SOW) for the implementation of the Removal Action. The SOW provides a list of deliverables, their submittal schedule, and the technical requirements each deliverable has to meet in order to implement the Early Action.

As part of the execution of the Early Action, the Port completed an engineering evaluation and cost analysis (EE/CA) (BBL 2005) in which various Removal Action alternatives were identified, compared, and ranked for their relative performance at meeting specific objectives associated with the evaluation criteria of effectiveness, implementability, and cost. Based on the alternatives evaluated in the EE/CA, the USEPA issued an Action Memorandum on May 11, 2006 (USEPA 2006a) that documented the selection of the Removal Action that is described in Section 2.2 and detailed in the remainder of this report. The selected Removal Action includes dredging most of Slip 3 and placing the dredged sediment in a Confined Disposal Facility (CDF) in Slip 1, capping various areas, and Monitored Natural Recovery (MNR). Figure 2 shows the components of the Removal Action.

Following issuance of the Action Memorandum, execution of the Removal Action proceeded with the preparation of the Conceptual (30 percent) Design, the first of a number of additional deliverables required in accordance with the AOC and SOW prior to construction activities. The Conceptual Design deliverables were submitted to USEPA and its partners on August 9, 2006. The USEPA-issued comments on the 30 percent design deliverables were received by the Port on September 8, 2006. The remaining additional deliverables prior to Removal Action construction are the following:

- Prefinal (60 percent) Design Documents
- Final (100 percent) Design Documents
- Draft and Final Removal Action Work Plan

This document details the Prefinal Design process as described below. The Prefinal Design progresses the specificity of the project details from the Conceptual Design in terms of refining areas and volumes of sediment involved, selecting construction processes, technology and equipment where appropriate, disposal facilities and material borrow sources, and other project particulars. The Prefinal Design involves the preparation of design calculations and analyses to work out design details, the preparation of design drawings, specifications, and establishing performance standards and procedures that will be used to verify that Removal Action Objectives (RAOs) have been met. The Prefinal Design deliverables provided in this document and related appendices include the following information as described in the SOW:

- Design Analysis Report providing the design criteria and basis of design for the Removal Action, including technical parameters and supporting calculations upon which the design will be based, including but not limited to design requirements for each Removal Action technology to be employed (e.g., dredging, capping), and other activity-specific details
- Construction Documents and Schedule, including Drawings and Construction Specifications
- Design Plans including a Draft Construction Quality Assurance Plan detailing the Removal Action verification methods and approach to quality assurance during

construction; and a Draft Water Quality Monitoring Plan detailing the water quality monitoring approach.

Additionally, the Action Memorandum outlined a number of USEPA directed modifications to the selected Removal Action as a result of public comment. The modifications listed below were introduced in the Conceptual Design and have been updated to the Prefinal Design level in this and related documents:

- Determine CDF Sediment Disposal/Acceptance Criteria. Section 5.5 of this document, as well as the separate Sediment Acceptance Criteria Memorandum, address this directed modification.
- Consider Additional CDF Geotechnical Parameters. Section 5.2 of this document addresses this directed modification.
- Determine MNR Contingency. The Long-term Monitoring and Reporting Plan (LTMRP) will address the monitoring program for MNR areas as well as any contingency measures.
- Determine Appropriate Mitigation. The Draft Mitigation Plan, a separate document, addresses this directed modification.

The Port has conducted extensive analyses and evaluations as part of the Prefinal Design preparation process and additional analyses to address the Conceptual Design Comments and issues identified at interim meetings. The Port held interim Prefinal Design meetings with USEPA to discuss the following topics:

- Dredge Plan and Construction Quality Assurance Plan Measures
- Confined Disposal Facility Berm Modeling Updates and Results
- Water Quality Monitoring Plan

The results of all the analyses and evaluations to address comments and concerns have been incorporated into this Prefinal (60 percent) Design document. USEPA will review this document and provide comments back to the Port. The Final (100 percent) Design will address the comments from USEPA and will be used to competitively procure contractors for the implementation of the Removal Action in the field. The Final Design will also provide specific project execution requirements and a combination of prescriptive specifications (where deemed necessary) and performance requirements (where appropriate to allow flexibility to contractors).

The Prefinal Design deliverables are intended to be as complete as possible; however, several design issues remain outstanding and will require additional evaluation to bring to completion for the Final Design submittal. Table 1 in the Preface identifies these outstanding issues by construction activity and identifies a plan for resolution.

1.2 Monitoring Activities Associated with the Terminal 4 Early Action

Throughout this document and the appendices there are numerous sampling and monitoring requirements both for short-term construction activities during implementation of the Removal Action and long-term after the Removal Action is complete. Short-term monitoring assures construction measures are in compliance with performance objectives, minimizes water quality impacts, and protects archeologically sensitive areas. Long-term monitoring assures that the Removal Action is performing as intended and that the Removal Action objectives are being met. Table 2 summarizes each of these monitoring requirements.

1.3 Organization of this Document

The remainder of this document provides detailed information on the development of the Prefinal Design as follows:

- **Section 2 – Removal Action Area and Activities** describes the setting of the Removal Action, summarizes the Removal Action objectives and performance standards, and details the Removal Action activities by subarea.
- **Section 3 – Existing Conditions** summarizes the information and data collected within the Removal Action Area that will be used as the basis of the design, including physical conditions, hydrogeologic and geotechnical conditions, hydrodynamic characteristics, sediment quality, site uses, source control, and sediment quality objectives (SQOs).
- **Section 4 – Dredge Plan** provides the conceptual dredge plan for the Removal Action, including the basis for design, design approach, dredge design surface,

neatline dredge prism, volumes, equipment selection, and an assessment of dredging residuals.

- **Section 5 – Confined Disposal Facility Design** provides the conceptual CDF design including the basis for design, design approach, containment berm stability, containment berm erosion resistance, consolidation and settlement, CDF surface layer, CDF filling procedure and weir outfall design, assessment of potential impacts on Willamette River flood stage, demolition of Slip 1 structures, outfall and stormwater rerouting, waterfront structures and berth replacement, volumes, management of CDF during filling, and equipment selection.
- **Section 6 – Capping Plan** provides the conceptual cap design including the basis for design, design approach, source material description, in-situ cap design, Wheeler Bay and Slip 3 pile removal, volumes, and equipment selection.
- **Section 7 – Water Quality** discusses water quality criteria, contaminant mobility testing, and predicted water quality for the different Removal Action elements.
- **Section 8 – Habitat Mitigation** generally describes the habitat mitigation components and design process.
- **Section 9 – Substantive Requirements of Permits** discusses the regulatory requirements that must be achieved during the implementation of the Removal Action.
- **Section 10 – Construction Schedule and Sequencing** describes the duration and order of the Removal Action construction activities.
- **Section 11 – Access and Easement Requirements** provide access and easement information related to implementation of the Removal Action.
- **Section 12 – Institutional Controls** details the actions required to maintain capped areas and the CDF.
- **Section 13 – References** summarizes the references used in the document.

The appendices provide the following information:

- Appendix A—Geotechnical Assessment of the Containment Berm
- Appendix B—Confined Disposal Sediment Management Plan
- Appendix C—Construction Quality Assurance Plan (CQAP)
- Appendix D—Water Quality Monitoring Plan

- Appendix E—Outline of the Long-term Monitoring and Reporting Plan
- Appendix F—Construction Drawings
- Appendix G—Construction Specifications
- Appendix H—Pre-construction Sampling Data Report
- Appendix I—Contaminant Transport Modeling at the CDF
- Appendix J—Contaminant Transport Modeling through the Caps
- Appendix K—River Current Analysis
- Appendix L—Cap Armor Design
- Appendix M—Flood Analysis
- Appendix N—Confined Disposal Facility Effluent Discharge and Weir Evaluation
- Appendix O—Removal Action Construction Sampling and Analysis Plan (SAP)
- Appendix P—Removal Action Construction Quality Assurance Project Plan (QAPP)
- Appendix Q—Removal Action Construction Health and Safety Plan (HASP)

2 REMOVAL ACTION DESCRIPTION

2.1 Removal Action Area

The Port is a port district of the State of Oregon, which owns the Terminal 4 uplands between River Miles (RMs) 4.1 and 4.5 on the Lower Willamette River. The Port also owns a portion of the submersible and submerged lands in Slip 1 and Slip 3 located within the Removal Action Area (defined below). The remainder of the submersible or submerged land is owned by the State of Oregon and managed by the State of Oregon Department of State Lands (DSL). The Port is currently in the process of acquiring this land from DSL.

The Terminal 4 facility itself is within or adjacent to the Portland Harbor Superfund Site. The Removal Action Area (RAA) is defined in the AOC as "that portion of the site adjacent to and within the Port of Portland's Terminal 4 at 11040 North Lombard, Portland, Multnomah County, Oregon, extending west from the ordinary high water line on the northeast bank of the Lower Willamette River to the edge of the navigation channel, and extending south from the downstream end of Berth 414 to the downstream end of Berth 401, including Slip 1, Slip 3, and Wheeler Bay."

A vicinity map and site plan locating Terminal 4 is provided on Figure 1.

2.2 Removal Action Activities

2.2.1 Removal Action Objectives

The RAOs established by USEPA in the EE/CA and Action Memorandum for the RAA are to:

1. Reduce ecological and human health risks associated with sediment contamination within the RAA to acceptable levels—reduction in contact for human health risks and attenuation of exposure pathways for ecological receptors.
2. Reduce likelihood of recontamination of sediments within the RAA—removal or capping of sediments as well as evaluation of potential ongoing sources.

2.2.2 Performance Standards

To achieve the RAOs, performance standards were established as described below. These performance standards were used to guide the design of Removal Action activities and will be used to guide Removal Action construction and verification/monitoring activities.

1. Dredging—Remove sediments that exceed Probable Effects Concentrations (PEC) criteria and evaluate magnitude above other criteria as directed by USEPA (30 percent design comments). These are the sediments that pose the highest ecological and human health risk. Specifically, the dredging will meet the following performance standards:
   - Confirm that PEC concentrations have been achieved by evaluating residual concentrations on an individual sampling grid location basis and comparing the new surface concentrations with other criteria such as TECs, sediment toxicity, and the current status of the Portland Harbor sediment-based bioaccumulation criteria (pending final Portland Harbor Record of Decision [ROD] standards). In comparing the new surface concentration to these other criteria, the following factors will be considered:
     - The magnitude that the post-dredge concentrations are above or below these criteria,
     - Previous site specific toxicity data as well as current direction of the harbor-wide risk assessments, and
     - The benefit of a further action. Other potential actions that will be considered include an additional dredging pass, placement of a thin-layer cap, and MNR. For those grid locations that exceed Total Effects Concentrations (TEC), MNR will be designated at a minimum if other actions are not selected.
   - Conduct the removal in a manner that minimizes to the extent practicable water quality exceedances of turbidity (or total suspended solids [TSS]) and chemistry outside the construction zone.
2. Capping—Isolate surface sediments containing contaminant concentrations exceeding PECs from benthic communities and the aquatic environment by evaluating appropriate long-term erosive and contaminant transport

mechanisms. Specifically, the cap shall meet the following performance standards:

- The chemical isolation layer shall be of such thickness that: (1) potential groundwater exiting the cap shall be below USEPA's national recommended chronic water quality criteria and (2) sediment quality of the biologically active zone of the cap shall be below PECs and ultimately evaluated against risk-based criteria and/or clean up goals established by USEPA through the Portland Harbor RI/FS process and ROD.
- The armor layer of the cap shall be designed to resist bed shear velocities induced by the largest of 100 year flood flow, 100 year waves, vessel-induced waves from typical passing vessels, and anticipated propeller wash from vessels that operate in the area.
- The material used for capping shall meet the requirements established in the December 2003 Technical Plans and Specifications (Ecology and the Environment 2003) for the McCormick & Baxter sediment cap located within the Willamette River. Specifically, the "cap material to be used for construction of the sediment cap will be imported, clean, granular material free of roots, organic material, contaminants, and all other deleterious and objectionable material."
- Conduct the placement of material in a manner that minimizes to the extent practicable water quality exceedances of turbidity (or TSS) and chemistry outside the construction zone.

3. CDF—Isolate contaminated sediments placed within the CDF from biota and the environment by evaluating appropriate long-term seismic, erosive, and contaminant transport mechanisms. Specifically, the CDF shall meet the following performance standards:

- The berm shall have a static safety factor of 1.5 or greater and a seismic safety factor of 1.1 or greater. The design seismic event shall correspond to a 10 percent probability of exceedance in 50 years.
- Final Applicable Relevant and Appropriate Requirements (ARARs) related to surface water will not be established for the Portland Harbor Superfund Site until the time of the ROD. To ensure that the CDF will meet ROD standards

and as directed by USEPA, the CDF shall be designed such that the quality of groundwater exiting the CDF to the river will meet USEPA's national recommended chronic water quality criteria or ambient background conditions at the point of discharge, and fish consumption criteria, and drinking water criteria/guidelines in the receiving water. In addition, the LTMRP will incorporate evaluation of these criteria on an interim basis pending finalization of the Portland Harbor ROD.

- Conduct the construction of the CDF in a manner that minimizes to the extent practicable water quality exceedances of turbidity (or TSS) and chemistry outside the construction zone.

2.2.3 Site Specific Sediment Quality Objectives

Site specific sediment quality objectives (SQOs) are necessary to guide the delineation and design of dredging, capping, and MNR areas at Terminal 4. Although SQOs have not yet been finalized for the Portland Harbor, it is the intent that this Removal Action will ultimately comply with the results of the Portland Harbor RI/FS and USEPA ROD. Therefore, some conservative assumptions are necessary to increase the likelihood that this Removal Action will meet the requirements of the ROD and thus serve as the final remedy for Terminal 4.

The Terminal 4 data collected during the EE/CA characterization effort and the pre-construction additional sampling event were compared to PEC, TEC, draft Portland Harbor toxicity-based criteria, and bioaccumulative considerations (e.g., PCBs) as guidelines to achieve the SQOs (Table 3). Based on this evaluation, the following design guidelines were used to delineate actions within the RAA:

- Areas with the highest risk sediment were selected for dredging and incorporation into the CDF.
- Areas with the lowest risk sediment were selected for MNR.
- Areas with sediments containing moderate levels of contaminants of concern where *in situ* confinement could limit risk to receptors, areas where it was deemed impractical to dredge, and areas where Port uses would not affect the integrity of the cap, were selected for capping.

2.2.4 Area-Specific Activities

As described in the Action Memo (USEPA 2006a) and depicted on Figure 2, the Removal Action includes the following elements:

- Construction of a CDF in Slip 1
- Dredging with sediment placement into the CDF.
- MNR
- Capping

These elements are described in detail below.

2.2.4.1 Slip 1 – Full At-Grade Confined Disposal Facility

An at-grade CDF that will have a footprint of approximately 14 acres will be constructed in Slip 1. Sediments to be placed in the CDF from the RAA include Slip 3 and Berth 414 sediments as well as soft sediments over-excavated beneath the containment berm. The CDF has excess capacity available for other dredged sediment from the Portland Harbor Superfund Site; however, the CDF must be selected as an appropriate disposal site through a separate removal or remedial action decision and the potential dredged sediment must demonstrate compatibility with Terminal 4-specific sediment acceptance criteria. Sediment acceptance criteria will be developed during design (see Sediment Acceptance Criteria Technical Memorandum). By constructing the CDF to an at-grade surface, the newly gained land can be used for water dependent commercial purposes. A containment berm will be constructed at the mouth of Slip 1 to serve as an isolation/retention structure for the dredged sediment. The Port will acquire State of Oregon property for the purpose of constructing the CDF. Section 5 provides more details on the conceptual design of the CDF.

2.2.4.2 Slip 3 – Combination of Dredging, Capping, and Monitored Natural Recovery

The Removal Action in Slip 3 consists of a combination of dredging, capping, and a relatively small area of MNR (i.e., the underpier area at Berth 410 below the finger pier portion; see Figure 2). A majority of the area in Slip 3 will be dredged, except for the small MNR area previously mentioned and a few capping areas. The area directly adjacent to and under the former Pier 5, the nearshore slopes under Pier 4 at Berth 411, and the head of Slip 3 and in front of the existing pinch pile bulkhead will all be capped. Dredging under Pier 4 is impractical due to the presence of riprap and structural stability issues. The activities of the Removal Action will be coordinated with the operations of Kinder Morgan, the Port's Slip 3 tenant. Dredged sediments from Slip 3 will be placed in the Slip 1 CDF.

2.2.4.3 Wheeler Bay – Monitored Natural Recovery and Capping

Low surface contaminant concentrations were identified in most of Wheeler Bay; therefore, a combination of MNR and capping approaches will be used in this subarea.

2.2.4.4 North of Berth 414 – Dredging, In situ Capping, and Monitored Natural Recovery

Similar to Wheeler Bay, low surface contaminant concentrations were found in the area north of Berth 414 except for an area towards the middle of site. In this subarea, high polycyclic aromatic compound (PAH) concentrations were reported in two historical samples; the Port collected additional data in July 2006 to determine if elevated PAHs are present and to what extent. The results in this area confirm the presence of elevated PAHs; therefore, a combination of dredging and capping will be used to address sediments in this subarea. MNR will be used in the remainder of the area north of Berth 414.

2.2.4.5 Berth 401 – Monitored Natural Recovery and Capping

MNR will be used for the majority of the Berth 401 area because of low contaminant concentrations. An area in the northeast corner of the Berth 401 area will be capped because of polychlorinated biphenyl (PCB) concentrations in one sample location.

3 EXISTING CONDITIONS

Existing conditions within the RAA were used to inform the Removal Action design. The primary information describing the existing conditions is the data collected as part of the Terminal 4 Early Action EE/CA (BBL 2005) as summarized in the Terminal 4 Characterization Report (BBL 2004a), supplemented with additional pre-construction data (see Section 2.4.2 below). This information includes data on physical, hydrodynamic, wind, and geotechnical, conditions of the RAA; sediment quality; and other Removal Action design considerations such as site use, source control, and SQOs. This information on existing site conditions, along with how the site is currently used by the Port and its tenants, are important considerations that were factored into the Removal Action design. Source control information is important to ensure that the contaminants addressed during the Removal Action activities are not re-introduced to the RAA.

The remainder of this section describes the different categories of existing conditions that are available for the RAA and how they were used in the design process.

3.1 Physical Site Characteristics

Information on the physical conditions that were used to inform the Removal Action design include Terminal 4 physical characteristics and a description of the typical vessels that call at Terminal 4.

The Terminal 4 physical site characteristics and subarea characteristics were used to generally inform the dredging, capping, and CDF design process.

The RAA encompasses roughly 38 acres, of which Slip 1, Slip 3, and Wheeler Bay make up about 28 acres, while the area from the mouths of the slips to the Harbor Line encompasses approximately 10 acres. Boundaries of the Slip 1 and Slip 3 uplands, which are within Terminal 4 but are not included in the RAA, are shown on the RAA site plan on Figure 1. These uplands are about 283 acres in area (Port of Portland 2002), including the Toyota lease areas, and are generally flat in grade in proximity to the slips. The surface covering is primarily asphalt, with minor areas of gravel and/or ballast associated with the rail lines.

Elevation of Terminal 4 generally ranges from 30 to 35 feet mean sea level (MSL) in proximity to the slips (see Figure 3). The river stage (i.e., elevation) is typically between 3.7 and 11.7 feet NGVD (also MSL), with the exception of peaks in river stage. This range is generally based on information from the Morrison bridge gage. The diurnal tidal range in the St. Johns area is 2.2 feet at low river stages and becomes progressively less with higher river stages (NOAA 2003b). East of Terminal 4, the topography is slightly sloping, but somewhat variable. The most notable nearby variation is a gradual rise in the ground surface to an elliptical hill feature about 50 feet MSL. Southeast of Terminal 4, the ground surface rises at 5H:1V or shallower to an elevation of about 100 feet MSL, corresponding to the St. Johns area of Portland. To the west of Terminal 4 and immediately west of the Willamette River channel are the Tualatin Mountains (Portland Hills), with elevation rising relatively steeply at about 1.5H:1V to 3.5H:1V to an elevation of about 1,000 feet MSL.

3.1.1 Berth 401 Physical Characteristics

Along the Berth 401 area, embankment slopes above the shoreline are highly variable, generally ranging from very shallow to about 2H:1V or steeper. Where very shallow, the slopes usually transition gradually to a steeper slope some distance from the water—the slope behind the pier at Berth 401 is relatively flat for about 20 to 40 feet, then transitions to a steeper slope (refer to Figure 3).

Slope protection consisting of variable-sized rock (having the appearance of 8-inch-minus size) is present from the shoreline to about mid-slope on the river-facing embankment slopes, which generally have vegetation where no slope protection has been placed. On the northern embankment slope near the mouth of Slip 1 are rows of remnant concrete columns from a former pier built in the same manner as the existing piers in the slip. On the embankment slope north of Berth 401 by the Schnitzer Steel property, there are a number of remnant timber piles (and concrete panels lying against the embankment slope). No slope protection is present in this area, and driftwood lines the embankment above the shoreline. More remnant square concrete columns with concrete pile caps exposed occur just south of this area on the embankment slope. The slope includes what appears to be a remnant from a tiered crib wall at the base of the slope.

3.1.2 Slip 1 Physical Characteristics

Slip 1 is the larger of the two slips (approximately 13 acres) and is currently infrequently utilized. The mudline elevation ranges from about –32.3 feet to –36.3 feet NGVD according to the most recent annual bathymetric condition survey by the Port (see Figure 3).

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

Shoreline conditions in a majority of the areas of Slip 1 not covered by a pier structure are either steep sloped or armored with large riprap (see the Conceptual Mitigation Plan Proposal, submitted as part of the Conceptual (30 percent) Design). The opposite embankment slope west of Berth 408 does not have slope protection west of the existing pier and is showing signs of erosion in the form of scarps and surficial sloughing. Factors that contribute to erosion could include undercutting resulting from propeller wash during former uses of the pier; ongoing forces such as surface currents and wind waves; and possibly cycles of soil wetting and drying that result from tidal and seasonal variations in river stage combined with the relatively steep slope.

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

3.1.3 Wheeler Bay Physical Characteristics

Wheeler Bay is the small bay (approximately 3 acres) between Slip 1 and Slip 3. Wheeler Bay was originally to become Slip 2, but Slip 2 was never completed. Wheeler Bay is immediately adjacent to Slip 3, separated by Pier 4.

The embankment slopes above the shoreline at Wheeler Bay are similar to the configuration noted for Slip 1 near Berth 401, with the exception that the very shallow, flat area abruptly transitions to a steeper slope generally 2H:1V or shallower. The transition to the steeper embankment slope is farther from the shoreline than at Slip 1, ranging from about 5 to 30 feet away. Above the mean higher shoreline, the embankment area is littered with driftwood debris such as tree stumps, logs, and scattered plant matter.

The submerged slopes are very shallow, with mudline elevations generally ranging from –4.3 feet to –13.3 feet NGVD within the bay, then increasing in slope below Pier 4 to Slip 3 and toward the river.

Remnants from a partially demolished timber pile-supported structure span the relatively shallow embankment slope and remaining timber piles in the bay. Several single timber piles associated with this former structure are present. The only current structure at Wheeler Bay is Pier 4, which separates the bay from Slip 3.

3.1.4 Slip 3 Physical Characteristics

Slip 3 is the southern and smaller (approximately 12-acre) slip in the RAA; Slip 3 is very actively used for KMBT soda ash export.

The mudline elevation ranges from about –34.3 feet to –48.3 feet NGVD (see Figure 3). The shallower depths occur at the head of the slip. Maintenance dredging of Berths 410 and 411 is performed relatively frequently, and the water depth is from –38.3 feet to –43.3 feet NGVD adjacent to the pier in Slip 3. The deeper portion of the slip (to –48.3 feet NGVD) consists of a trough that extends from the east side of Pier 4 to the mouth of the slip at its center. This trough appears to be related to erosion caused by the movement of ships out of berth as part of the KMBT operations. The active berthing areas for KMBT are Berths 410 and 411, which are on the north side of Slip 3. The trough widens and deepens near the mouth of the slip.

Under-pier slopes range from about 1.5H:1V to 2.5H:1V or shallower (Port of Portland, 2002). The bathymetry includes the submerged slope at the mouth of the slip, which is about 5H:1V to the deeper channel of the Willamette River.

Embankment slopes above the shoreline and the general locations of slope protection are similar to Slip 1, with the exception that slopes on the south side of Slip 3 (north of the Toyota facility) are generally flat and have less elevation between the shoreline and upland properties. The embankment slope on the south side of Slip 3 has remnant concrete columns from a former pier structure.

On the north side of Slip 3 at Berths 410 and Berth 411, a large pier structure, presently used extensively by KMBT, extends to the Harbor Line and visually separates the slip from Wheeler Bay. The structure is similar to the previously described piers, except that the structure foundation apparently included pre-stressed concrete, steel, and timber piles. A large crane is present on the deck of the pier. The remnant of a former pier with construction similar to the piers previously described occurs on the south side of Slip 3; all the above-water portions of the pier have been demolished and the timber piles remain in place, partially visible.

3.2 Hydrodynamic Characteristics

This section summarizes the hydrodynamic characteristics of Terminal 4. These characteristics will be used for sizing armor material on the berm face and cap surfaces to prevent erosion and for evaluating potential water quality impacts during dredging. The hydrodynamic characteristics of the RAA were summarized in BBL, 2004b as follows.

- Hydrodynamics within Slips 1 and 3 are affected by variations in river flow, river stage, ship-induced currents, and, to a lesser extent, localized currents from stormwater discharges. In general, given the orientation of the slips relative to the river, river-induced currents in the slips are low in velocity compared to the river velocity.
- Although river-induced currents have an influence on hydraulics of the RAA, current velocities in a majority of the RAA are dominated by propeller-induced currents.

- Propeller-induced currents cause circulation and increased velocities and turbidity levels that extend beyond the paths that ships take in Slip 3.
- Propeller-induced currents influence hydrodynamics and sediment transport in the RAA.
- Ongoing river-induced sedimentation of suspended sediments occurs nearly continuously throughout the RAA. The periodic redistribution of this material affects long-term sediment accumulation patterns within the slips.
- The data gathered during the field program are representative of low-flow, low-rainfall conditions; additional data are needed to support characterization of hydraulics and sedimentation in the slips under high-flow, high-rainfall conditions.

Appendices K and L provide more information on hydrodynamics.

3.3 Wind Conditions

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

3.4 Geotechnical Conditions

Geotechnical information that was used for various components of the design is provided by Removal Action activity. In general, this information was used for dredgeability assessment in the different dredge areas, for short-term and long-term CDF berm stability assessment, and for assessing stability of shoreline structures near to which dredging and/or capping will occur.

3.4.1 CDF Footprint and the Replacement Berth Footprint

Subsurface geotechnical conditions in Slip 1 where the CDF will be constructed are important to understand during the design process because the CDF berm must be geotechnically stable (will not subside, slough, or fail under ambient and or earthquake conditions) for long term performance of the CDF. Therefore, the contents of 24 geotechnical reports prepared for past projects within Terminal 4 were reviewed. These data were screened for applicability to the project relative to proximity and exploration methodology. Over 80 borings and 10 cone penetrometer tests (CPTs) were included in this review. Of the borings reviewed, 11 were found to have been within the general CDF area and completed with modern drilling equipment. The most significant data available from the borings consisted of standard penetration test (SPT) blowcounts. The SPT test results were summarized and corrected for rod length, overburden pressure, and hammer efficiency. For all corrections, mid range values as recommended by the Federal Highway Administration (FHWA) were utilized. SPT results were important to determine the density or strength of the sediment.

The following soil units were encountered in the explorations reviewed:

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

- **Troutdale Gravel.** Dense, partially cemented deposits of gravel and sand were encountered below the alluvial sands. This deposit likely consists of the Troutdale Formation.

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

3.4.2 Dredge and Cap Areas

Existing geotechnical conditions of the dredge and cap areas are important to understand during the design process for dredgeability and cap stability. Geotechnical data in these areas was provided by performing laboratory tests on samples from the in-water borings/cores and field tests including pocket penetrometer tests, torvane tests, and standard penetration resistance.

Results of the laboratory tests show that the recently deposited sediments overlying the grey, loose to medium dense sands consist predominantly of very soft organic silt and clay with liquid limits ranging from about 70 percent to nearly 100 percent and moisture contents ranging from 67 percent to 106 percent. The fines content of these sediments generally ranges from 51 percent to 96 percent, with average fines content ranging from 75 percent to 85 percent.

Based on consolidation and plasticity results, as well as on testing conducted in the field (including pocket penetrometer tests, torvane tests, and standard penetration resistance), it is expected that these soils are normally consolidated and have very low undrained shear strengths. The undrained strength of the very soft sediments is estimated to be on the order of about 20 to 140 pounds per square foot (psf). The material to be dredged in Slip 3 consists of very soft to soft, slightly sandy to sandy organic silt and clay. Areas of higher density sediment may be encountered during dredging. The sediment to be dredged at Berth 414 consists of very soft to soft, clayey, fine sandy silt with occasional wood chunks. In addition, debris is anticipated to be encountered during the dredging.

3.5 Hydrogeologic Conditions

A summary of hydrogeologic conditions in Slip 1 and the capping areas are provided below. This information was used as the basis for the contaminant transport analysis for the CDF and the different cap areas.

3.5.1 Slip 1 and Vicinity

After the CDF is constructed and filled, groundwater that passes through the CDF will enter the Willamette River. Therefore, it is important to know whether the groundwater is likely to transport dissolved contaminants as it passes through the CDF and into the river. To understand how the groundwater will move, groundwater flow was computer-modeled. A conceptual site model was established based on the hydrogeologic conditions at Terminal 4 as described below.

The hydrogeology of Terminal 4 is summarized in Appendix D of the EE/CA report and presented in greater detail in the Terminal 4 characterization report (BBL 2004). BBL (2005) summarized the geologic stratigraphy adjacent to and beneath the proposed CDF; the stratigraphy consists of the following:

- Upland fill material, consisting of medium to fine sand ranging in thickness from about 5 to 40 feet.
- Unconsolidated Alluvial Deposits, consisting of fine sand west of the former shoreline and interbedded layers of gravel, sand, silt, and clay to the east of the former shoreline ranging in thickness from 120 to 160 feet
- Troutdale Gravel, encountered at an elevation of approximately -112.3 to -166.3 feet NGVD.

The groundwater flow direction is toward the Willamette River. In nearshore locations, groundwater in the upland fill material, Unconsolidated Alluvial Deposits, and Troutdale Gravel is in direct hydraulic connection with the river, and groundwater elevations respond rapidly to changes in river stage.

3.5.2 Capping Areas

Groundwater properties in the cap areas were used in the modeling of contaminant transport through the cap. Darcy and seepage velocities provide an understanding of how fast the water is flowing through the cap. The Darcy and seepage velocities (i.e., U and v, respectively) summarized below were calculated for each cap area based on measurements of vertical gradients in groundwater monitoring wells and estimates of hydraulic conductivity from sediment geotechnical properties (BBL 2005).

- Berth 401: U = 0.20 centimeters per year (cm/yr); v = 0.49 cm/yr
- Wheeler Bay: U = 0.15 cm/yr; v = 0.38 cm/yr
- Berth 411: U = 0.28 cm/yr; v = 0.69 cm/yr
- Head of Slip 3/Pier 5: U = 0.17 cm/yr; v = 0.43 cm/yr
- Berth 414: U = 0.15 cm/yr; v = 0.38 cm/yr

3.6 Sediment Quality

Sediment quality information, including sediment chemistry data in the EE/CA database supplemented with additional pre-construction data, was used to guide the design of the Removal Action. Specifically, sediment quality data was used to determine the extent of dredge, cap, and natural recovery areas.

To determine the appropriate data to include in the database, a data quality review of the existing sediment chemistry data has been completed. The review was conducted to determine whether the data were classified as Category 1 or Category 2 data according to the data quality criteria defined in the Portland Harbor RI/FS (Lower Willamette Group 2003, currently in revision based on USEPA comments). Only Category 1 data (highest quality) were selected for use in the design of the Terminal 4 Removal Action. (Note that for the Portland Harbor RI/FS, USEPA allows only Category 1, QA2 data [most rigorous validation criteria] to be used in risk assessments.) Category 1, QA1 data were considered adequate for use for the design of the Terminal 4 Removal Action. In addition to the data quality review, information related to maintenance dredging activities was considered when identifying the appropriate data to use. As a result, any sediment chemistry data for surfaces that were dredged and are no longer present at Terminal 4 were removed from the dataset.

A more detailed description of existing sediment chemistry that is used in the design of the Removal Action is provided in the following sections.

3.6.1 Existing Sediment Chemistry Data

A number of sources of existing sediment chemistry data for Terminal 4 are available from historical investigations of sediment contamination. The Port has been investigating the nature and extent of sediment contamination at Terminal 4 since before 1988. Other organizations, including the U.S. Army Corps of Engineers (USACE), USEPA, and Oregon Department of Environmental Quality (DEQ), have investigated the nature and extent of sediment contamination in the Willamette River and have collected sediment samples in the vicinity of Terminal 4 as part of their investigations (BBL 2004a). Most recently, sediment chemistry data were collected as part of the Terminal 4 Early Action design.

The primary source of sediment chemistry data that was used for the design of the Removal Action is the data collected as part of the Terminal 4 Early Action EE/CA (BBL 2005). Other historical reports containing data with acceptable quality assurance and documentation (Category 1 data) that was considered include:

- USEPA Portland Harbor Sediment Investigation Report (Weston 1998)
- Remedial Investigation Report, Terminal 4, Slip 3 Sediments (Hart Crowser 2000)
- Willamette River Channel Maintenance Characterization Study (USACE 1999)

Based on a review of the existing data, the following chemicals of concern (COCs) at Slip 3 exhibited exceedances of PEC values in the EE/CA or in prior investigations. These COCs are listed in Table 4 along with their maximum PEC enrichment ratios (i.e., maximum concentration divided by PEC value). PEC values and actual concentrations for various areas are provided on figures referenced in the dredge and cap sections.

These identified COCs were used to guide the design of the Removal Action in terms of identifying the target areas for dredging, capping, and MNR as well as which parameters to model for contaminant transport evaluations.

3.6.2 Additional Pre-Construction Data

Additional pre-construction samples were collected in the RAA in July 2006. As described in the *Sampling and Analysis Plan for Additional Column Settling Testing, Geotechnical Testing, and Sediment Quality Characterization* (Anchor 2006a), the objectives of the pre-construction sampling event, included:

- Specialty testing of composite sediment samples (CST and seepage induced consolidation [SIC] tests) to be used in determining settlement and consolidation properties of the dredged sediment in the CDF
- Bulk sediment testing of the composite sediment samples, including grain size, specific gravity (including bulk measurements, particles greater than 0.074 millimeters [mm], and particles less than 0.074 mm), moisture content, and Atterberg limit determinations to characterize the geotechnical properties of the dredged sediment in the CDF
- Chemical analysis of 10 surface and 57 subsurface samples from eight core locations in Slip 3 to further define the extent of contamination in areas where previous cores were not advanced deep enough to bound the depth of contamination

The results are presented in the Pre-Construction Sampling Data Report, which is provided as Appendix H. The results have already been incorporated into the existing sediment quality dataset for use in the design of the Removal Action.

3.7 Extent of Sediment Under Pier 4

As part of the investigation for the 60 percent design, bathymetric surveys were conducted under the Pier 4 area. The linear edge where the sediment accumulation begins was determined by using the single beam trace and the Hypack digitized soundings. Figure 4 shows the boundary of sediment under Pier 4. This information was used to determine the extent of capping required under the Pier structure.

3.8 Additional Site Information

This section addresses other site considerations that were important in guiding the design process.

3.8.1 Site Uses

The history of the Terminal 4 area and historical tenant operations are described in detail in the EE/CA Work Plan (BBL 2004b) and in Appendix A of the EE/CA (BBL 2005). Appendix A of the EE/CA provides a chronology of facility development between 1906 and 1999, a chronology of dredging and filling activity between 1917 and 2003, and a detailed description of Terminal 4 operations beginning in 1917.

Current tenants at Terminal 4 adjacent to the RAA are Cereal Food Processors, International Raw Materials (IRM), Rogers Terminal, and Kinder Morgan Bulk Terminals (KMBT). Adjacent property owners include Schnitzer Steel Industries, Northwest Pipe and Casing, and Burgard Industrial Park (housing both Boydstun Metal Works and Western Machine Works), all of which are under Voluntary Cleanup Program (VCP) Agreements with the DEQ for remedial investigation of those properties. Toyota leases land from the Port on the southern portion of Terminal 4 facility adjacent to Berth 414.

At this time, three active waterfront tenant operations occur at Terminal 4:

- **IRM.** Currently IRM imports liquid bulk materials at Berth 408. Both barges and ships call on the berth. Vessel calls are very infrequent, typically less than once per month.
- **KMBT (Berths 410/411).** KMBT exports soda ash from the Berth 410/411 facility. The facility has a fixed loader so ships are brought in and line-towed during loading. Ships are typically loaded over a 2-to-3-day period. Ships call on the facility approximately eight times per month. The current lease provides the Port the option, with certain conditions, to schedule a shut down with a maximum duration of 10 consecutive days per year of KMBT's operations at Slip 3 to facilitate necessary maintenance. Additional time required to complete the dredging would have to be negotiated with KMBT.

- **Toyota.** Berth 414 is currently used to offload automobiles. Toyota's shipping activities are not anticipated to impact the currently planned Removal Action.

Berth 401 is currently inactive; however, IRM operations will be relocated to that berth prior to demolition of Berth 408 and construction of the berm at the mouth of Slip 1. Potentially, other tenants may also start operating at Berth 401 during the timeframe of this project.

It is important to consider site uses during the design process to ensure that Removal Action activities will not be compromised by day to day activities occurring at the site.

3.8.2 Typical Vessels that Call at Terminal 4

Local pilots were contacted to determine typical operational conditions at Terminal 4. Commercial vessels that call on Berth 411 in Slip 3 are "Panamax" size, deep-draft Bulk Carrier (primarily grain) ships. While Berth 401 is not currently in operation, future operations at the berth are likely to include similar vessels. These vessels are assisted in and out of port by large privately-owned tractor tugs. In addition to maneuvering within Slip 3 and around Berth 401, the tugs may also operate in Wheeler-Bay and Berth 414 while on stand-by. Appendix L provides more information on vessels that call on the site and their characteristics. This information was used in the propwash analysis conducted as part of the cap design to determine the required thickness of the chemical isolation layer and the material size for the armor layer.

3.8.3 Source Control

This section describes historic and/or ongoing sources at the RAA and how they are being addressed as part of the Removal Action. Sources that are directly addressed by the Removal Action include the following:

Resuspension of Slip 3 sediments. Slip 3 sediments will be dredged and placed within the CDF.

Resuspension of Slip 1 sediments. Slip 1 sediments will be confined beneath the CDF.

Resuspension of Wheeler Bay, Berth 411 underpier, Slip 3 side-slopes, and Berth 401 sediments. Sediments within these areas will be confined below an isolation cap.

River bank erosion along the Wheeler Bay shoreline. As part of the RI/FS and Source Control Measure VCP agreement between DEQ and the Port, the river bank area was identified as requiring a source control measure for stabilization and confinement below a cap. This action will be completed as part of the Removal Action because of the contiguous nature of the two actions (capping and slope stabilization).

Diesel seep at head of Slip 3. Historic diesel seep located at the head of Slip 3 has been remediated as part of the Bank Excavation and Backfill Replacement Area (BEBRA; Hart Crowser 2000). In addition, caps placed in certain locations at the head of Slip 3 will be amended with organoclay to provide additional source control for areas below the BEBRA action (outside the BEBRA ROD boundary).

Stormwater Outfalls. Stormwater system improvements were implemented in conjunction with the railroad realignment project on the south side of Slip 1. Additional stormwater evaluation is being conducted.

Potential Upstream Sources. The following potential upstream sources are being evaluated as part of the recontamination analysis.

- Resuspended sediment from other upstream contaminated sites
- Municipal and private stormwater discharges
- Point-source industrial discharges (both permitted and illicit)
- Nonpoint source discharges (e.g., agricultural runoff)
- Overwater activities (e.g., material handling, fueling, vessel traffic, etc.)

4 DREDGE PLAN

Dredging is the physical removal of sediments from a specific area of concern. As part of the Removal Action, dredging is required in a majority of Slip 3 (see Figure 2) and at Berth 414. Dredging will also be required beneath the containment berm to remove soft sediment that may compromise the stability of the berm if it was left in place. The depth of removal beneath the berm is governed by geotechnical conditions and not by sediment concentrations. Therefore, this section focuses more on Slip 3 and Berth 414 dredging.

4.1 Basis of Design

The basis of the dredge design relates to dredging performance standards and design objectives and criteria. As described below, these elements were used to guide the development of the dredge plan.

4.1.1 Performance Standards

Performance standards for dredging include:

- Remove sediments that exceed PEC criteria and evaluate magnitude above other criteria as directed by USEPA (30 percent design comments). These are the sediments that pose the highest ecological and human health risk.
- Confirm that PEC concentrations have been achieved by evaluating residual concentrations on an individual sampling grid location basis and comparing the new surface concentrations with other criteria such as TECs, sediment toxicity, and the current status of the Portland Harbor sediment-based bioaccumulation criteria until Portland Harbor ROD standards are determined. In comparing the new surface concentration to these other criteria, the following factors will be considered:
  - The magnitude that the post-dredge concentrations are above or below these criteria,
  - Previous site specific toxicity data as well as current direction of the harbor-wide risk assessments, and
  - The benefit of a further action. Other potential actions that will be considered include an additional dredging pass, placement of a thin layer cap, and MNR.

For those grid locations that exceed TEC, MNR will be designated at a minimum if other actions are not selected.

- Conduct the removal in a manner that minimizes to the extent practicable water quality exceedances of turbidity (or TSS) and chemistry outside the construction zone.

4.1.2 Design Objectives and Criteria

The following design objectives and related criteria were used to develop the dredge prism.

Remove sediments with chemical concentrations above sediment quality objectives. As mentioned in Section 2.2.3, the sediment quality objectives for the Terminal 4 Removal Action will ultimately comply with the results of the Portland Harbor RI/FS and USEPA ROD. In absence of these values, PEC values were used as the primary design criteria in delineating the dredge prism. In addition to the PEC criteria, USEPA (30 percent design comments) directed the Port to evaluate TEC criteria values as a secondary screening tool. During the design process, sediment quality data showing exceedances of PEC criteria on the surface and at depth were used to delineate the dredge prism. Figure 5 shows the number and extent of sediment characterization sample station locations in Slip 3 and Berth 414 that were used for the design of the dredge prism.

Minimize water quality impacts outside of the construction zone. The need to meet water quality chemistry and turbidity or TSS standards factored into the selection of dredging methods. Water quality monitoring activities and criteria for dredging are described in detail in the Water Quality Monitoring Plan (Appendix D). The removal of material in Slip 3 and Berth 414 must meet, to the extent practicable, the water quality criteria defined in the Water Quality Monitoring Plan and the USEPA-issued Water Quality Monitoring and Compliance Conditions Plan (WQMCCP).

4.1.3 Additional Considerations

Additonal considerations that helped guide the development of the dredge plan include the following:

- Physical characteristics of the site, including dredging in 20 to 50+ foot water depths, and the presence of waterfront structures (e.g., piers, sheetpile wall).
- Disruption to the Port's tenant operations in Slip 3 needs to be minimized.
- Dredged material will be placed into a CDF in Slip 1, therefore the dredging technology needs to be compatible with the CDF.
- The quantity and design ramifications associated with dredging below the PEC threshold to remove additional material that exceeds TEC criteria (see Section 4.2.4)

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

4.2 Dredge Design

Based on the information provided above, the dredge prism was developed using the following process (Figure 6):

1. Identify the depth of contamination (DOC; i.e., depth of sediments exceeding any PEC value) in all sediment core samples. Develop an elevation contour surface for the DOC using an inverse-distance weighting interpolation technique.
2. Identify the depth to native alluvium in all sediment cores. Develop an elevation contour surface on the native contact using inverse distance weighting interpolation, and using the same interpolation parameters that were used in Step 1. Compare the elevation of the DOC and native contact. If native material is close to but slightly deeper than the DOC, adjust the design surface down to the native contact.
3. Develop the Neatline Dredge Prism. Bound the contaminant distribution using a constructible mosaic of rectilinear dredging units with constant elevation or constant slope. The engineering design process must also incorporate allowances for stable slope requirements, waterfront structures, utilities, obstructions, navigation requirements, and other constraints.

4. In consideration of the dredging equipment best suited for the RAA conditions, as well as the depth and extent of removal, determine an appropriate overdredging allowance.
5. As directed by USEPA, evaluate areas where it is expected that material with concentrations above other criteria, including TEC values, sediment toxicity values, and the current status of the Portland Harbor sediment-based bioaccumulation criteria, will remain after dredging Evaluate the efficacy with which the additional material above the TEC and other criteria can be removed and modify the design as appropriate
6. Develop a CQAP to minimize the potential for short-term water quality effects during construction and to verify the target contaminated sediments have been effectively removed.
7. Use equipment modifications, operation methods, and potentially multiple passes or thin-layer capping to address post-dredging residual sediment concentrations such that final concentrations are at or below acceptable levels.

These steps are described in more detail below.

4.2.1 Determination of Dredge Surface

4.2.1.1 Depth of Contamination (DOC) Surface

The depth and elevation of contamination in Slip 3 sediments has been determined based on a core-by-core analysis of PEC exceedances. The USEPA Action Memorandum (USEPA 2006a) defines the sediment selected for dredging at Slip 3 as "that sediment with prevalent PEC exceedances." The DOC has been determined for each core location using compaction-corrected sampling intervals and chemical analytical results. Figure 5 shows the bulk sediment concentrations for cores located within the dredge prism. A statistical interpolation model has been used to create an elevation contour surface of the DOC. The interpolation model included the following input parameters:

- Inverse distance weighting algorithm to the power of 2
- Quadrant search rotated 45 degrees from true north
- Search radius of 500 feet

- Minimum of two and maximum of four nearest neighbors in each quadrant

The interpolation was performed using Surfer (version 8). The dataset was not large enough to apply more complex geostatistical methods such as kriging.

The elevation (in National Geodetic Vertical Datum; NGVD) of the depth of contamination is the primary input variable for interpolation. Although the *depth* of contamination may change over time in response to dredging events, propwash, erosion and deposition, and other processes, the *elevation* at the base of the contaminated sediments should be more constant over time and between sampling events. The DOC elevation surface has been subtracted from the current bathymetric surface to estimate a contaminated sediment thickness and volume. The current estimate of the DOC elevation surface based on PEC exceedances is shown on Figure 7. This figure been updated to include the results of the pre-construction sampling that occurred in July 2006, as well as the July 2006 bathymetry.

Boundary areas of Slip 3 that are extrapolated beyond existing sample control impart a higher level of uncertainty to estimated DOC elevations. The area of Slip 3 adjacent to the sheetpile wall along the base of Berth 411 is an area of particular uncertainty where deep levels of contamination (in fact, the deepest levels in all of Slip 3) are projected right up to the sheetpile wall with little or no sample control to verify the projected depths. The uncertainty of the DOC estimates is further complicated by the need to understand the structural stability of the sheetpile wall in response to dredging and removal of toe material from the adjacent berth, and the difficulty of getting reliable core information in a gravely deposit that has been scoured and reworked by propwash. For this reason, additional sampling using a barge-deployed sonic drill rig is proposed to be conducted in December 2006 to better characterize the dredge prism in this area.

4.2.1.2 Deepest Historical Dredge Depths

The deepest historical dredge depths in Slip 3 were also used to inform the development of the dredge surface in Slip 3. Historical dredge depths were compiled, mapped, and compared to the DOC to better understand the contaminant distribution in Slip 3. Historical dredging activities have included maintenance dredging activities in the Slip 3 area, as well as remediation dredging associated with the Pencil Pitch Removal Action in 1994 and 1995 (Hartman Associates, Inc. 1995).

4.2.2 Depth to Native Surface

The depth and elevation of the top of native alluvium in Slip 3 was evaluated based on a core-by-core analysis of geologic logs and other field observations. The native contact is often evidenced by a deposit of relatively clean sand with low fines content, overlain by more recently deposited mud with higher water content and organic content that contains most of the contaminated sediments.

It was hoped that the native contact would be a good surrogate for the depth of contamination in Slip 3, and would therefore be used to help delineate the dredge prism. However, the native contact has been smeared by propwash and prior dredging activities in Slip 3, and contaminated sediments have been mixed into the underlying native sediments in some areas. Also, native sediments may contain TEC exceedances for certain metals derived from Cascade volcanic terrains. Although a majority of cores obtained sufficient penetration to define the depth of contamination based on chemical analytical profiles, the native contact could be definitely identified in only a fraction of the cores. For these reasons, the native contact was part of the information considered in delineating the dredge prism in some areas, but it did not prove useful as a quantitative, site-wide mapping parameter.

4.2.3 Neatline Dredge Prism

Once the dredge design surface was completed based on the DOC surface, the neatline dredge prism was prepared. The dredge design surface was sectioned into dredging units with constant dredging elevations based on engineering constraints. The dredge prism within each unit was set at or below the deepest point of contamination within a given area. The sizing and orientation of the units was established based on anticipated dredging approaches:

- The units were oriented parallel to the Berth 410/411 pier. Dredging will progress in the longest direction for efficiency—either from the mouth of the slip towards the head or vice versa.
- The width of the units varies between 50 to 150 feet.
  - Immediately adjacent to the sheetpile wall the contractor will likely need to remove the sediment mechanically. Mechanical dredging will minimize damage to the sheetpile wall induced by the cutterhead and be more efficient removing sediment next to the wall. An efficient width for a mechanical dredge is the width of the derrick, which is commonly 50 feet.
  - The units further away from the sheetpile will be dredged with a hydraulic dredge. The size of dredge likely to do this work has optimal swing arcs of 100 to 150 feet. This means for the dredge to be the most efficient it needs to take cuts 100 to 150 wide at a time. Therefore, the units away from the sheetpile wall have widths of 100 to 150 feet.
- The length of the units was kept in multiples of 50 feet (i.e., nothing shorter than a 50 foot run). The longer the unit, the more efficient the dredge can work. However, the compromise is that more material will need to be removed.

As is typical with developing a dredge plan, there is balance between creating an efficient dredge prism and limiting the amount of removal of non-impacted sediment. Therefore, the neatline dredge prism includes removal of variable amounts of sediment that does not exceed the PEC to ensure complete removal of the target sediment.

Finally, an allowable overdepth thickness of 12 inches will be given based on dredging equipment tolerances and other constructability considerations. Figure 8 presents the dredge plan for Slip 3 and Berth 414. The plan considers the elements discussed earlier in this section as well as the engineering considerations discussed in the following section.

4.2.3.1 Engineering Considerations

During the development of the neatline dredge prism, other engineering constraints have been incorporated in the design, for example, slope stability requirements to avoid oversteepening and failure of cut surfaces or impacts to waterfront structures, underwater debris, nearshore utilities, navigation requirements, and other considerations.

4.2.3.1.1 Slope Stability and Oversteepening

There are two areas within Slip 3 that present a potential for slope instability if the impacted sediments are fully removed. These areas are at the southeast corner of Slip 3 where the steel sheetpile wall stops and only the timber bulkhead remains and along Pier 5 (Berth 412) where only a timber bulkhead remains at the toe. In these two areas the timber bulkhead at the toe of the slope support over a five foot cut in areas. Geotechnical and structural evaluations indicate that if material is removed in front of the old bulkhead the slope would become unstable. Figure 9 illustrates the typical conditions at the two locations, how the dredge prism will be offset from the bulkhead, and measures implemented to improve the stability of the slope.

All areas not dredged because of slope stability concerns will be capped with an in situ cap as detailed in Section 6.

4.2.3.1.2 Impacts to Waterfront Structures

Figure 3 shows the location of the steel sheetpile wall along Berths 410/411. An evaluation of the sheetpile wall given the structural properties of the wall and the geotechnical properties of the surrounding soils was completed. There is a limiting dredge elevation in front of the wall beyond which dredging deeper than this elevation causes unacceptable wall movement and potential damage to Berth 410/411. Evaluations indicate that these elevations vary by condition and are:

- **Short-term.** This condition occurs before the Berth 411 cap is placed behind the wall. This limiting dredge elevation is -52 feet NGVD
- **Long-term.** This condition represents conditions after the RAA is implemented (considering cap surcharge and seismic loading). This limiting dredge elevation is -46 feet NGVD.

Therefore, based on these results, dredged material could be removed to elevation -52 feet NGVD, but all areas will need to be backfilled to elevation -46 feet NGVD for long-term stability. Temporarily dredging to -52 feet would induce 4 to 5 inches of deflection of the wall—this is the upper limit of acceptable deflections. The Contractor will be given a 1-foot overdredge allowance for their dredging work. Due to the critical nature of the wall stability and the control of dredging equipment an additional foot will be factored in the dredging depth. Therefore, dredging below -50 feet NGVD will not be feasible.

Based on the current interpolation of the PEC surface (see Section 4.2.1.1), the dredge plan (Figure 8) indicates an area 50 feet wide by 350 feet long that would require leaving some deeper contaminated material behind to avoid undermining the sheetpile wall (between Bents 12 and 47 on Figure 8). However, the PEC surface in the vicinity of the wall is extrapolated beyond the limits of existing sample control, in part due to the difficulty of penetrating the gravely deposits in this area, which have been scoured by propwash, using conventional coring techniques. Because this area includes the deepest dredge cuts in all of Slip 3, as well as the structural complications described above, six additional cores are proposed to be collected in December 2006 using a sonic drill rig to refine the boundary of the dredge cut at the toe of the sheetpile wall in Berth 411. These data will be incorporated into the Final (100 Percent) Design.

4.2.4 Comparison to Other Criteria

As discussed in Section 4.1 the dredge prism was designed to completely remove PEC impacted sediment. USEPA also directed the Port to evaluate TEC values, sediment toxicity values, and the current status of the Portland Harbor sediment-based bioaccumulation criteria as a secondary screening tool. Although the initial step in the development of the dredge prism was to target removal of material exceeding PEC criteria, after factoring in engineering and constructability considerations and the allowable overdredge depth, the dredge prism also removes material above TEC and other criteria in most areas of Slip 3. Figure 10 presents a comparison of the dredge plan including the 1-foot allowable overdredge to the bottom of TEC surface. Values in red indicate the thickness of sediment below the TEC surface that will be removed with the dredge plan and allowable overdredge. Values in blue indicate the thickness of sediment that will be left above the TEC surface.

The first version of the dredge plan shown to the Agency Team had two "blue" areas identifying where TEC impacted material will be left below the dredge plan. One was located at the head of Slip 3 and the other was located near the mouth (see below). The location at the head of Slip 3 would require an addition 790 cy to remove. With a slight modification to the overdredge allowance, the dredge design prism in this area was modified as directed by USEPA to encompass the additional volume, which captures the TEC footprint.

As can be seen with the current dredge plan, the targeted removal within the vast majority of Slip 3 will include TEC impacted sediments. There is one pocket of material near the mouth of the slip where TEC impacted sediment is expected to remain after dredging. This area is controlled by one sample (core T4-VC26; see Figure 5). The core had 3 to 4 feet of sediment with DDT concentrations just above TEC. Therefore, in order to remove all of the material such that that the resulting elevation is below the TEC threshold, a relatively thick layer of sediment with marginal TEC exceedance would need to be removed. The additional dredge volume associated with this area is 9,100 cy or roughly 11 percent of the Slip 3 dredge volume. This additional volume will not be included within the dredge design prism due to the substantial quantity of sediment involved, and the low potential risk from just one constituent (DDT). Recognizing that this constituent is a bioaccumulative compound, the Port will continue to evaluate the post dredge surface in this area to determine which additional Removal Action is necessary. The evaluation will consider the following factors:

- The magnitude that the post-dredge concentrations are above or below the criteria,
- Previous site-specific toxicity data as well as current direction of the harbor-wide risk assessments, and

- The benefit of a further action. Other potential actions that will be considered include an additional dredging pass, placement of a thin layer cap, and MNR. For those grid locations that exceed TEC, MNR will be designated at a minimum if other actions are not selected.

4.2.5 Volumes

The neatline dredge prism volume was calculated. Because of dredging limitations, the actual volume dredged will be somewhat higher than this neatline volume. The allowable overdredge volume was computed by taking the spatial footprint of the dredge prism and multiplying that area by a 12-inch allowable overdepth.

The dredging volumes for Slip 3 and Berth 414 are presented below:

Area	Neatline	1-Foot Overdredge	Total
Slip 3 – Adjacent to Wall	13,880	2,030	15,910
Slip 3 – Away from Wall	69,100	10,110	79,210
Slip 3 – Total	82,980	12,140	95,120
Berth 414	1,490	1,000	2,490
TOTAL	84,470	13,140	97,610

4.2.6 Equipment Selection

The selection of appropriate dredging equipment is necessary to balance effectiveness, engineering feasibility (given site constraints), potential for environmental impacts, potential for impacts to Port/tenant operations, cost, and scheduling. Some of the main issues considered when selecting appropriate equipment included:

- Availability and types of equipment
- Maximizing environmental effectiveness
- Production rate capability
- Maintaining navigation access
- Minimizing disruption of Port tenant operations
- Water depths

- Thickness of dredge prism
- Geotechnical properties of sediment targeted for removal and underlying materials
- River currents and tides
- Presence of significant debris
- Minimizing short-term water quality impacts
- Proximity to structures
- CDF capacity and management of hydraulically dredged sediment and water
- Accessibility of equipment

4.2.6.1 Hydraulic Dredging

Hydraulic dredging will be the primary dredging technique in Slip 3. Mechanical dredging will be performed along the sheetpile wall as depicted on Figure 8, and described below. Based primarily on production rate capability, water depths, and the availability of equipment, a 16 to 18-inch hydraulic cutterhead dredge is likely to be used for dredging Slip 3 (additional input from the contractor is required to make this decision). This size hydraulic dredge will be able to effectively dredge to the design depths and complete the project in a short time frame that will minimize disruption of the Port tenant operations. Based on average production rates, the hydraulic dredging may be performed within a two-week period.

4.2.6.2 Mechanical Dredging

Mechanical dredging will be used for the berm overexcavation, dredging adjacent to the sheetpile wall area, and the limited surficial dredging in Berth 414. An 8 cy clamshell bucket is anticipated for mechanical dredging (input from the contractor is required before making the final equipment selection). Berm overexcavation will be performed in the first construction season, while Slip 3 and Berth 414 dredging will be completed in the second season. Material from the excavation of the berm key will be placed at the head of Slip 1.

4.2.7 Overdredge Allowance

Depth control with dredging equipment has certain tolerances. To improve the reliability of achieving the design depths, an overdredge allowance is commonly given to the contractor. The Contractor is paid for this allowance, but not for material removed below this allowance.

4.2.8 Assessment of Dredging Residuals

A verification sampling program will be used to evaluate the effectiveness of dredging in Slip 3 at the completion of the Removal Action. Dredging residuals are not a concern at Berth 414 because the dredge area will be capped after the dredging is completed. Although the dredge plan is designed to minimize the potential for residuals, the presence of some amount of residual contamination is expected any time when dredging contaminated sediments due to the inability of any dredging equipment to completely remove all sediment in the designated dredge prism. Disturbance of sediment during dredging, whether hydraulic or mechanical, may cause some fine-grained sediment to be suspended and redeposited in the vicinity of the construction site.

A multifaceted management approach will be implemented to minimize the potential for recontamination of the Slip 3 Removal Action subarea from dredging residuals. This approach includes the following components:

- After incorporation of overdepth allowance, dredging sediments with concentrations below PEC concentrations to reduce the potential for residual generation.
- Specifying appropriate construction best management practices (BMPs) to minimize the loss of sediments and contaminants during dredging operations. BMPs are outlined in the Construction Specifications and CQAP (Appendices G and C).
- Employing a post-dredge verification sampling program to characterize and, if necessary, adaptively manage any significant residual contamination after the completion of dredging. This is described in more detail in Section 4.9 below.

BMPs and engineering controls have been developed as part of the Construction Specifications to minimize, to the extent practical, impacts from residual contamination. These controls include, but are not limited to, the following:

- Requiring experienced operators that have familiarity with the selected equipment, water conditions, and environmental dredging.
- During construction, controlling vessel draft and movement within the construction area to limit the potential for scour and redistribution of contaminants from vessel propeller scour.
- Employing adequate containment measures and inspections during transport and handling of sediment to minimize spillage.
- Developing spill control and countermeasure plans to contain and recover to the extent practical any unexpected releases of hazardous substances to the environment.
- Designing stable dredge slopes along the banks of Slip 3 and on the boundaries between dredging units to control sloughing back into the completed dredge cut.
- Employing an appropriate dredge sequencing strategy to prevent more highly contaminated dredging units from dispersing to adjacent areas.

4.2.9 Construction Quality Control Related to Dredging

The CQAP (Appendix C) describes in detail the measures that will be implemented during construction to ensure the design objectives of dredging are met to achieve the performance standards. There are three specific quality control measures that will be implemented to ensure the dredge design is completed to meet the design objectives: achieving the specified dredging depths and lateral extents, meeting sediment quality performance, and meeting water quality monitoring standards outside of the construction zone. Each of these is described in more detail below.

- **Achieve Specified Dredging Depths and Extents.** Confirmation must be obtained that the contaminated sediments were removed to the target elevations and full lateral extents as depicted on the contract drawings and specifications. This will be accomplished by completing post-dredge surveys and comparing them to the dredge plan. Post-dredge survey comparisons will be completed at both Slip 3 and Berth 414. Any high areas will be re-dredged by the contractor.

- **Sediment Quality Performance.** Dredge confirmation sampling must indicate that material exceeding PEC criteria has been completely removed. Additionally, as directed by USEPA, confirmation sampling results will be compared with other criteria, including TECs, sediment toxicity data (i.e. bioassays), and the current status of the Portland Harbor sediment-based bioaccumulation assessment. In comparing the new surface concentration to these other criteria, the following factors will be considered:
  - The magnitude that the post-dredge concentrations are above or below these criteria,
  - Previous site-specific toxicity data, post-dredge confirmation bioassays (if conducted), Portland Harbor toxicity data, and the current direction of the Harbor-wide risk assessment, and
  - The benefit of a further action. Other potential actions that will be considered include an additional dredging pass, placement of a thin layer cap, and MNR. For those grid locations that exceed TEC, MNR will be designated at a minimum if other actions are not selected.

Quality assurance measures that will be implemented to help achieve sediment quality criteria are related to minimizing residuals and ensuring full vertical and lateral dredging is completed. The dredging specifications (Appendix G) include measures to minimize the occurrence of residuals.

In addition, the Slip 3 dredge plan as shown on Figure 8 was developed to remove the contaminants of concern. The target dredge depths were developed to remove sediments exceeding PEC and after factoring in engineering considerations and overdredge allowance, the dredge target depth includes a majority of the material exceeding TEC as well.

Figure 11 presents a flow chart of the decision process that will be used to evaluate the effectiveness of the sediment removal activities within Slip 3. As a first level of evaluation, the effectiveness of sediment removal will be determined by comparing the post-dredge surface elevations using the post-dredge bathymetry with the target dredge elevations shown on the dredge plan. If target dredge depths have not been achieved, the contractor will be required to conduct additional dredging until target depths are achieved.

Following completion of dredging to the target depth in the dredge prism, as defined by the dredging drawings and specifications, surface sediment verification samples will be collected within the dredged areas. Verification samples will be collected from the post-dredge surface to ensure that cleanup is complete. Surface samples will be collected from the upper 10 centimeters (cm) within the Slip 3 dredge prism. Samples will be collected on a 150-foot grid as shown on Figure 12. Samples will be analyzed for the contaminants of concern for Slip 3, which include PAHs, cadmium, lead, zinc, and DDTs.

The post-dredge verification sample results for each grid will be compared to PEC criteria. All results must meet PEC criteria; if PEC criteria are not met, an active remedial measure (i.e. dredging or capping) will be implemented. If PEC and other considerations, including TEC values, sediment toxicity values, and the current status of the Portland Harbor sediment-based bioaccumulation criteria are met on an interim basis pending finalization of the Portland Harbor ROD, the Removal Action is complete. If other criteria and/or PEC criteria are not met, the following factors will be used to determine the need for and scope of subsequent Removal Action measures in each grid

- Mudline elevations in each grid will be considered when determining an additional Removal Action measure to implement. For instance, deeper areas may be more suitable for an isolation cap than shallow areas currently near the navigation depth.
- Locations of each grid within the waterway with respect to piers, bulkheads, river, etc., will be considered when determining an additional Removal Action measure to implement, as additional dredging may not be feasible for areas close to waterfront structures.

  - In Slip 3, dependent on the contaminant, specific toxicity data and current trends in the Portland Harbor sediment-based bioaccumulation assessment will be compared to verification sampling results to inform the determination of an additional Removal Action measure to implement.
  - The benefit of a further action. Other potential actions that will be considered include an additional dredging pass, placement of a thin layer cap, and MNR. For those grid locations that exceed TEC, MNR will be designated at a minimum if other actions are not selected.

- **Achieve No Off-site Tracking of Contaminants During Transport of Disposal Materials.** It is necessary to confirm that there is no spreading of contamination during transit to the off-site disposal facility. The performance criterion is no statistical difference between samples collected before and after transit activities begin. The specifications will present requirements to minimize off-site tracking of contaminants. In addition, sampling will be completed to confirm no off-site tracking. More detailed information will be provided to USEPA by the end of January describing the specifics of the sampling approach, including sampling quantities, compositing schemes, approach to archiving samples, and contingency measures. Additionally, for off-site areas that are paved, an important component of the sampling investigation design will be to target catchment basins or other areas of topographic depression where contaminated material may have been released and accumulated. Another important component of the investigation will be to adequately sample pre-transport conditions to be able to distinguish whether or not the presence of contaminated sediment in the post-transport condition can be attributed to the Removal Action activities.
- **Minimize Short-term Water Quality Impacts.** To ensure compliance with water quality criteria outside of the construction zone, monitoring of conventional field parameters (turbidity, dissolved oxygen [DO]) and laboratory parameters (TSS and target chemical analytes) will occur during dredging activities as described in more detail in the Water Quality Monitoring Plan (Appendix D).

5 CONFINED DISPOSAL FACILITY DESIGN

As described in the EE/CA, a CDF is an engineered structure for permanently containing dredged material in a nearshore environment. Confinement berms or dikes enclose the disposal area below the surface of the adjacent surface waters, thereby isolating the dredged sediment from adjacent waters. Confined disposal in a CDF is a proven technology that isolates contaminants from the aquatic environment and ensures protection of human health and the environment.

Over the last 20 years, CDFs have been successfully designed and constructed at many other Superfund sites around the country and within USEPA Region 10. Provided below in Table 5 are basic characteristics of five CDFs in Washington's Puget Sound area, which were used as reference during the design process.

Table 5
Characteristics of Puget Sound CDFs

Milwaukee Waterway Fill, Tacoma, WA	Port of Tacoma	1993 to 1995	2.6 million cy	Formed part of an existing marine container cargo facility. Functioning as designed.
Eagle Harbor, Bainbridge Island, WA	Washington State Ferries	1997	20,000 cy (approx)	Developed for use as a ferry maintenance facility. Functioning as designed.
St. Paul Waterway, Tacoma, WA	Simpson Tacoma Kraft Company	2003 to 2005	650,000 cy (approx)	Accepted sediment from the Thea Foss Waterway Superfund site.
Slip 1 CDF, Tacoma, WA	Port of Tacoma	2002 to 2004	1 million cy (approx)	Accepted sediment from multiple users including the outer Hylebos Waterway Superfund site, Middle Waterway Superfund site, and other sites.
Terminal 91, Seattle, WA	Port of Seattle	Completed 1985	600,000 cy (approx)	In use as a marine terminal and environmental monitoring is complete. Functioning as designed.

The remainder of this section describes the design basis and design specifics for constructing a CDF in Slip 1 at Terminal 4.

5.1 Basis of Design

The CDF design was conducted according to guidance procedures contained in the USACE's Confined Disposal of Dredged Material manual (USACE 1987) and procedures followed for the recently constructed St. Paul (City of Tacoma 2003) and Port of Tacoma Slip 1 CDFs (Occidental Chemical and Port of Tacoma 2003), both located in USEPA Region 10. As described for the development of the dredge prism, the basis of the CDF design relates to performance standards and design objectives and criteria. As described below, these elements were used to guide the design of the CDF. A layout of the CDF that will be constructed in Slip 1 is shown on Figure 13.

5.1.1 Performance Standards

- Isolate contaminated sediments placed within the CDF from biota and the environment by evaluating appropriate long-term seismic, erosive, and contaminant transport mechanisms.
- The berm shall have a static safety factor of 1.5 or greater and a seismic safety factor of 1.1 or greater. The design seismic event shall correspond to a 10 percent probability of exceedance in 50 years.
- Final Applicable Relevant and Appropriate Requirements (ARARs) related to surface water will not be established for the Portland Harbor Superfund Site until the time of the ROD. To ensure that the CDF will meet ROD standards and as directed by USEPA, the CDF shall be designed such that the quality of groundwater exiting the CDF to the river will meet USEPA's national recommended chronic water quality criteria or ambient background conditions at the berm face and fish consumption criteria, and drinking water criteria/guidelines in the receiving water. In addition, the LTMRP will incorporate evaluation of these criteria on an interim basis pending finalization of the Portland Harbor ROD.
- Conduct the construction of the CDF in a manner that minimizes to the extent practicable water quality exceedances of turbidity (or TSS) and chemistry outside the construction zone.

5.1.2 Design Objectives and Criteria

The following design objectives and related criteria were used to design the CDF.

Develop a containment berm that is stable and will contain the confined sediment under a design level seismic event and withstand erosion generating forces. The configuration of the berm was designed to be a stable structure based on a static factor of safety of greater than 1.5. In addition, the structure was designed to have a seismic factor of safety of 1.1 or greater and to withstand erosion from river currents associated with a 100-year flood wind-induced waves typical of the Terminal 4 site, and prop wash generated by the size of vessels that typically transit into and out of Terminal 4.

Select berm materials with permeabilities that allow transport of groundwater through the berm structure while retaining solids. The berm is designed to be permeable and to allow the transport of groundwater through the structure, while containing the contaminated sediments in the CDF behind the berm. Water quality standards must be met in the Willamette River adjacent to the CDF berm. See below for more details on the water quality standards.

Design the berm such that its permeability, composition, and configuration result in groundwater releases that are protective of the beneficial uses in the Willamette River. Modeling of groundwater moving through the berm with specified permeability, composition, and configuration characteristics was used to predict chemical concentrations that would be transported into the Willamette River to confirm that chronic water quality criteria or ambient background conditions are met at the point of release, and fish consumption criteria and drinking water criteria/guidelines (as directed by USEPA) are met in the receiving water as the CDF operates long-term.

Minimize water quality impacts to the extent practicable outside of the construction zone. The need to meet water quality criteria for both conventional parameters (e.g. turbidity and TSS) and chemical parameters factored into the selection of berm material placement methods and the operation of the CDF during filling to minimize the need to discharge effluent through the weir. Water quality monitoring activities and criteria for construction of the berm and effluent discharge are described in detail in the Water Quality Monitoring Plan (Appendix D).

Control movement of dredged solids through the berm. The berm shall be of appropriate grain size to filter and trap solids in the dredged material and prevent them from flowing through the berm.

5.1.3 Additional Considerations

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

- Consolidation and settlement characteristics of the dredged material placed within the CDF.
- The contaminated sediments behind the berm must remain saturated to minimize leachability. Groundwater modeling was used to determine the elevation at which material will be saturated at all times. This elevation was determined to be 9.5 feet NGVD, which is the upper elevation at which contaminated sediments will be placed into the CDF.
- Future plans for the use of the upland area created by completion of the CDF
- Weir and outfall size and location necessary to handle elutriate leaving the CDF during filling, as necessary.
- It was assumed that in the future the channel outside of the berm may be dredged to a maximum elevation of -46 feet NGVD.
- CDF must not impact the Willamette River flood stage.
- Slip 1 structures must be demolished prior to material placement in the CDF
- Stormwater outfalls that currently enter Slip 1 should be re-located prior to placement of material into the CDF.
- A replacement berth for those demolished in Slip 1 will be constructed parallel to the berm face.

5.2 CDF Berm, Fill, and Surface Layer Design

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

5.2.1 Containment Berm Constructability

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

The optimal size of the training terraces is a function of rock costs and ease of construction. For instance, larger training terraces allow the select fill to be placed more efficiently at a lower cost; however, because the training terraces are larger they require more rock and are more costly. On the other hand, smaller training terraces use less rock and more select fill so they have less material costs. However, they require more time to construct reducing productivity and increasing costs. Therefore, there is an optimal size that balances production and material costs.

There are two main design elements which are impacted by the size of the training terraces: seismic stability of the berm; and contaminant transport through the berm. The Conceptual (30 Percent) design evaluated the use of 3-foot-high training terraces and found that the berm would contain the confined sediments during a design level earthquake. Contaminant transport modeling of the containment berm using 3-foot-high training terraces also determined that water quality criteria would be met within the Willamette River adjacent to the CDF berm.

Subsequent to the modeling of the 3-foot-high training terraces, a constructability review was conducted by the contractor. During that review, it became evident that using larger training terraces would greatly improve constructability. The modeling was rerun using 20-foot-high training terraces (see Figure 14). As discussed in Sections 5.2.2 and 7.5 and Appendices A and I, using 20-foot-high training terraces was found to increase the seismic stability of the berm and not impact the water quality of groundwater leaving the berm as compared to 3-foot-high training terraces. Therefore, the drawings and specifications have been written to allow the contractor to use training terraces no smaller than 3 feet in height and no larger than 20 feet in height.

5.2.2 Containment Berm Stability

Appendix A presents a detailed summary of the CDF containment berm geotechnical design. Figure 14 shows a generalized cross section through the containment berm.

The conceptual berm configuration evaluated for stability was modeled after the containment berms used for the St. Paul and Port of Tacoma Slip 1 CDF. The conceptual design of the berm incorporates 2 horizontal to 1 vertical (2H:1V) inward and outward faces. To reduce the amount of shallow water habitat lost in Slip 1 due to the CDF, the outward side of the berm will have a habitat bench between elevations -3.2 to 2.8 feet NGVD and will have gentler slopes of 5H:1V. The crest of the structure will be constructed to elevation 33.2 feet NGVD and is assumed to be 20 feet wide. Similar to the other Region 10 CDFs, the berm material will be constructed of sandy gravel or gravelly sand; training terraces consisting of quarry spalls will be placed at both ends the CDF to assist with construction. The training terraces will be up to 20 feet high built with 2H:1V outside side slopes and 1.5H:1V inside side slopes.

Behind the berm, contaminated dredged sediments will be placed to elevation 9.5 feet NGVD or below so that they will remain in a saturated condition at all times. Fill material will be placed above the contaminated sediment. The upper portion of the CDF will be filled with imported granular materials (see Figure 14).

5.2.2.1 Methods of Stability Analysis

Similar containment berm stability procedures used to assess the stability of the St. Paul and Port of Tacoma Slip 1 CDFs were followed for the Slip 1 CDF containment berm stability evaluation. A number of typical cross sections through the berm were further developed and analyzed for global stability. Based on the preliminary analysis, the cross section through the middle of the berm was determined to be the critical section (i.e., possessing the lowest factors of safety).

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

Soil parameters used in the analyses were developed based on the results of the geotechnical review. SPT blow counts, CPT values, laboratory strength testing, and gradation data were used in concert with published references to develop preliminary strengths and unit weights. Statistical distributions were applied to each value based on a subjective evaluation of the potential variability of assumed and measured data. The values assumed for non-native soils (dredged material) are comparable to assumed values used in designing the St. Paul and Port of Tacoma Slip 1 CDF facilities in USEPA Region 10. A summary of soil parameters employed in the analyses is presented in Appendix A.

The cross section was evaluated for the following four cases:

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

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

5.2.2.2 Short-Term Static Stability

The critical section for the short-term static stability reflects the conditions present during filling of the CDF when the entire CDF may be used to decant hydraulically dredged sediments. The analysis was based on the most critical case for this condition, with the dredged sediment placed, the water in the CDF to within 2 feet of the crest of the containment berm, and with the river at a low water stage.

Based on these very conservative assumptions, the slope stability factor of safety relative to a shallow slope movement was 1.58. The factor of safety for slope stability for a deep slope movement that would intersect the decant water was 1.66. These values indicate that the berm would be stable during hydraulic filling. Note that the condition modeled is not anticipated to actually occur during the filling operation.

5.2.2.3 Long-Term Static Stability

The long-term static stability case reflects a finished condition for the CDF. For this case, it was assumed that the groundwater table within the CDF would approach current levels observed inland of Slip 1. The factor of safety for the long term static stability analysis was 1.67. The factor of safety for deep slope movements was 2.04. These values indicate that the berm will be stable under normal operating conditions.

5.2.2.4 Seismic Stability

In accordance with the USEPA approved EE/CA (BBL 2005) and the Action Memorandum (USEPA 2006a) the CDF and the containment berm were evaluated for stability against a contingency level seismic event. The contingency level event

(CLE) represents an earthquake with a 10 percent probability of exceedance in 50 years (i.e., 475-year return period). During the CLE, waterfront facilities may suffer significant damage that would impair operations and major repair work would likely be required, but no catastrophic failure would develop. Although design components, such as a CDF containment berm, may suffer deflections, containment of the contaminated sediments would not be jeopardized.

The Action Memorandum (USEPA 2006a) requires the following design-level geotechnical seismic analysis for the Terminal 4 RAA and the CDF containment berm stability:

- Detailed characterization of seismic sources (known regional faults) in the vicinity of the Terminal 4 RAA for development of a site-specific seismic hazard analysis.
- Development of input ground motions from seismic sources considering site-specific geotechnical considerations.
- Evaluation of liquefaction potential for CDF containment berm, foundations soils, dredge sediment, and surrounding site soils potentially contributing to instability of the CDF during the design-level earthquake, including evaluation of liquefaction-induced deformations and lateral spreading.
- Evaluation of slope stability and deformation for both pseudo-static and post-earthquake conditions.
- Development of a contingency plan for post-earthquake inspection and repair.

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

A Probabilistic Seismic Hazard Evaluation (PSHA) using the most up to date information from agencies such as the United States Geological Survey (USGS), Department of Geology and Mineral Industries (DOGAMI), and the Oregon Department of Transportation (ODOT) was completed to determine the appropriate seismic acceleration to use with stability design. This information has been supplemented with seismic hazard data from numerous other technical resources. On the basis of the PSHA analyses, the two primary seismic sources considered for design purposes have been considered to include: (1) a magnitude 9.0 mega-thrust earthquake along the CSZ having a source-to-site distance of roughly 100 kilometers (km); and (2) a magnitude 6.2 shallow, crustal event with a source-to-site distance of 14 km. The relative contributions of the two closest faults, the Portland Hills Fault and the East Bank Fault, to the cumulative seismic hazard are small for the return period of interest (475 years). In light of the low slip rates and corresponding low rates of seismicity estimated for these faults, and based on input from DOGAMI personnel who are actively studying these faults (Madin 2006), these two potential seismic sources have not been incorporated in the current analyses. The design team has selected the following scenarios for subsequent analysis of dynamic soil response, soil liquefaction, and design for the CDF berm:

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

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

5.2.2.5 Pseudostatic Stability

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

Results of the analysis show that the factor of safety relative to shallow, surface movement was 1.04. The factor of safety for deep shear surfaces that intersect the dredged sediments was 1.12. This analysis indicates the potential exists for displacement of the berm toe under a design level earthquake event. However, the remaining berm possesses sufficient residual strength to contain the contaminated sediments within the CDF.

The impact of a progressive failure of the toe of the berm resulting from a design earthquake was evaluated. In order to evaluate this potential, we assumed that the deepest failure surface with a pseudostatic factor of safety of less than 1.1 occurred. Further, we took the conservative assumption that all of the material within the slide block was removed by river currents. For strength values, we used the reduced strengths described under Post Earthquake Stability below. This includes strength reductions for excess poor pressures and liquefaction. Ultimately, these phenomena would be short lived. Even with these conservative assumptions, the results of this analysis indicate that the factor of safety against a further shallow failure is in excess of 1.4.

5.2.2.6 Post-Earthquake Stability

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

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

The factor of safety relative to shallow, surface movement on the berm face was greater than 1.13. The factor of safety for the deep shear surfaces that potentially intersect the dredged sediments was 1.68. These values indicate that the berm will be stable after a design level earthquake.

5.2.2.7 Seismically Induced Berm Deflection

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

As described in Appendix A, two methods were used to predict the amount of deflections (Dickenson et al. 2002; Jibson and Jibson 2003). Conservative input values were used for the modeling. The estimated total displacement ranged from less than 6 inches to up to 24 inches for large-scale, deep-seated movements. These small amounts of movement will not compromise the integrity of the CDF.

5.2.2.8 Summary of Stability Results and Conclusions

Based upon our analysis, the CDF structure as proposed is protective of the contaminated sediment placed within the CDF. The structure will adequately protect and contain the dredged sediment. The berm design and corresponding safety factor reflect a number of modifications and improvements. First, the foundation of the berm will be overexcavated and backfilled with structural fill. For the majority of the berm structure, the removal of loose sediment will likely be less than 5 feet, but in some locations the removal thickness could be 10 feet. The current design assumes that 5 to 10 feet will be removed below the outer toe of the berm. Secondly, the habitat bench constructed on the outer face of the berm also improves the stability of the containment berm.

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

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

For each case evaluated, the statistical evaluations indicate that the probability for a deep movement that would impact the dredged sediments was 0. This analysis indicates that the proposed design more than adequately addresses the potential for variability within the strength of the soils present and proposed for use in the construction of the berm.

5.2.3 Containment Berm Erosion Resistance

The outward face of the containment berm will be exposed to the same potential erosive forces as the in situ caps (Section 6) including river currents, waves, and propeller wash. To resist this erosion an armor layer will be placed on the face of the berm. This section presents the design approach and results for the armor sizing.

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

- **River current**. WEST Consultants, Inc. used the Lower Willamette Group's river-wide EFDC model (WEST Consultants 2006) and refined the existing grid to provide increased resolution at the berm face. The predicted currents associated with the 100-year flood flow conditions along the face of the berm are presented in Appendix K. At the lower section of the berm (-35 to approximately -15 feet NGVD), the velocities range from 1.01 to 1.32 fps resulting in a medium sand needed for erosion protection. Along the face of the berm, elevation -15 to +25 feet NGVD, the velocities decrease to 0.42 to 1.14 fps, resulting in the need of fine to medium sand. Therefore, at a minimum a medium sized sand is required to resist the river current velocities.
- **Waves**. For wind-induced waves a medium sand is needed to resist the bottom shear stress due to the passing wave prior to breaking. As the water depth over the cap area decreases to roughly 2.5 feet, a fine gravel is required. For vessel-induced waves, a coarse gravel is required to resist the orbital velocity of a passing wave. Breaking waves impart more erosive force on the berm than a passing wave. A riprap sized material (d_{50} between 7 and 10 inches) will be necessary to protect the berm within the surf zone areas. The surf zone is assumed to be at elevation -3 feet NGVD given a river level elevation of 0 feet NGVD up to ordinary high water (OHW), 16.6 feet NGVD. Therefore, at a minimum a coarse gravel is required to resist the subsurface force of a wave approaching and a riprap sized material is required to resist the force of a wave crashing in the surf zone.

- **Propeller Wash**. To assess the propeller wash potential imparted on the berm face the new replacement berth and Berth 401 were assumed to be operational supporting ship traffic. Both tugs and ocean going vessels were evaluated at different river stages. The analysis indicates that riprap will be needed on the berm face; the gradation depends on the elevation. From elevation -25 feet NGVD to the toe of the berm riprap with a d_{50} of 15 inches is required. From elevation -25 feet NGVD to -10 feet NGVD riprap with a d_{50} of 7 inches is required. Above that elevation riprap with a d_{50} of 4 inches is required. Therefore, at a minimum a rip rap is required to resist propeller wash from approaching vessels.

Therefore, to properly design the face of the berm to resist the most critical erosion the largest sized armor was selected. For the berm face, the armor layer is controlled by the propeller wash and crashing waves. In summary, the face of the containment berm adjacent to the river will require riprap with a d_{50} of 15 inches from elevation -25 feet NGVD to the berm toe and d_{50} of 7 to 10 inches above -25 feet NGVD up to the OHW. To be conservative the boundary between these two layers will be raised up to the base of the habitat bench (elevation -3.2 feet NGVD).

5.2.4 Containment Berm Consolidation

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

5.2.5 Consolidation and Settlement of Contaminated Dredged Sediment

Similar to containment berm consolidation, the weight of the sediment placed within the CDF will also induce consolidation. This consolidation has been considered in order to determine the total amount of contaminated dredged sediment that can be placed into the CDF. The contaminant transport model of the CDF (see Section 7.5) indicates that the top elevation of the confined contaminated sediment will be 9.5 feet NGVD. Not considering consolidation, the capacity of the CDF for contaminated dredged sediment up to 9.5 feet NGVD is approximately 670,000 cy. Contaminated dredged sediments will include material from Terminal 4 (approximately 125,000 cy) and other sites within the Portland Harbor Superfund Site. As this material consolidates to a denser condition than it is in situ and the foundation materials below the CDF consolidate, additional contaminated sediment will be able to be placed below elevation 9.5 feet NGVD. The remainder of this section details the expected consolidation and predicts a new capacity for the dredged contaminated sediments that can be placed within the CDF below elevation 9.5 feet NGVD.

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

5.2.5.1 Consolidation of the Confined Contaminated Sediment

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

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

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

Consolidation properties of the fill material were obtained from laboratory tests on representative samples of the dredged Slip 3 material (Appendix H – Pre-Construction Sampling Data Report). Two composite samples were analyzed from Slip 3 (Comp-1 and Comp-2). For the analysis described in this section, the consolidation properties of the non-Terminal 4 contaminated material was assumed to be as the Slip 3 dredged sediment.

The computer program CONDES was used to estimate the amount of sediment settlement. Figure 15 illustrates the top elevation of the contaminated sediment within the CDF during the filling process. The line represents the elevation of the top of the placed material. The initial steep upward portion of the curve is during the filling process. This is the four month fish window (July through October). The flat or downward segment after the filling period is the settlement that occurs during the eight month fish closure period (November through June). The filling period and subsequent waiting period create a "step" on the graph.

The first "step" is the placement of the Terminal 4 sediments. The next three "steps" are the placement of contaminated sediments from other sources. Note that the three year filling process of the other material could take longer or shorter depending on the availability of material. After the contaminated sediment is placed the import fill and cover layers would then be placed. On the graph it is represented by the period between years four and six. Again, this filling process could take longer or shorter than the assumed two years depending on the availability of materials.

As can be seen on Figure 15, if 670,000 cy of in situ contaminated sediment were placed within the CDF, the top of this layer would be between elevation 0 to -9 feet NGVD after the import fill and cover layers were placed. This indicates that an additional 9 to 18 feet of contaminated sediment could be placed within the CDF and still be below elevation 9.5 feet NGVD.

5.2.5.2 Consolidation of Foundation Below the CDF

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

5.2.5.3 Total Estimated Settlement

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

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

5.2.6 CDF Surface Layer

The last stage of the CDF construction is the placement of the CDF surface layer (see Figure 14). Approximately 146,000 cy of material will be placed as the surface layer.

The surface of the CDF will have a layer suitable to support long-term site uses. This layer will be constructed of imported granular material. Figure 14 shows the thickness of the surface layer. This surface layer will be graded for drainage and site use.

As discussed in detail later in Section 7.5, the surface of the CDF does not need an asphalt pavement in order to meet water groundwater quality criteria—infiltration of surface water does not impact the groundwater quality discharging through the berm face. The ultimate post-filling use of the CDF surface by the Port is currently not known. Therefore, given these two factors the Prefinal (60 percent) Design assumes a compacted crushed rock surface.

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

Figure 16 shows the conceptual grading plan for the CDF surface layer. The surface grading plan will be finalized as part of the 100 percent design. Once future development plans are identified, appropriate stormwater treatment associated with the planned development will be implemented under a separate permit process unrelated to this action. The current surface of the CDF is being designed to be pervious and minimize stormwater discharge to the Willamette River.

5.3 Fish Removal

In order to minimize take of listed fish species and to ensure compliance with ORS 509.585 regarding providing fish passage, an effort will be made to remove fish from Slip 1 prior to Terminal 4 dredged material placement in the CDF. Fish removal will occur following initial berm construction when the height of the berm isolates water from the CDF from the river, and prior to Slip 3 dredged sediment placement in the CDF, and is expected to span 3 to 5 fishing days near the second half of the summer in-water work window in 2007. This removal is intended to minimize impact to listed fish, but will also have the effect of minimizing impacts to other fish species that are collected with the listed fish. Following this work, the absence (or near absence) of fish from the CDF area should minimize or eliminate the potential contact of piscivorous birds with potentially affected water, sediments, or prey from Slip 1.

Based upon typical juvenile salmonid behavior, fish removal efforts will be focused on shallow water habitat and the top portion of the water column (NMFS 2005). Methods were selected that should be reasonably effective for the areas where juvenile salmonids and other fish are expected to be located, and are consistent with the provisions in the NMFS fish collection guidance (NMFS 2000), typical methods used for fish collection (Murphy and Willis 1996), and with previous successful methods used to capture salmonids and other fish in the Terminal 4 vicinity (Gasco Removal Action; Anchor 2006b; and Portland Harbor Remedial Action/Feasibility Study; Striplin et al. 2003). These methods are listed in order of expected catch effectiveness, and this order will be used in sequencing the effort, as follows:

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

During sampling, shifts in priority for the methods or concurrent use of two or more methods in this list may occur depending on observed effectiveness of these methods and actual catch rates, in order to maximize potential for catching and removing as many fish as practicable.

Coordination will be ongoing with NMFS during this effort regarding actual catch per unit effort (CPUE) efficiencies encountered. As stated previously, this removal would be expected to span approximately 3 to 5 days in the fall of 2007.

Once fish are captured, water quality conditions within fish transport systems (e.g., buckets or tanks) will be maintained as sufficient to promote fish recovery, including using brief holding times, aerators, and clean, cold, circulated water. Collected fish will be released into the river as quickly as possible in shallow water near the shore on the opposite side of the containment berm. The selection of release sites will be coordinated with NMFS prior to the fish removal effort. In the event of mortalities, federally listed fish will be transferred to the Services if requested.

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

5.4 CDF Filling Methods and Weir and Outfall Design

Following construction of the containment berm, the CDF will be filled with dredged sediments. The filling of the CDF will occur both directly with hydraulic dredging equipment and by offloading of barges with sediments dredged by clamshell.

5.4.1 Hydraulic Filling

For Slip 3 hydraulic dredging, the sediment will be pumped hydraulically from Slip 3 to a diffuser barge located within the CDF. The alignment of the dredge pipeline between the dredge and the CDF will either be in the water or over the upland. The Contractor will determine the preferred location of the line. Figure 3 shows a possible upland alignment of the dredge line.

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

- Reduces the energy of the slurry material
- Is capable of delivering the slurry to any elevation within the water column

- Can be moved around the CDF to varying discharge locations

If filling progresses at a relatively fast rate, the water level within the CDF will rise. If water rises high enough, it will be discharged over a weir, through a pipeline and into the river. During dredging, the water within the CDF will contain some suspended sediments and dissolved chemical constituents. The TSS and chemical concentrations in the water that goes over the weir needs to be controlled so that water quality standards are met (see Section 7). The TSS concentration at the weir is influenced by several factors, including filling or dredge production rate, solids concentration of influent, size of the CDF and ponding depth, dredging volume, and sediment settling characteristics.

The estimated volume of material to be dredged hydraulically is roughly 79,000 cy. As the hydraulic dredge removes sediment it entrains additional water. Commonly, 4 to 10 parts of water is entrained for every 1 part sediment (the amount of additional water is a function of the cut thickness, cut geometry, and dredge operator). Therefore, total dredge slurry volumes of 400,000 to 880,000 cy could be generated during the removal of Slip 3 sediments. On a daily basis dredging could produce 50,000 to 100,000 cy of slurry.

Figure 14 presents a conceptual detail of a drop-inlet structure or weir. A weir is a structure that controls the level of water within a CDF. To lower the water level in the CDF, the top elevation of the weir is lowered; to raise the water level the top elevation of the weir is raised. The elevation at which the weir is set to start removing water can vary. For this project, the water level could be as high as elevation 29 feet NGVD—the berm has been designed to be stable under this water level. From a construction standpoint the lowest elevation of the weir will be set at is elevation 15 feet NGVD. Figure 17 shows a conceptual schematic of the weir, pipeline and outfall as it relates to the containment berm.

Figure 18 shows the cumulative capacity of the CDF for different elevations within the CDF. When filling starts in early July the water level within the CDF will likely be near elevation 0 feet NGVD. If the weir is set to draw water out somewhere between elevations 15 to 25 feet NGVD there is 300,000 to 550,000 cy of storage capacity.

Therefore, there is a chance that no water will be discharged through the weir during the hydraulic dredging of Slip 3 materials. As the CDF is being filled, water will continue to seep through the surrounding ground and containment berm providing more storage capacity. Based on conceptual calculations the estimated seepage is roughly 10,000 cy per day of water out of the CDF or approximately 10 to 20 percent of the daily input volume.

Although there is a likelihood that water may not be discharged through the weir, modeling was completed to predict water quality out of the weir outfall incase a discharge was required. Section 7.4 addresses the predicted water quality from the weir.

Appendix N evaluates in more detail effluent from the CDF and specifically sizing of the weir. Appendix N conservatively assumes a weir elevation of 15 feet NGVD. The predicted effluent TSS concentration leaving the CDF is 15 mg/L. A minimum weir width of 1.5 feet is required to achieve this TSS concentration. Wider weirs will further help the water quality leaving the CDF.

There is a potential that dredged material from other Portland Harbor Superfund Site locations could be dredged hydraulically and pumped directly to the Slip 1 CDF. The dredged material would need to be evaluated on a case-by-case basis to see if the TSS could be an issue in the effluent. Specific testing of the material as well as an understanding of the dredging equipment would be required to complete the evaluation.

5.4.2 Mechanical Filling

Material dredged mechanically in Slip 3 and at Berth 414 will need to be transferred into the CDF over the containment berm using a pumping system. Dredged sediment brought from other Portland Harbor Superfund Site locations will most likely be brought to the CDF via a haul barge—this material will also need to be transferred into the CDF with a pumping system. If the material is brought by haul barge sediments will be offloaded with a pump into the CDF.

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

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

The offloading system would connect to a diffuser barge system similar to that described in Section 5.6.1.

5.5 Construction Quality Control During CDF Construction

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

- **Containment Berm Construction.** Construction performance standards and criteria associated with the construction of the containment berm include the following:
  - **Achieve Specified Grades and Extents.** Berm construction materials must be placed at the specified grades within 1 foot of the extents shown on the contract drawings and specifications. Surveys will be completed to confirm grades.
  - **Achieve Proper Stability of the Containment Berm**. Berm slopes must be constructed to the grades shown on the drawings and need to be monitored for stability throughout construction. Surveys and visual observations will be completed to confirm berm stability.
  - **Verify Import Material Quality**. Import material must meet specified physical and chemical properties, as outlined in the specifications, prior to the use of any imported material. Sampling and analysis of materials before construction and during construction coupled with visual inspections of import materials will be completed to verify suitability.

- **Minimize Short-term Water Quality Impacts**. Water quality monitoring activities are required to ensure compliance with federal and state water quality standards. Water quality criteria for berm construction are described in detail in the Water Quality Monitoring Plan (Appendix D to the DAR).
- **Minimize Potential Impacts to Cultural Resources**. Archeological monitoring activities are required in specifications to ensure no impacts to cultural resources or historic structures.

- **CDF Filling.** Construction performance standards and criteria associated with the filling of the CDF include the following:
  - **Verify Fill Material Quality**. Material being placed in the CDF will be in accordance with that tested and approved as described in the Sediment Acceptance Criteria Memorandum.
  - **Prevent Release of Dredged Material (Mechanical Transport).** Action must be taken to minimize the potential for and prevent releases of dredged material during the filling of the CDF. Releases outside the CDF could also occur during transport. The specifications will require certain types of haul barges for transport.
  - **Prevent Release of Dredged Material (Hydraulic Transport).** Action must be taken to minimize the potential for and prevent releases of dredged material during the filling of the CDF. Action must also be taken to prevent releases of material outside the CDF during transport. Specifications will require certain equipment and testing of the equipment before dredging begins. In addition, inspections will be required during dredging to confirm no losses of materials during dredging.
  - **Minimize Spillage of Material at the Transfer/Offload Facility**. Action must be taken to minimize the potential for releases of dredged material during the transfer or offloading into the CDF. The specifications require certain measures be implemented to minimize spillage during offloading. In addition, sampling of the sediments at the offloading facility will be completed after offloading to confirm no spillage occurred. If spillage is indicated, remedial measures will be implemented to clean up the area.

  - **Achieve Specified Placement Elevations**. Materials must be placed to the specified grades within the specified extents as shown on the drawings and as determined by the process for accepting sediment as described in the Sediment Acceptance Criteria Memorandum. Surveying requirements are defined in the specifications for vertical and lateral confirmation during placement.
  - **Achieve Expected CDF Consolidation**. Confirm that settlement and consolidation of placed material is occurring as predicted in the design is necessary. The Contractor will be required to install settlement plates within the cover material to monitor settlement of the dredged fill as a result of cover placement and self weight consolidation.
  - **Minimize Short-term Water Quality Impacts**. Water quality monitoring activities are required to ensure compliance with federal and state water quality standards. Water quality criteria for CDF filling activities (i.e., transport of material to the CDF for mechanical dredging and effluent discharge through the weir) activities are described in detail in the Water Quality Monitoring Plan (Appendix D).
- **CDF Covering**. Construction performance standards and criteria associated with the covering of the CDF include the following:
  - **Verify Import Material Quality**. Import material must meet specified physical and chemical properties, as outlined in the specifications, prior to the use of any imported material. Sampling and analysis of materials before construction and during construction coupled with visual inspections of import materials will be completed to verify suitability.
  - **Achieve Specified Cover, Thickness, and Extent**. Topographic surveys will be required by the contractor to confirm accurate placement of materials. The Contractor will also be required to have a location control system appropriate to meet the construction tolerances.

5.6 Assessment of CDF Impacts on Willamette River Flood Stage

An assessment of potential impacts to the Willamette River as part of the EE/CA demonstrated that no rise in the base flood elevations would result from the CDF and the action would comply with Federal Emergency Management Agency (FEMA) regulations.

Compliance with the FEMA "no rise" criteria, completed and approved as part of Appendix K of the EE/CA (BBL 2005), has been confirmed with the existing CDF configuration as part of the Prefinal (60 percent) Design using the same models and process (see Appendix M).

5.7 Demolition of Slip 1 Structures

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

Slip 1 of Terminal 4 currently contains two piers, one on each side of the slip. Berth 405 is located on the north side while Berth 408 is located on the south side of the slip. These piers are wooden and concrete structures with asphalt topping that support storage and crane loads above. A system of wood piling and some steel piling is used as the fendering system at each pier.

Two existing open pier structures located in Slip 1 will be demolished as part of this project. Berths 405, to the north, and 408, to the south, are to be demolished and removed. Each berth structure includes wood and concrete piles and concrete superstructure with asphalt or concrete topping. The piles at Berth 405 are to be cut or broken off at the mudline. The piles at Berth 408 are to be pulled and removed to the extent practicable.

Figure 19 shows the extent of demolition in Slip 1 required for the CDF construction.

Construction quality control procedures to confirm demolition meets the intent of the design are presented in the CQAP of Appendix C. Briefly, construction performance objectives for pile/structure demolition include the following:

- **Remove Specified Structures and Piles and Protect Remaining Structures.** It is necessary to confirm that the piles and structures identified in the contract drawings and specifications have been adequately removed and that structures not requiring removal are not damaged during the demolition operation. Performance criteria include total removal of specified structures and piles and less than 1 inch of movement of protected structures (i.e., structures not identified for removal). Settlement monitoring of adjacent structures will be required of the contractor.

- **Appropriate Disposal/Recycling of Demolition Materials.** Demolition material removed from the Removal Action Area must be properly disposed or recycled. The performance criterion is disposal or recycling of demolition materials at the appropriate facility as detailed in the contract specifications. The Contractor will be required to track and document all loads of material leaving the site for disposal or recycling.
- **Achieve No Off-site Tracking of Contaminants During Transport of Disposal Materials.** It is necessary to confirm that there is no spreading of contamination during transit to the off-site disposal facility. The performance criterion is no statistical difference between samples collected before and after transit activities begin. The specifications will present requirements to minimize off-site tracking of contaminants. In addition, sampling will be completed to confirm no off-site tracking. More detailed information will be provided to USEPA by the end of January describing the specifics of the sampling approach, including sampling quantities, compositing schemes, approach to archiving samples, and contingency measures. Additionally, for off-site areas that are paved, an important component of the sampling investigation design will be to target catchment basins or other areas of topographic depression where contaminated material may have been released and accumulated. Another important component of the investigation will be to adequately sample pre-transport conditions to be able to distinguish whether or not the presence of contaminated sediment in the post-transport condition can be attributed to the Removal Action activities.
- **Minimize Short-term Water Quality Impacts**. Water quality monitoring activities are required to ensure compliance with federal and state water quality criteria. Performance criteria are specified in the Water Quality Monitoring Plan (Appendix D).

- **Minimize Potential Impacts to Cultural Resources and Historic Structures**. Archeological monitoring activities are required to ensure that construction activities do not impact cultural resources and historic structures.

5.8 Outfall and Stormwater Rerouting

The goal of the stormwater reroute is to relocate multiple existing discharge outfalls currently used by the Port of Portland and the City of Portland out of Slip 1. The reroute minimizes the number of trunk lines, as well as impact to existing utilities and site surface features. Design and layout of the stormwater reroute system was based on estimated flow rates of adjacent basin areas, current outfall and utility locations, and location of new construction at Berth 401 and Pier 2 rail yard. Consideration was also given to minimizing the depth of excavation for installation and providing the shortest run possible.

Currently, five storm drain mains are known to outfall into the most inward (eastern) portion of Slip 1 at Terminal 4. Four of these are Port-owned and operated storm lines while the fifth outfall is owned by the City of Portland. When Slip 1 is filled, these discharge points will be buried; therefore, these pipes will be relocated to provide suitable points of discharge into the Willamette River. Figure 20 shows the location of the new lines and outfalls. Three new lines will be run:

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

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

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

The new berth replacement pier is intended to provide a new berth for grain-carrying river barges and act as a platform to support a grain offloading facility to be used by the Port's tenants. The dock is also intended to provide flexibility for future tenant use and is designed to support vessels up to the size of ocean-going barges. The dock has been designed to carry loads up to 1,000 pounds per square foot (psf) uniform load to support future uses of the dock structure and will have vehicle access that is also designed for 1,000 psf to more easily accommodate future expansion. Additionally, this berth will be used for offloading the mechanically dredged sediments from barges from Terminal 4 and other future Portland Harbor Superfund Site clean up projects. Figure 21 shows the location of the replacement berth.

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

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

The structures associated with this new barge berth will require in-water work involving pile-driving operations, overwater concrete placement for the precast concrete pile bents, and installation of steel or aluminum walkways. It is anticipated that precast concrete deck panels will be placed by a crane-loaded barge, as will prefabricated steel or aluminum access catwalks.

The IRM berthing facility is to be relocated to Berth 401 to provide an area for IRM to berth once Slip 1 is filled. Modifications to Berth 401 are required to provide access to the barges that are used by IRM. Berth 401 was chosen because it provides a berthing location close to IRM's current facilities and does not interfere with existing shipping traffic. Berth 401 will have new gangways for access, piping for the transport of liquid bulk materials, and a pump house to provide the mechanical facilities to deliver the material to and from IRM's facility.

5.10 Post-Terminal 4 Dredging CDF Management

After the Terminal 4 sediments are placed within the CDF, acceptable contaminated sediments from other Portland Harbor Superfund Site locations may be placed within the CDF. This section describes the criteria to be used to determine if the material is acceptable for placement and how the CDF will be managed between placement operations.

5.10.1 Acceptance Criteria for Non-Terminal 4 Material

Physical and chemical testing will be required of any sediments proposed for placement in the CDF as either contaminated fill material or overlying cover material. These requirements are detailed in the Sediment Acceptance Criteria Memorandum and described briefly below. After the placement of Terminal 4 sediments in the CDF, the remaining capacity will be available for contaminated sediments generated by other Removal Actions or Remedial Actions in the Portland Harbor, provided certain acceptance criteria are met. These criteria include:

- **No Hazardous Waste**. No sediments designated as hazardous waste, whether listed waste or characteristic waste, will be eligible for placement in the CDF.
- **No Free Oil**. Sediments containing "free oil" (defined as greater than 1 percent total petroleum hydrocarbons) are not eligible for placement in the CDF.
- **Suitable Geotechnical Properties**. The geotechnical properties of the fill materials must be of an acceptable quality such that they do not impact the long-

term performance of the CDF, e.g., they must be free of debris and significant organics (i.e. wood chips) which could cause unacceptable obstructions, settlement, or gas generation.

- **Suitable Geochemical Properties**. The geochemical properties of the contaminated sediments accepted for placement in the CDF must be shown to be protective of human health and the environment, and the beneficial uses of the Willamette River, when allowance is made for mixing and attenuation of contaminants during subsurface transport through the fill materials and the berm.
- **Other Considerations**. The Port and USEPA may consider other more qualitative factors in determining acceptability of contaminated material for placement in the CDF, including presence of principal threat compounds, physical nature of the material, form of the chemical contaminants, quantity of the material, long-term site liability, indemnification, and cost.

The applicant will prepare a sampling and analysis plan (SAP) for review and approval by the Port and USEPA prior to conducting various testing requirements to determine suitability. Upon approval, field sampling and laboratory testing will be conducted and results will be summarized in a Sediment Characterization Report (SCR). The Port and USEPA will review the SCR and issue a suitability determination for the proposed dredged material. The testing requirements needed to support a suitability determination will include the following:

- **Bulk Sediment Chemistry**. Bulk sediments will be analyzed for metals, semivolatile organic compounds (SVOCs), volatile organic compounds (VOCs), PCBs, chlorinated pesticides, and total petroleum hydrocarbons (TPH).
- **Bulk Physical Properties**. Bulk sediments will be analyzed for total organic carbon (TOC), grain size, and Atterberg limits. Appropriate consolidation tests will also be require of material to be placed within the CDF.
- **Toxic Characteristic Leaching Procedure (TCLP)**. TCLP testing for hazardous waste designation will be conducted for TCLP metals. Other TCLP parameters (TCLP VOCs, SVOCs, and/or pesticides) will be determined on a case-by-case basis.

- **Pancake Column Leaching Test (PCLT)**. PCLT testing for sediment leachability will be conducted for metals, SVOCs, PCBs, chlorinated pesticides, and possibly other parameters as determined on a case-by-case basis.
- **Other Testing Requirements**. If material will be placed in the CDF is such a manner that overflow of the weir is expected, causing return flow to the Willamette River, a Modified Elutriate Test (MET) and Column Settling Test (CST) may also be required.

5.10.2 CDF Operations after Terminal 4 Sediment Placed

Terminal 4 sediments will first be placed within the CDF. The remaining capacity of the CDF for contaminated sediments will be filled with sediment from other locations within the Portland Harbor Superfund Site. Fill material will then be placed above the contaminated sediments. Appendix B presents the Confined Disposal Sediment Management Plan. Below is a summary of what is included in the Confined Disposal Sediment Management Plan (Appendix B).

The Confined Disposal Sediment Management Plan (Appendix B) describes the following inspection and quality control measures that will be implemented between future filling events:

- **Physical Inspections of the CDF.** The containment berm will be inspected at the end of each filling season until the CDF is completed.
- **Physical Inspections of the Placed Material.** Bathymetric surveys will be completed at defined intervals to track the elevations of placed materials.
- **Interim Wildlife Protection.** Wildlife protection during filling of the CDF will include placing a thin layer of clean material over the contaminated sediment when the average expected water depth after a filling event is shallow enough that exposures potentially causing wildlife risk may exist. During the majority of the filling operations, wildlife protection will not be necessary due to the significant water depths over the sediment and the initial removal of fish from the CDF following berm closure. These factors minimize the potential contact of piscivorous birds with affected sediments or prey from Slip 1.

The Confined Disposal Sediment Management Plan (Appendix B) also describes the management of future filling events in the CDF. The management within the Plan describes:

- **Port and USEPA Administration**. A framework and responsibilities for administration of CDF filling activities is presented. Contacts at the Port and USEPA are identified and the required information for application is outlined. Scheduling constraints on filling operations are also presented.
- **Management of Offloading**. The docking facilities for offloading are discussed as well as the acceptable offloading methods. Spill prevention requirements are discussed. Finally, equipment necessary to properly place the material within the CDF to the elevations and extents identified on the drawings are presented.
- **Water Quality Monitoring**. Water quality monitoring requirements during future filling events are presented.
- **Environmental Controls**. Environmental controls for surface water management, dust control, and erosion control are listed.

5.10.3 Long-Term CDF Management

Long term management activities will be addressed in the LTMRP that will be included as part of the Final (100 percent) Design. An outline of the LTMRP is presented in Appendix E.

6 CAPPING PLAN

Capping is a generic term for the in-situ containment of contaminated sediment. Contaminated sediments are covered (capped) by an appropriate material that isolates the contaminants from the water body and from ecological and human receptors.

Capping involves the placement of a natural material such as sand or gravel or a synthetic material on top of the contaminated sediment, thereby isolating chemicals from the overlying water. A cap will therefore prevent receptors from having direct contact with chemicals in the sediment, as well as prevent or substantially decrease the rate of flux of chemicals from the underlying sediments. In addition, a cap will prevent resuspension and downstream migration of chemicals adsorbed onto suspended sediment.

Capping was the remedy selected in six different areas as follows:

- Berth 401
- Wheeler Bay
  - Shoreline cap
  - Aquatic cap
- Berth 411 Underpier
- Head of Slip 3
  - Behind the sheetpile bulkhead
  - In front of the timber bulkhead
- Pier 5 area
- Berth 414 area

Figure 22 shows the boundaries of the six cap areas (Figure 23 shows a detail of the Wheeler Bay cap boundary). The boundaries of the cap areas have been refined based on the July 2006 pre-construction sampling data and additional data collected as part of the Prefinal (60 percent) Design.

6.1 Basis of Design

The in-situ caps were designed using USEPA and USACE guidance documents, including ARCS Program Guidance for In-Situ Subaqueous Capping of Contaminated Sediments

(Palermo et al. 1998). As described for the development of the dredge prism and CDF design, the basis of the in-situ cap design relates to performance standards and design objectives and criteria. As described below, these elements were used to guide the design of the in-situ caps.

6.1.1 Performance Standards

- Isolate surface sediments containing contaminant concentrations exceeding PECs from benthic communities and the aquatic environment by evaluating appropriate long-term erosive and contaminant transport mechanisms.
- The chemical isolation layer shall be of such thickness that: (1) potential groundwater exiting the cap shall be below USEPA's national recommended chronic water quality criteria and (2) sediment quality of the biologically active zone of the cap shall be below PECs and ultimately evaluated against risk-based criteria and/or clean up goals established by USEPA through the Portland Harbor RI/FS process and ROD.
- The armor layer of the cap shall be designed to resist bed shear velocities induced by the largest of 100 year flood flow, 100 year waves, vessel-induced waves from typical passing vessels, and anticipated propeller wash from vessels that operate in the area.
- The material used for capping shall meet the requirements established in the December 2003 Technical Plans and Specifications (Ecology and the Environment 2003) for the McCormick & Baxter sediment cap located within the Willamette River. Specifically, the "cap material to be used for construction of the sediment cap will be imported, clean, granular material free of roots, organic material, contaminants, and all other deleterious and objectionable material."
- Conduct the placement of material in a manner that minimizes to the extent practicable water quality exceedances of turbidity (or TSS) and chemistry outside the construction zone.

6.1.2 Design Objectives and Criteria

The following design objectives and related criteria were used to design the in-situ caps.

Delineate cap area boundaries based on PEC exceedances in surface sediments. Areas that were not identified for dredging that had surface concentrations exceeding PEC criteria were identified for capping. For this purpose, surface sediments were conservatively defined as the sediments within 3 feet of the surface. This conservative depth was used to protect sediments that are currently buried by deposits of clean sediment, but that could potentially be exposed through erosion. Figure 24 shows the number and extent of sediment characterization sample station locations in the identified cap areas that were used to determine the extent of cap area boundaries.

In addition to PEC exceedances, the capping area at Berth 401 was delineated on the basis of a TEC exceedance for PCBs and DDTs in core T4-VC01. Although both of these constituents were well below their respective PEC values, the total PCB concentration (250 μg/kg) was 4.2 times the TEC and the total DDT concentration (29 μg/kg) was 5.5 times the TEC. TEC exceedances were found in the top three feet of sediments. Considering these constituents could potentially bioaccumulate at concentrations below the PEC, and the likelihood that PCBs and DDTs will be bioaccumulative COCs in the Portland Harbor, a more active cleanup technology was designated in the EE/CA for this area.

One very minor and isolated PEC exceedance for lead remains outside the capping area and is included in the MNR area for Wheeler Bay. Sample T4-VC-18 has a lead concentration of 131 mg/kg in the top foot of sediment relative to the PEC value of 128 mg/kg. This slight exceedance is surrounded by samples with no PEC exceedances and is also superficial in nature; concentrations decrease rapidly to below TEC values in the 1 to 3 foot interval (34 mg/kg). Given the exceedance is marginal, thin, and isolated, it is appropriate to address this location using MNR.

Delineate extent of sediment in the underpier areas. Much of the area beneath the Berth 411 area is riprap without any surface sediment. The sediment that has accumulated is adjacent to the sheetpile wall. Figure 4 shows the estimated extent of sediment under the pier at Berth 411. This boundary was extended a minimum of 10 feet up the slope as an added safety factor when determining the area to be capped.

Determine cap thickness necessary to isolate contaminated surface based on site characteristics. The cap thickness for each area was determined based on the following (from Palermo et al. 1998) components:

- Chemical isolation of contaminants (T_i). The cap thickness and composition need to be sufficient to meet appropriate water quality and surface sediment criteria.
- Bioturbation (T_b). The cap thickness and composition need to be sufficient to protect the underlying sediments from bioturbation.
- Consolidation (T_c). The cap thickness needs to account for consolidation of the cap material.
- Erosion (T_e). The armor layer thickness and gradation need to account for design level erosive events.
- Operational considerations (i.e., placement inaccuracies and other pertinent processes) (T_o). The cap and armor thickness need to account for anticipated placement methods.

Stabilize shoreline areas that are unstable and are potential sources of contamination to the river. A number of areas, including Wheeler Bay and Pier 5, were identified for capping to stabilize the shoreline. These areas have shorelines that are currently unstable and a potential source of contamination or will become potentially unstable due to dredging as part of the Removal Action.

Minimize water quality impacts outside of the construction zone. The need to meet water quality chemistry and turbidity or TSS standards factored into the selection of cap material placement methods. Water quality monitoring activities and criteria for capping are described in detail in the Water Quality Monitoring Plan (Appendix D).

6.1.3 Additional Considerations

The presence of a historical diesel seep at the head of Slip 3 was considered in the cap design in that area.

6.2 In-Situ Cap Design

The cap sections will consist of the following layers (from the sediment surface upward):

- **Chemical isolation layer (Base Cap)**. The purpose of this layer is to isolate the underlying contaminated sediments from benthic communities and the aquatic environment. Section 6.3.1 presents the chemical isolation component for the different capping areas.
- **Erosion protection layer (Armor Layer)**. This layer varies in material type, thickness, and gradation by location depending on the anticipated erosive forces. The purpose of this layer is to resist the erosive forces from currents, waves, and propeller wash. Section 6.2.2 presents the erosion component for the different areas.

An appropriate thickness of cap will be determined individually for each component based on site-specific design parameters as summarized below. The individual component thickness contributes to a total cap thickness that satisfies all design components as shown below.

$T = T_i + T_b + T_c + T_e + T_o$

The erosion component and the bioturbation component of the cap will be required to have a concurrent thickness, rather than independent thickness. That is, a set thickness of an armor layer can serve to resist erosion as well as accommodate bioturbation.

Figures 25 through and 27 show the cap design sections for each cap area. The design of each layer of the cap is described in detail below.

6.2.1 Chemical Isolation Component

Appendix J presents a detailed discussion of the chemical isolation analysis completed for the different cap areas. Design of an effective chemical isolation layer for an in situ cap includes consideration of the movement of contaminants by advection (flow of porewater), molecular diffusion (across a concentration gradient), and sorptive transport (movement of sediment particles with contaminants attached). Based on the design analyses used, appropriate chemical isolation thicknesses were determined for each cap area to ensure that COCs are below levels of concern and to be protective of the benthic communities that might reside in the overlying cap layers.

Chemical isolation modeling used a transient model described in Appendix B of the *ARCS Program Guidance for In Situ Subaqueous Capping of Contaminated Sediments* (Palermo et al. 1988) to estimate contaminant flux through the chemical isolation layer and the time to achieve steady state chemical flux conditions in the isolation layer of the cap. In addition, the steady state model of Reible et al. (2004) was used to estimate chemical concentrations in the surficial (bioturbation) sediment layers of the cap once steady state conditions are achieved.

The COCs that were assessed in the chemical isolation model are those chemicals with the highest and most frequent exceedances of PECs (MacDonald et al. 2000) in the proposed capping areas. The COCs include the following (see Table 1; Appendix J):

- Lead
- Zinc
- PAHs (phenanthrene, fluoranthene, and chrysene)
- Total dichlorodiphenyltrichloroethane (DDTs)

In addition, PCBs and DDTs were evaluated in the Berth 401 area due to an exceedance of TEC values, even though these constituents were well below their PEC values. Considering the bioaccumulation potential of these constituents, and the likelihood that PCBs and DDTs will be bioaccumulative COCs in the Portland Harbor, the Port elected to implement a more rigorous cleanup technology in this area rather than MNR.

The following criteria were used to select COCs for each capping area:

- The PAH group was modeled using three surrogate chemicals that represent a range of chemical behavior and mobility—phenanthrene (a light-weight PAH), fluoranthene (a medium-weight PAH), and chrysene (a heavy-weight PAH). Chrysene is one of the only heavy-weight PAHs to have a detected leachate concentration in the pancake column leaching test (PCLT).

- All chemicals or chemical groups with exceedances of PEC values were modeled in their respective areas.
- In addition, the highest concentrations of several chemicals that exceeded their TEC values were modeled. For example, although they never exceeded PEC values, the highest concentrations of DDTs (Wheeler Bay and Slip 3) and PCBs (Berth 401) were modeled.
- The highest sediment concentrations (metals) or carbon-normalized sediment concentrations (organics) in the top 3 feet of each capping area were used as input to the chemical isolation model to provide a worst-case prediction. The mobility of organic chemicals is directly related to the sedimentary organic carbon content; thus, carbon-normalized concentrations are more appropriate.

The following key inputs and assumptions were used in the modeling:

- The armor layer was conservatively assumed to not provide any chemical isolation component.
- The total organic carbon content in the bioturbation zone of the new cap as well as the porosity of existing sediments were determined based on existing conditions at each of the capping sites.
- The underlying sediment was conservatively assumed to maintain the maximum estimated porewater concentration for all time without degradation or depletion due to transport into the cap.
- The Darcy and seepage velocities were calculated for each cap area based on measurements of vertical gradients in groundwater monitoring wells and estimates of hydraulic conductivity from sediment geotechnical properties. These parameters are consistent with those used in the CDF contaminant transport model.
- A range of anaerobic biodegradation rates were determined from the literature for the various COCs. The geometric mean of a given range was used as input to the model for the biodegradation rate of the corresponding chemical. For most organic chemicals, anaerobic biodegradation rates are slower than aerobic rates, so these rates are likely conservative.

- The maximum chemical concentrations for sediment underlying the prospective caps were obtained from available sediment samples in the top 3 feet of the capping areas. These data were compiled from various recent studies at Terminal 4.
- The maximum sediment concentrations, as described above, were converted into porewater concentrations assuming equilibrium partitioning conditions and using the minimum (conservative) partitioning coefficients (K_d) for metals, or minimum organic carbon partitioning coefficients (K_{oc}) for organic constituents, as determined from the Terminal 4 PCLT results. If PCLT leachate concentrations were not detected or rarely detected, literature values were also consulted.
- The cap shall be of such thickness that: (1) potential groundwater exiting the cap shall be below USEPA's national recommended chronic water quality criteria and (2) sediment quality of the biologically active zone of the cap shall be below PECs and ultimately evaluated against risk-based criteria and/or clean up goals established by USEPA through the Portland Harbor RI/FS process and ROD.

Based on the modeling results and assumptions presented above, the following base cap isolation thicknesses were determined (note that the specified cap thickness on the drawings is rounded to 6 inch increments due to constructability considerations):

- Berth 401 – 9 inches required; 12 inches specified
- Wheeler Bay – 3 inches required; 6 inches specified
- Berth 411 – 12 inches required and specified
- Head of Slip 3 – 9 inches required; 12 inches specified
- Pier 5 – 9 inches required; 12 inches specified
- Berth 414 – 3 inches required; 6 inches specified

A sensitivity analysis was conducted to determine the potential for variation in the model results as presented (see Appendix J). The analysis concluded that the design parameter inputs used in the modeling result in a reasonably conservative design for cap isolation layer thickness.

Two cap areas may require the use of organoclay supplemented cap material. The first area that will require the use of organoclay is located behind the bulkhead at the head of Slip 3. This area was the location of a previous remediation (Bank Excavation and Backfill Remedial Action [BEBRA]). Due to a historic diesel release in the area the organoclay was used to address any remnant diesel contamination. The second area of potential concern is along the eastern edge of the Pier 5 cap. In the early 1970s there were historic seeps of petroleum product. Pile removal in this area may potentially cause the presence of sheens. The specifications will require the contractor to have present enough organoclay to supplement any caps needed in the Pier 5 area to address sheens.

Two previous investigations studied organoclay use in caps (Hart Crowser 2003; University of Texas, 2005). Based on a review of these documents, the specifications require the use of organoclay either manufactured by CETCO remediation Technologies or Biomin, Inc. or similar.

6.2.2 Erosion Component

There are a number of different erosive forces that can potentially act on a cap surface:

- Wind-induced waves
- Vessel-induced waves
- River currents
- Propeller wash

This section summarizes each of these erosive components. Each erosive component produces a unique design level bed shear velocity at each cap area. These bed velocities from the four conditions analyzed were used to determine the necessary armor layer grain size required to resist the erosion.

6.2.2.1 Wind-Induced Wave Analysis

Appendix L presents a detailed memorandum describing the cap armor analysis for wind-induced waves. The methodology used for wind-induced wave analysis was comparable to that used for the McCormick & Baxter Superfund Site, located approximately 3 miles upstream of Terminal 4, (PB Ports & Marine 2002). Wind data was obtained for the Portland International Airport from the National Climatic Data Center (1976 to 2004) and the Meteorological Resource Center (Webmet.com) (1961 to 1975). Based on the wind information, a wind rose was developed for the site to determine the dominant wind directions—predominant winds blow from the southeast, northwest and south.

The USACE's Coastal Engineering System (ACES) program was used to model wave growth and propagation due to winds. Bottom orbital velocities were calculated from waves approaching shore. The stable sediment size was linked to the bottom orbital velocity generated by the wave using the stable stone size equation developed by Blaauw et al. (1984) as recommended by the USACE *Guidance for In-Situ Subaqueous Capping of Contaminated Sediments, Appendix A: Armor Layer Design*.

Based on the modeling discussed above, the following grain sizes were determined to be necessary to resist wave induced orbital velocities:

- Berth 401 – medium sand to fine gravel
- Wheeler Bay – fine sand to fine gravel
- Berth 411 – due to the configuration of the slip and cap location wind-induced wave erosion is very minimal
- Head of Slip 3 – fine gravel
- Pier 5 – silt to fine gravel
- Berth 414 – fine sand

6.2.2.2 Vessel-Induced Waves Analysis

Waterway traffic in the vicinity of Terminal 4 ranges from Panamax vessels (which call at nearby Berths 410/411 and 415) to smaller recreational vessels. The analysis performed for the McCormick & Baxter Superfund Site, located approximately 3 miles upstream of Terminal 4 concluded the following, "Ship, tug, and barge tow-generated wave heights were found to be smaller than those generated by fireboats during a response." (PB Ports & Marine 2002). Therefore, for the Terminal 4 analysis, a fireboat (converted tug) was selected as the most conservative vessel for wave generation. An empirical computer model was used to predict wave heights from the design vessel. The same approach used above for wind-induced waves was used to predict orbital velocities of these waves as they approach shore.

Based on the modeling discussed above, the following grain sizes were determined to be necessary to resist wave induced orbital velocities:

- Berth 401 – coarse gravel
- Wheeler Bay – coarse gravel
- Berth 411 – vessel generated waves were determined to be less than 1 foot in height due to the low operating speeds of less than 5 knots within the slip. Therefore, the wind-induced waves would control.
- Head of Slip 3 – vessel generated waves were determined to be less than 1 foot in height due to the low operating speeds of less than 5 knots within the slip. Therefore, the wind-induced waves would control.
- Pier 5 – vessel generated waves were determined to be less than 1 foot in height due to the low operating speeds of less than 5 knots within the slip. Therefore, the wind-induced waves would control.
- Berth 414 – coarse gravel

The largest erosive force that a wave imparts is when it breaks on the shoreline. This area is called the surf zone (see Section 5.2.3). The shoreline portions of the aquatic cap areas (i.e., cap areas that extend from OLW to OHW) adjacent to Berth 401, Wheeler Bay, and the river-ward corner of Pier 5 are subject to breaking waves. From the previous sections, it is evident that vessel generated waves would result in more erosive forces than those developed from wind waves. Accordingly, only vessel generated breaking waves were considered. The ACES Rubble Mound Revetment Design module was used with the design wave characteristics to determine the appropriate armor size. The model indicates that cobbles (armor grain sizes between 7 and 10 inches) will be necessary to protect caps within the surf zone areas.

6.2.2.3 Currents

The Willamette River will impart an erosive force on caps from its flow. This erosive force, as well as the required armoring to resist this force was evaluated under a 100 year flood event. Appendix L presents the detailed analysis.

The USACE provides guidance for determining the material gradations for maximum flood flow or storm velocities near capped sediments. Appendix A, Armor Layer Design, of the *Guidance for In-Situ Subaqueous Capping of Contaminated Sediments* (Palermo et al. 1998) and Chapter 3 of the Engineering Manual (EM) 1110-2-1601 entitled, "Hydraulic Design of Flood Control Channels" (USACE 1994) provided procedures for evaluating the design.

The hydrodynamic and sediment transport (EFDC) model of the Lower Willamette River used by the Lower Willamette Group (LWG) was used to estimate bed shear velocities associated with river currents. The model is intended to help understand circulation and sediment transport processes in the system and be used to help evaluate sediment remediation alternatives. The model is two-dimensional and depth averaged.

Maximum river flow velocities were obtained from the hydrodynamic analysis of the 100-year flood event performed by WEST Consultants (Appendix K). The following grain sizes were determined to be necessary to resist flood flow conditions:

- Berth 401 – silt
- Wheeler Bay – silt
- Berth 411 – silt or finer
- Head of Slip 3 – silt
- Pier 5 – silt to medium sand
- Berth 414 – fine sand

6.2.2.4 Propeller Wash

The propeller jet of a maneuvering vessel has the potential to impact the cap surface and may cause erosion of capping materials if they are not sized appropriately. Propeller wash in prospective capping areas include commercial vessels and tugs. Propeller wash velocities from vessels will likely be localized and of short duration. The propeller wash from passing tugs and commercial vessels along the Willamette River will not likely affect the cap surface. However, the propeller from these vessels during a maneuvering operation (e.g. berthing with bow thruster or tug assist) can cause significant erosion of bottom sediments if an appropriate armor stone is not in place to resist the propeller-induced bottom velocities.

This evaluation approach is recommended in Appendix A of the USEPA/USACE guidance document *Guidance for In-Situ Capping of Contaminated Sediments* (Palermo et al. 1998b). This model requires specific input regarding vessel characteristics (e.g., propeller diameter, depth of shaft, and shaft horsepower) and has been used for several cap designs approved by state and federal agencies.

Discussions with local tug operators and the Columbia River Pilots indicate that the bulk carrier vessels and large tractor-tugs normally navigate in the deeper portions of Slip 3 as they enter from the river. Tugs that typically operate at the Port's facilities and were selected for analysis include the *Daniel Foss* (owned and operated by Foss Maritime) and the *Portland* (owned and operated by Shaver Transportation Company). The *Portland* is the most powerful tug that operates at the Port, with a maximum horsepower (HP) of 3,600 and a draft of 12.6 feet. The *Daniel Foss* has a larger draft, 16 feet, and a maximum HP of 3,200. Communications with the tug captains revealed that the tugs use an average of approximately 25 percent of their maximum HP for typical maneuvering and repositioning, and between 50 and 75 percent for escort operations when thrust is applied during initial movement of the larger vessels. In addition, the higher HP is typically applied in short, 30 second to 1 minute, bursts for initial movement of the vessels, then decreased to lower levels (50 percent or less) for continual movement.

The large, deep-draft, foreign-flagged bulk carrier ships typical at Terminal 4 are single propeller with engine power from 5,000 to 12,000 HP and lengths of 500 to 700 feet. The *Duncan Bay*, 555 feet long with a 32-foot draft and a maximum HP of 7,800 is typical of vessels that call at Berth 411 in Slip 3. The *Monte Pelmo* is a larger vessel, nearly 740 feet long with a roughly 40-foot draft and maximum HP of 12,000, which could call at Berth 401 along the river where there is more room.

Characteristics of each design vessel were obtained and are summarized in Appendix L. Assumed physical characteristics of each capping site were also evaluated and summarized in Appendix L.

Based on the model runs using Terminal 4 specific characteristics, the following grain sizes were determined to be necessary to resist prop wash conditions:

- Berth 401 – coarse gravel
- Wheeler Bay – cobbles
- Berth 411 – cobbles and boulders (6 inches to 12 inches in size depending on location on the slope). The existing sheetpile wall affects the armor requirements.
- Head of Slip 3 – the sheetpile wall on the northern side shields the cap area from propeller wash. The area in front of the timber bulkhead on the southern side would require cobbles (7 inch material) for erosion protection.
- Pier 5 – cobbles (7 inch material)
- Berth 414 – cobbles (8 inch material)

6.2.2.5 Final Armor Section

Figures 25 through 27 show the design cap thickness in each of the 6 areas to be capped. The final armor selection was completed by taking the largest sized armor required for each cap area considering waves, propeller wash, and currents. In most conditions, propeller wash was the controlling factor for armor sizing. Five armor sizes are presented in the specifications (Appendix G): Armor Type 1, 2, 3, 4 and 5. Armor Types 2 through 5 are Oregon Highway Department riprap specifications.

Armor Type 1 is a coarse granular material. The appropriate armor type was selected based on the required armoring size.

6.2.3 Bioturbation Component

Based on a review of bioturbation depths from freshwater systems, the potential bioturbation depth at the RAA is expected to be limited to the upper 5 to 10 centimeters (Palermo et al. 1998; Clarke et al. 2001). Consistent with Palermo et al. (1998), the cap design presented herein will provide an erosion protection layer component (T_e) of the cap that is sufficient for both physical isolation and bioturbation (T_b).

6.2.4 Consolidation Component

The material to be used for the cap layers is granular in nature and any consolidation of these layers will be minimal and occur during construction. Therefore, the T_c will be equal to zero.

6.2.5 Operational Component

Given the inherent difficulties in achieving accurate placement tolerances for in-water construction, an additional thickness (overplacement allowance) is typically specified in the capping contract. For the Terminal 4 project, the overplacement amount is expected to be 6 inches for each discrete layer. This is based on anticipated cap placement equipment (mechanical clamshell), experience at other similar capping projects, and considerations of likely contractor incentives to limit the amount of excess thickness.

6.3 Source Material

Sources for capping material will most likely be upland site quarries. All materials used in cap/cover placement will meet the requirements established in the December 2003 Technical Plans and Specifications (Ecology and the Environment 2003) for the McCormick & Baxter sediment cap located within the Willamette River. Specifically, the "cap material to be used for construction of the sediment cap will be imported, clean, granular material free of roots, organic material, contaminants, and all other deleterious and objectionable material." The specifications (Appendix G) present both physical and chemical parameters for the cap materials. Base cap materials will either be fine to medium sand or sandy gravel/gravelly sand depending on the steepness of the area being capped. Steeper areas will require the sand and gravel material. Armor layers are varying sizes of riprap.

The CQAP (Appendix C) and Section 6.6 describe the methods that will be employed to confirm appropriate material types are being used for the caps.

6.4 Construction Quality Control During Cap Construction

The CQAP (Appendix C) describes in detail the measures that will be implemented during construction to ensure the design objectives of capping are met. Each of these measures is summarized below:

- **Verify Quality of Import Material.** Import material must meet specified physical and chemical properties, as outlined in the specifications, prior to the use of any imported material. Sampling and analysis of materials before construction and during construction coupled with visual inspections of import materials will be completed to verify suitability.
- **Achieve Specified Thickness and Extent.** Cap construction materials must be placed at the specified grades within 1/2-foot of the extents shown on the contract drawings and specifications. Surveys will be completed to confirm grades.
- **Avoid Impacts on Adjacent Structures and Tenants.** Capping in front of existing slopes and waterfront structures should not lessen the overall stability of the slopes and potentially cause movement greater than 1 inch in the structures. Settlement monitoring will occur on critical structures near capping areas to confirm no damage is occurring.
- **Minimize Release of Suspended Sediment.** The cap material must be placed in a manner that will minimize the release of suspended sediment (i.e., limiting the energy of the material as it strikes the bottom to minimize re-suspension and mixing of contaminated material with the cap material). Water quality measurements will be used to monitor sediment resuspension.
- **Minimize Short-term Water Quality Impacts**. Water quality monitoring activities are required to ensure compliance with federal and state water quality standards.

Water quality criteria for dredging activities are described in detail in the Water Quality Monitoring Plan (Appendix D to the DAR).

6.5 Volumes

Anticipated volumes of cap material are presented below by area and by material type:

- Berth 401 Cap
  - 2,000 cy of Base Cap Type 2
  - 2,000 cy of Armor Type 1
- Wheeler Bay Aquatic
  - 2,300 cy of Base Cap Type 2
  - 5,800 cy of Armor Type 3
- Berth 411 Underpier
  - 1,600 cy of Base Cap Type 2
  - 2,700 cy of Armor Type 4
- Head of Slip 3 Behind Steel Bulkhead
  - 200 cy of Base Cap Type 1
  - 200 cy of Armor Type 1
- Head of Slip 3 Behind Wooden Bulkhead
  - 100 cy of Base Cap Type 3
- Head of Slip 3 In Front of Wooden Bulkhead
  - 500 cy of Base Cap Type 1
  - 700 cy of Armor Type 3
- Pier 5 Cap
  - 5,000 cy of Base Cap Type 2
  - 6,700 cy of Armor Type 3
  - 9,100 cy of Armor Type 3 for bulkhead stability
- Berth 414
  - 1,000 cy of Base Cap Type 2
  - 2,100 cy of Armor Type 3

6.6 Equipment Selection

Some of the main issues to consider when selecting appropriate capping equipment include:

- Availability and types of equipment
- Production rate capability
- Maintaining navigation access
- Minimizing disruption of Port tenant operations
- Water depths
- Strength of the material being capped
- Gradation of the cap material
- River currents and tides
- Minimization of short-term water quality impacts
- Accessibility of equipment

Open water caps will be placed with mechanical equipment either from shore or from water. Anticipated equipment includes clamshell buckets or long reach excavators. The cap materials placed under the pier at Berth 410 will be placed using either a conveyor-type or hydraulic system.

7 WATER QUALITY

This section presents the water quality standards and guidelines that will be used on the Terminal 4 Removal Action, results of contaminant mobility testing, and predicted water quality around the different Removal Action activities. These factors will be used to inform the basis of design for the CDF, contractor-required BMPs to protect water quality during construction, the short-term and long-term water quality monitoring programs for all aspects of the Removal Action activities, and the sediment acceptance criteria for the CDF.

7.1 Water Quality Criteria

Water quality criteria are applied depending on the duration of the impact. Short-term and long-term water quality effects associated with the Terminal 4 Removal Action are evaluated in this chapter. Short-term effects are temporary and transient effects associated with construction activities, both at the point of construction (i.e., at the site of dredging, capping, demolition, etc.) and at the point of effluent discharge (i.e., discharge of return water over the weir at the CDF; discharge of groundwater through the CDF berm during filling). Long-term effects are associated with more continuous movement of groundwater through the CDF berm and into the river, or groundwater migrating through the cap surfaces. Water quality criteria used to regulate these various activities will be consistent with the scale and duration of exposure, and consistent with the regulatory conditions imposed at other recent Region 10 Superfund projects, including projects in Commencement Bay (Thea Foss/St. Paul Waterways, Blair Slip 1 CDF, Middle Waterway), and Portland Harbor.

Proposed water quality criteria for the Terminal 4 Removal Action project are summarized in Table 6.

7.1.1 Short-Term Water Quality Criteria

Short-term water quality criteria will be used to regulate in-water construction activities (dredging, capping, demolition, etc.) and overflow discharges from the CDF weir. Water quality monitoring associated with these construction activities will be specified in the USEPA-issued WQCCMP. It is anticipated that a single comprehensive certification will be issued for the Slip 1 CDF and this certification will be used to regulate all filling activities, including initial placement of Terminal 4 material, subsequent placement of external material from other Portland Harbor locations, and final placement of imported fill material to close the CDF. Because future candidate sites that are proposed for placement in the CDF may contain COCs other than those being evaluated at Terminal 4, additional site-specific monitoring parameters may be required and will be specified in an addendum to the USEPA-issued WQCCMP at such time as the materials are identified and accepted for placement. Although the USEPA-issued WQCCMP for Terminal 4 will cover water quality monitoring activities associated with placement in the CDF, the responsible parties will also need to obtain a separate USEPA-issued WQCCMP for their dredging and transport activities.

Short-term water quality criteria include acute and chronic ambient water quality criteria, with exposure times of one hour and four days, respectively, as well as narrative standards for conventional parameters, generally measured in terms of acceptably small deviations from ambient background conditions in the river. Chronic criteria will be used to regulate effluent discharges from the CDF outfall if these discharges occur continuously for four days or longer. Acute criteria will be used to regulate all other construction activities (USEPA and USACE 1994). Narrative standards will apply to all activities.

7.1.1.1 Conventional Parameters

Turbidity. State water quality standards allow for limited turbidity exceedances for "dredging, construction, or other legitimate activities" [OAR 340-041-036(b)]. Exceedances of the turbidity standard (or an alternative TSS guideline), would be limited to the vicinity of the construction site, as described in Section 7.2 below. Consistent with state regulations, the following turbidity criteria will apply at the compliance boundary:

- Turbidity should not exceed 5 NTUs above background if background is less than 50 NTUs
- Turbidity should not exceed 10% above background if background is greater than 50 NTUs.

TSS. As an alternative to the turbidity criteria, the following TSS criteria may be applied at the compliance boundary:

- TSS should not exceed 10 percent above background

TSS is an acceptable surrogate for turbidity for the following reasons:

- TSS is measured in concentration and is therefore relevant for contaminant transport and mass balance calculations, whereas turbidity is a measure of light transmission but not a direct measure of concentration
- TSS has greater ecological relevance, and literature studies have investigated the biological effects of high TSS concentrations on fish and other organisms
- In remedial dredging projects, migration of contaminated sediments outside the project area is a key concern. TSS is a more direct measure of construction-induced sediment resuspension and transport processes.
- When subjected to a column settling test (CST), Terminal 4 sediments showed high levels of residual turbidity even after much of the suspended solids had settled out (see Figure 28). Terminal 4 sediments appear to color the water, even though elutriate test results indicate the turbidity generated by these sediments is not associated with elevated levels of dissolved contaminants (see Section 7.3.3).

If elevated turbidity measurements are observed during monitoring activities, the Port may monitor TSS as a more reliable indicator of construction-related water quality effects. An initial estimate of TSS may be determined based on a best-fit power function of the Terminal 4 column settling test data (CST data; see Section 7.3.3), as shown on Figure 28. The TSS-turbidity correlation will be periodically updated with results of the background water quality survey and ongoing monitoring conducted during the project. To verify initial regression-based estimates, follow-up TSS measurements will be performed at a fast turnaround on-site field laboratory.

Dissolved oxygen (DO). At the compliance boundary, DO will not be less than 6.5 mg/L.

7.1.1.2 Ambient Background Concentrations

Ambient background water quality in the Willamette River will be determined using a pre-construction survey of ambient background conditions in the RAA, ongoing background measurements during the RAA, and current and ongoing monitoring efforts conducted by the USGS and others in the Portland Harbor. The background values for both conventional and toxic constituents will be calculated as the 90^{th} percentile value of ambient background data.

The USGS maintains a comprehensive monitoring program for conventional and trace metal parameters in the Willamette River at Portland (Station #14211720); water quality statistics for USGS measurements of turbidity, TSS, and dissolved metals are presented in Table 7. A pre-construction background survey will be conducted in the vicinity of Terminal 4, including multiple sampling events over a range of flow, tide, and weather conditions. Background stations will continue to be monitored during the RAA for flow events that may cause short-term excursions in water quality parameters, and ambient background statistics will be updated on a regular basis. Other ongoing studies in the Portland Harbor (e.g. Lower Willamette Group) will be evaluated and incorporated, as appropriate, as they become available.

Two background reference stations will be established upstream and across the river from the RAA. Both stations will be monitored during the pre-construction background survey, and one or both of these stations will continue to be monitored during construction to detect any excursions of ambient river conditions (e.g., turbidity caused by high flow events, etc.) that are not caused by the Removal Action, but which may nevertheless affect water quality in the vicinity of construction activities.

7.1.1.3 Chemical Parameters

Metals Criteria. Water quality criteria for metals (arsenic, cadmium, copper, lead, and zinc) are derived from current USEPA National Recommended Water Quality Criteria (USEPA 2006b; http://www.epa.gov/waterscience/criteria/wqcriteria.html), the same criteria that have been adopted by the State of Oregon. Hardness-based metals criteria (all except arsenic) have been adjusted to a hardness value of 25 mg/L based on ambient measurements in the Lower Willamette River (USGS 2006).

PAH Guidance Values. Aquatic life criteria for PAHs are not available in either federal or state standards. However, acute and chronic guidance values for PAHs have been developed by USEPA for use in deriving sediment quality benchmarks (USEPA 2003a). These PAH values, listed in Table 8, may be used as guidance values during the monitoring program to assess the effectiveness of construction BMPs for controlling releases of PAHs. However, these guidance values will not be used as compliance criteria.

Other Criteria. Acute and chronic water quality criteria for 4,4'-DDT and Total PCBs are derived from current USEPA National Recommended Water Quality Criteria (USEPA 2006b; http://www.epa.gov/waterscience/criteria/wqcriteria.html), These are limited-area COCs, applying to construction activities in the vicinity of T4-VC29 in the southeast corner of Slip 3, the only portion of the construction areas where PEC exceedances of these chemicals were found.

7.1.1.4 Parameters Likely to Drive Compliance

Based on the results of contaminant mobility testing on Terminal 4 sediments (see Section 7.3 below), turbidity and TSS will serve as reliable sentinels for water quality conditions during dredging, capping, CDF filling, and other construction activities. Based on those test results, it is expected that higher dilution factors will be required for turbidity and TSS than for any of the toxic constituents. By controlling releases of suspended sediments during construction, releases of sediment-associated contaminants will also be controlled. Although turbidity and TSS are the parameters likely to drive compliance, chemical testing will also be initiated for all of the construction activities. The intensity of the chemical monitoring will vary based on construction activity as well as location within the project site.

7.1.2 Long-Term Water Quality Criteria

The movement of groundwater through the CDF berm and into the river following completion of the CDF will be evaluated in this section. Unlike the short-term water quality effects described in Section 7.1.1, which are regulated by the project WQCCMP, the monitoring of long-term water quality will be described in the LTMRP to be submitted as part of the Final (100 percent) Design.

7.1.2.1 Water Quality Criteria Applicable to CDFs

Consistent with the monitoring requirements of other recently built CDFs in the USEPA Region 10, the evaluation of long-term water quality will include a comparison of groundwater release concentrations to chronic water quality criteria or ambient background water quality in the Willamette River adjacent to the CDF berm. The derivation of background water quality values is presented in Section 7.1.1.2. Applicable chronic criteria include National Recommended Water Quality Criteria for metals (USEPA 2006b) and PAH guidance values (USEPA 2003a) as presented in Section 7.1.1.3 and Table 8.

7.1.2.2 Fish Consumption Criteria

A key pathway of interest for the Portland Harbor risk assessment is the potential bioaccumulation of contaminants in fish and shellfish and subsequent risks posed to humans that eat fish from the harbor. The pathway of concern for bioaccumulation at Terminal 4 is groundwater release to the river. Bioaccumulation-based fish consumption criteria have been developed as a screening tool for evaluating this pathway (DEQ and USEPA 2005).

Consistent with USEPA guidance developed under Clean Water Act, Section 401, bioaccumulation exposures are averaged temporally over the lifetime of the fish being exposed to contaminants in the river, as well as the lifetimes of the humans that are consuming fish from the river (i.e., assumed human lifetime of 70 years;

USEPA 1991). In addition, USEPA draft guidance on estimating sediment-associated bioaccumulation risks is based on the fact that bioaccumulation exposures are averaged spatially over the home range of the fish and the harvesting area of the receptor (USEPA 2006c). Whereas chronic water quality criteria are applicable to a "point in space" (any location on the face of the berm) and a "point in time" (a 4-day duration is essentially instantaneous in the lifetime of the CDF), fish consumption criteria should be applied to conditions in the receiving water in consideration of the spatial and temporal scales of interest.

Table 8 provides an estimate of receiving water concentrations in the vicinity of the berm, and calculated bioaccumulation-based discharge criteria at the point of groundwater release necessary to meet fish consumption criteria in the receiving water. Because the groundwater flux (as determined from MODFLOW results; see Appendix I) is quite small compared to ambient currents in the river, groundwater releases are rapidly mixed to concentrations below fish consumption criteria in the receiving water. At the discharge criteria indicated, fish consumption criteria (DEQ and USEPA 2005) would be achieved a mere 10 cm above the face of the berm. As specified in USEPA (1991), these bioaccumulation-based discharge criteria would also be temporally averaged over a 70-year human lifetime. Based on these calculations, achieving chronic water quality criteria at the point of groundwater release from the CDF would be implicitly protective of bioaccumulative exposures in the receiving water.

7.1.2.3 Drinking Water Guidelines and Criteria

USEPA directed the Port to consider drinking water guidelines and criteria in its evaluation of groundwater releases from the CDF, specifically drinking water maximum contaminant levels (MCLs) and USEPA Region 9 "tap water" preliminary remediation goals (PRGs). Similar to the evaluation of fish consumption criteria, any potential drinking water exposure will be based on a receiving water concentration rather than a groundwater release concentration at the face of the berm.

Several points are relevant to the evaluation of drinking water exposures:

- **Drinking Water Not Yet an ARAR**. The Safe Drinking Water Act has been determined by USEPA to be potentially relevant and appropriate to the Terminal 4 Removal Action CDF. The exact application of drinking water criteria as an ARAR will not be determined until the Harbor-wide ROD. At this point, USEPA has directed the Port to evaluate drinking water exposures to be conservative and to prepare for any and all possibilities that may result from the issuance of the Harbor-wide ROD.
- **Drinking Water Criteria/Guidelines Are Applied at the Tap.** Drinking water guidelines and criteria are applied "at the tap" and not at the point of intake. Recent experience upstream in Wilsonville Oregon has shown that the background characteristics of Willamette River water are unsuitable for direct consumption without first subjecting the water to a multi-stage treatment process, including, in this case, sedimentation, ozonation, carbon filtration, sand filtration, and chlorination. Thus drinking water criteria/guidelines should account for water treatment requirements that apply prior to consumption.
- **Institutional Controls will Preclude Water Intake on Port Property.** The Port is in the process of acquiring the land beneath the CDF from the State of Oregon. The Port's ownership will extend out to the Harbor Line, and the Port will ensure through institutional controls that no drinking water intakes are placed on submerged Port land. Therefore, the closest possible point for a drinking water intake would be at the Harbor Line, between 10 and 50 meters from the face of the berm.

With these considerations in mind, Table 8 provides an estimate of receiving water concentrations at the Harbor Line, 10 meters from the berm, and calculated drinking water-based discharge criteria at the point of groundwater release necessary to meet "tap water" criteria in the receiving water. Because the groundwater flux (as determined from MODFLOW results; see Appendix I) is quite small compared to ambient currents in the river, groundwater releases are rapidly mixed to concentrations below drinking water criteria in the receiving water. Based on these calculations, achieving chronic water quality criteria at the point of groundwater release from the CDF will be implicitly protective of possible drinking water exposures at the Harbor Line. This evaluation is considered conservative because it does not take into account water treatment that is permitted to occur prior to application of drinking water criteria under state and federal law.

7.1.2.4 Total Maximum Daily Loads (TMDLs)

Currently, there are three TMDLs in effect in the Lower Willamette River:

- Temperature
- Bacteria
- Mercury

None of these TMDLs are relevant to groundwater releases from the CDF. Groundwater releasess from the CDF are not a source of elevated temperature or bacteria. Mercury is not a COC at Terminal 4.

Although mercury is not a COC at Terminal 4, USEPA directed the Port to consider the potential mercury load from the CDF in order to ensure the CDF is protective and will comply with the final ROD. The Oregon DEQ adopted an interim TMDL for mercury in September 2006. The interim TMDL determined that an overall loading reduction of 27 percent from all source categories (point source and nonpoint source) would reduce annual mercury inputs to the acceptable level guidance value of 94.6 kg/yr. DEQ's implementation strategy for the interim mercury TMDL includes general point source and nonpoint source reduction focused on wastewater discharge monitoring and mercury reduction plans at targeted facilities selected by DEQ, voluntary reduction of air emissions, and agency management plans to minimize soil erosion that contain naturally occurring mercury. No waste load allocations or load allocations have been conducted. DEQ plans to establish waste load allocations and load allocations for mercury after additional information is gathered in approximately 2011.

In the absence of a final TMDL for mercury, and in the absence of a final ROD, USEPA directed the Port to consider the potential mercury load from the CDF in order to ensure the CDF is protective and will comply with the final ROD. Because it is the intent that this Removal Action will ultimately comply with the results of the Portland Harbor RI/FS and USEPA ROD, some conservative assumptions were made for purposes of this analysis. It is assumed for preliminary purposes that mercury inputs to the river of 0.1 percent of total inputs would not adversely affect the TMDL analysis or mercury reduction plan. For the T4 CDF, this translates into a goal for groundwater releases from the CDF to the receiving water of 0.09 kg/yr.

As stated previously, mercury is not a COC at Terminal 4, and was not detected in PCLT leachate from Terminal 4 dredged sediments. For purposes of this assessment, however, it was assumed that mercury is present in T4 leachate at the level of the detection limit, and this value was used as an initial concentration in groundwater modeling predictions. At the peak discharge concentration at the face of the berm, which would not be realized for several centuries, the estimated annual mercury load in groundwater discharging from the CDF is estimated to be 0.00014 kg/yr. This load is almost three orders of magnitude below the 0.09 kg/yr preliminary conservative evaluation goal, and demonstrates that the CDF will not adversely impact the mercury TMDL analysis and reduction plan.

USEPA also directed the Port to consider minimizing impacts to the river of 303(d) listed parameters to show that the CDF will not contribute to existing in-river exceedances of water quality standards for these parameters. To address this directed request, the 303(d) listed parameters were evaluated in the long-term groundwater model and results were compared to water quality standards, guidelines, and background concentrations. Through this process, it is demonstrated that the CDF will be protective of the river for these parameters.

7.2 Compliance Boundaries

The proposed compliance boundaries for this project are:

- 100 meters from the mouth of Slip 1, Slip 3, or Wheeler Bay for any construction work taking place inside the slips and the bay;
- 100 meters from the construction activity for any construction work taking place outside the slips and bay;
- 100 meters radially from the CDF outfall location for narrative water quality criteria and acute criteria, and for chronic criteria if discharges are four days or more in duration;

The size and shape of the compliance boundaries were developed in consideration of the unique physical and biological characteristics of the site. The configurations of the compliance boundaries are shown in Appendix D – Water Quality Monitoring Plan. The supporting rationale for the compliance boundaries are discussed below.

7.2.1 Consistency with State Regulations

State regulations allow for limited turbidity exceedances for "dredging, construction, or other legitimate activities" [OAR 340-041-0036(b)]. Exceedances of the turbidity standard (or the alternative TSS guideline), would be limited to within the compliance area.

7.2.2 Tolerance of Short-Term Impacts for Long-Term Benefits

Impacts of suspended sediment to aquatic organisms, if any, will be short-term in nature and localized within the compliance zone. In contrast, long-term benefits to sediment quality, realized for years and decades in the future, will be achieved through dredging and capping of contaminated sediments. This trade-off of short-term impacts to accomplish long-term benefits was considered in the EE/CA and the selected alternative of the Action Memo.

7.2.3 Resuspended Sediment will be Contained and Monitored

The slips are confined on three sides and available data indicate weak river currents in the slips (~0.01 m/s; BBL 2005). DREDGE modeling results (see Section 7.4.1) indicate sediments that are resuspended during construction work within the slips are expected to be contained within the slips and resettle to the bed in close proximity to the construction activity. Post-construction confirmation sampling will be performed after dredging in Slip 3 to characterize any residual sediments that may have accumulated, and the Port and USEPA will determine if or what additional actions may be needed to reduce residuals concentrations in Slip 3. Sediments in Slip 1 will be covered by the CDF and thus isolated from the river. A compliance boundary at the mouth of the slips is therefore positioned to detect only suspended sediments or COCs that may be migrating out of the construction area.

7.2.4 Turbidity Compliance More Difficult than Toxics

Elevated turbidity and TSS are expected to be the monitoring parameters that are most difficult to control, whereas little or no water quality effects are predicted for toxic constituents, as shown in dredging elutriate test (DRET) results (see Section 7.3.1). The DRET test simulates the release of contaminants into the water column caused by sediment resuspension at the point of dredging. Turbidity levels near the dredge will need to be diluted within the compliance zone in order to meet water quality standards at the compliance boundary. In contrast, dissolved chemical constituents in DRET samples were either undetected, below water quality criteria, or comparable to ambient background levels.

7.2.5 No Impedance to Fish Passage

The proposed compliance boundary is a small proportion (<20%) of the river width, so fish passage will not be impeded. The river width at the upstream edge of Slip 3 is about 505 m, and the river width at the upstream side of Slip 1 is about 540 m. Thus, at least eighty percent of the river width will be available for fish species, such as salmonids, to avoid waters with possibly higher concentrations of suspended sediment. Suspended sediment levels decrease exponentially with distance away from the construction activity, with steep reductions typically observed within a short distance (i.e. 10 to 50 m; see Section 7.4.1) from the activity. Hydraulic dredging methods will be used where possible, and this method of dredging helps to minimize the amount of resuspended sediment that is released to the water column.

7.2.6 Minimal Salmonid Exposures

Juvenile salmon travel through the Removal Action Area on their outmigration to the ocean. Very few juvenile salmon are expected to be in the vicinity of Terminal 4 during the construction window, but a few may travel through the area. Juvenile Chinook (>100 mm) travel at a median rate between 8.7 and 11.3 km/day (ODFW 2005; Ward et al. 1994); juvenile steelhead travel between 11.9 and 17.9 km/day (ODFW 2005; Ward et al. 1994); coho migration rates are slower than Chinook and steelhead although specific rates were not provided in ODFW 2005. Given these migration rates, individual salmonids are not expected to remain in the vicinity of the Removal Action activities for longer than one day (conservatively estimated) and are more likely expected to encounter localized sediment plumes, if at all, for minutes or hours given that the compliance boundary is less than 20 percent of the width of the river and 0.1 km in diameter.

A study by Wilbur and Clarke (2001) showed that for juvenile salmonids, a one day exposure to TSS concentrations up to 1,000 mg/L caused biological responses limited to behavioral effects and some sublethal responses, such as reduced feeding. Higher levels of effects (e.g. survival, growth, and reproduction), beyond those reported, are generally used to develop water quality criteria. Suspended sediment concentrations are predicted to range from about 50 to 1,200 mg/L at the point of dredging, diminishing by an order of magnitude within 5 to 20 meters of the dredge.

7.2.7 Consistency with Other Region 10 CERCLA Projects

Compliance boundaries with similar dimensions have been used to control water quality effects during construction activities at a number of other sediment remediation sites in Region 10, in particular, Commencement Bay and Portland Harbor. For example, 300-foot compliance boundaries were used to control work on the Thea Foss Waterway, Middle Waterway, and Hylebos Waterway in Commencement Bay and a 100-meter compliance boundary was used at the Northwest Natural Gasco site on the Lower Willamette River.

7.3 Contaminant Mobility Testing

A number of different contaminant mobility tests have been completed on sediments within the RAA. The results from these tests will be used with modeling approaches described in subsequent sections to predict water quality effects associated with different actions. One of the composite samples subjected to contaminant mobility testing [T4-CM2] includes sediment from Slip 3, Berth 414, and Wheeler Bay, and is therefore most representative of sediment characteristics in the RAA. The other composite sample [T4-CM1] was collected from Slip 1 and Berth 401 and is therefore not representative of the RAA; it is provided here for comparison purposes only.

7.3.1 Dredging Elutriate Test

The dredging elutriate test (DRET) is used to help assess water quality at the point of dredging. The DRET results for the composite dredge prism sample T4-CM2 show that water quality effects from toxic constituents resuspended by dredging will be negligible (Table 8; BBL 2005). All metals results were well below their respective acute water quality criteria, with the exception of copper. The DRET copper concentration (4.3 μg/L) was just slightly above the hardness-based acute criterion (3.6 μg/L, a very stringent criterion considering the low hardness of 25 mg/L in the Willamette River); similar concentrations have been reported as ambient background levels in the Willamette River (~5 μg/L dissolved copper; USGS 2006). Only a few PAHs were detected, and the few detected PAHs were two or more orders of magnitude below their acute water quality guidance values (USEPA 2003a). No DDT isomers, PCBs, or petroleum compounds were detected.

7.3.2 Modified Elutriate Test

The modified elutriate test (MET) is designed to predict the quality of effluent flowing over the weir of the CDF. The MET results for the composite dredge prism sample T4-CM2, expressed on both total ("T") and dissolved ("D") basis, are summarized in Table 9 (BBL 2005). These data indicate water quality effects from toxic constituents discharged in the return flow to the Willamette River during filling of the CDF may be effectively managed with an appropriate level of short-term mixing within the compliance zone (see Section 7.8). Copper was the only metal in the MET that was detected in the dissolved phase (15.9 μg/L) above its acute criterion. However, copper is not a chemical of concern in the sediments at Slip 3, evidenced by the fact that the copper concentration in the bulk sediment sample from the dredge prism (23 mg/kg; Table 7; BBL 2005) is below both the threshold effects concentration (TEC at 32 mg/kg per MacDonald et al. 2000) and the average background concentration in Pacific Northwest soils (36 mg/kg; WDOE 1994).

Chronic water quality criteria may also apply if effluent from the filling of the CDF is discharged continuously for four days or more. Dissolved lead was below its acute criterion but about nine times higher than its chronic criterion. DDT was 150 times lower than its acute criterion but above its chronic criterion in the whole-water sample; however, it was not detected in the dissolved phase. Similarly, PCBs were twenty times lower than the acute criterion but above the chronic criterion in the whole-water sample, and were not detected in the dissolved phase. Only a few PAHs were detected in the dissolved phase of the elutriate, and none of the PAHs in either total or dissolved phase samples were above acute or chronic water quality guidance values. These data indicate COCs, although present in bulk sediment and in suspended particulates in the elutriate water, are not being dissolved in the water column to any significant degree.

The MET was conducted using a default settling period of 24 hours. This is extremely conservative because the estimated mean retention time for the CDF is 132 hours, over five times longer. As a result, the elutriate will experience significantly more settling time and clarification prior to discharge.

7.3.3 Column Settling Test

The column settling test (CST) is used to help predict the amount of suspended solids at the weir of a CDF. A CST was performed on a representative sample of the dredge prism at Slip 3 using a slurry concentration representative of the hydraulic dredging discharge to the CDF, as summarized in Table 11 (Appendix H). The CST was run for 265 hours (11 days) to simulate progressive settling and clarification of the dredging elutriate water. The settling column is sampled at various times and water depths, with near surface samples being most representative of the water that will be decanted over the weir.

The estimated mean retention time during filling of the Slip 1 CDF with Terminal 4 sediments is 132 hours (5.5 days). After 24 hours of settling, the turbidity of the elutriate is 5,500 NTU and the TSS content is 6,200 mg/L. At the mean retention time of 132 hours, the turbidity is 2,600 NTU and the TSS content is 1,900 mg/L. Between 1 and 5 days, the turbidity was reduced by about 50 percent, whereas the TSS content was reduced by two thirds.

Turbidity and TSS are well correlated (r2 = 0.98) and described by a power function, as shown on Figure 28. The nature of this correlation suggests suspended solids (TSS) drop out more quickly over time whereas residual discoloration of the water (expressed as turbidity) may persist even at relatively low TSS concentrations. As indicated by the DRET and MET tests, TSS concentrations have more relevance to water quality and contaminant transport compared to turbidity.

7.3.4 Pancake Column Leaching Test

The pancake column leaching test (PCLT) is used to help predict long-term water quality in the CDF and specifically pore-water concentrations in the fill sediments. The PCLT data for the RAA are summarized in Table 12 (BBL 2005). The effects of CDF pore waters on groundwater quality migrating through the CDF berm and eventually discharging to the river are evaluated using these PCLT data in conjunction with a groundwater contaminant transport model, as described in Appendix I.

Groundwater COCs were selected for further study and modeling based on exceedances of chronic water quality criteria in the leachate, including the following:

- Cadmium
- Copper
- Lead

In addition, the following constituents were selected for further evaluation because of their bioaccumulation potential:

- Arsenic
- Chrysene
- DDE

It should be noted, however, that chrysene and DDE were detected in only one out of eight leaching cycles. No other carcinogenic PAHs other than chrysene were detected in the leachate. No PCBs were detected in the leachate.

None of the leachate concentrations exceeded drinking water standards (MCLs).

7.4 Short-Term Water Quality Effects

7.4.1 Water Quality during Dredging Activities

A number of factors will control the water quality around the dredging operations. These factors include dredging equipment and methods, sediment characteristics, hydrodynamic conditions, water depth, and others. Hydraulic dredging is currently anticipated to be the primary method of environmental dredging in Slip 3, but mechanical dredging will also be utilized in some areas, such as for areas near structures in Slip 3, in Berth 414, and excavation of the berm key.

The USACE model DREDGE was used to predict suspended sediment concentrations around the dredging operation (Kuo and Hayes 1991). DREDGE model input parameters are summarized in Table 13. Both mechanical and hydraulic simulations were performed. A range of loss rates was used for hydraulic dredging (ranging from 0.5 to 2 percent loss) and mechanical dredging (ranging from 5 to 10 percent loss). The critical conditions for mechanical dredging included somewhat higher ambient current speeds (i.e. to simulate clamshell work in the more open portions of the RAA) and shallower water depths (i.e. typical of Berth 414).

DREDGE model results are shown on Figure 29. Higher TSS concentrations were predicted for hydraulic dredging because, although hydraulic dredging is characterized by lower percent loss rates, this is offset by much higher production rates. The model predicts initial TSS concentrations in the immediate vicinity of the hydraulic dredge could be as high as 1,200 mg/L. In most scenarios, both hydraulic and mechanical, concentrations drop off rapidly within about 25 meters from the dredge. When dredging in shallow water and open currents (i.e., mostly the mechanical scenario), TSS concentrations may extend farther downstream. The DREDGE model predicts that TSS concentrations typical of ambient conditions in the Willamette River (i.e. 24 mg/L; see Table 7) will generally be reached within 25 meters of the dredge.

Dredging BMPs to control water quality impacts are presented in the Water Quality Monitoring Plan and incorporated into the Construction Specifications.

7.4.2 Water Quality during Capping Activities

A number of factors will control the water quality around the capping operation. These factors include capping equipment and methods, sediment and cap material characteristics, hydrodynamic conditions, water depths, and others. The capping materials are anticipated to be placed using mechanical equipment such as clamshell bucket.

Predicting water quality associated with capping activities is difficult due to the lack of specific models. Resuspension of contaminated sediment during construction (both dredging and capping) is anticipated. However, monitoring data available from other similar projects indicates that resuspension during capping operations can be minimized depending on placement techniques employed. Two investigations conducted by USEPA's National Risk Management Research Laboratory (NRMRL) measured the release of in situ contaminated sediments during cap placement at Boston Harbor, Massachusetts and Eagle Harbor, Washington (USEPA 2005). The results of both investigations indicated that resuspension occurred during the initial run(s), and progressively decreased and dissipated with each subsequent run. (Elevated releases were observed for the first lift only in Boston Harbor and for the first three lifts at Eagle Harbor due to the more aggressive placement technique in the latter case.) These results suggest that resuspension during cap placement may be minimized by placing cap materials in several lifts, such that the initial lift involves methods with minimal disturbance (i.e., low energy) followed by more aggressive techniques for subsequent lifts.

Cap placement BMPs to control water quality impacts during capping operations will be presented in the Water Quality Monitoring Plan and incorporated into the Construction Specifications.

7.4.3 Water Quality during Filling of the CDF

If filling of the CDF with dredged sediment progresses at a relatively fast rate, the water level within the CDF will rise. If water rises high enough, it will be discharged over a weir, through a pipeline, and out an outfall into the river. During dredging, the water within the CDF will contain some suspended sediments. The turbidity and TSS concentrations in the water that goes over the weir will need to be controlled to ensure that water quality standards are met and unacceptable levels of contaminants are not released back to the river.

The turbidity and TSS concentrations at the weir are influenced by several factors, including dredge production rate and schedule, solids concentration of influent, size of CDF and ponding depth, dredging volume, and sediment settling characteristics. It is possible that during the dredging of Slip 3 sediments, the CDF will be able to fully contain the dredge slurry and no water will need to be discharged over the weir. However, the weir structure and water management operations will be employed in the cases that an overflow of the weir and water discharge will be required. The management of CDF filling operations will be adjusted as required to control water quality at the compliance zone boundary.

7.4.3.1 Effluent Outfall

As discussed in Sections 7.4.2 and 7.4.3, the results of the MET and CST are used to estimate the quality of the dredging elutriate water in the CDF pond that may be discharged to the river. The USEPA model PLUMES (Frick et al. 2005) was then used to estimate the amount of mixing that occurs in the compliance zone, as well as in the zone of initial dilution (ZID). PLUMES model input parameters are presented in Table 14. The model is based on a discharge of 7.6 MGD through a 17-inch outfall submerged beneath 28 feet of water.

The PLUMES predicted dilution factors are shown on Figure 30. The ZID extends 125 feet (38 meters) from the outfall, at which point an average dilution of 37:1 is achieved. Beyond the ZID, a minimal amount of additional dilution occurs. At the compliance boundary, the estimated dilution factor is 39:1.

A dilution analysis is presented in Table 15. A very conservative estimate of the TSS concentration at the weir overflow is obtained from the CST results (See Section 7.3.3), estimated at 1,900 mg/L at the mean retention time. This estimate is very conservative because it does not account for the substantial ponding depth in Slip 1, and the accelerated settling caused by large-scale flocculation and density stratification. Based on the estimated background TSS concentration in the Willamette River, plus ten percent (49 + 5 = 54 mg/L; see Table 7), a dilution factor of about 35 would be needed to reduce TSS concentrations to near background. PLUMES model results indicate this amount of dilution will generally be achieved at the compliance boundary.

TSS clearly appears to be the determining parameter for compliance. On the other hand, ample dilution is available to reduce all toxic constituents to acceptable levels in shorter distances. Copper requires a four-fold dilution to meet its acute criterion, a condition that will be achieved within about 10 to 30 feet of the outfall. Copper and several other constituents require dilutions of 6:1 to 9:1 to achieve chronic criteria, conditions that will be achieved within 30 to 60 feet of the outfall.

The Contractor will be required to use a submerged diffuser for placement of dredge slurry into the CDF. The use of a submerged diffuser will reduce the velocity of the slurry before it is discharged and reduce the distance the slurry falls through the water column. These two factors will reduce the amount of suspended solids in the CDF and keep the material that is suspended close to the CDF bottom.

7.4.3.2 Groundwater Seepage through the Berm

A steady state groundwater transport model was set up to evaluate the quality of groundwater that may be seeping through the berm during filling operations. The model conservatively simulates a relatively extreme and unlikely condition in which a head differential of 16 feet (water elevation at 20 feet in the CDF pond and at 3.8 feet in the river) is imposed continuously across the berm for 15 consecutive days, stimulating groundwater transport velocities significantly higher than those observed under typical long-term conditions.

Copper and lead were the only dissolved constituents in the MET that exceeded their chronic criteria. Model predictions of berm seepage quality for copper and lead are shown on Figure 31, and further details are provided in Appendix I. In spite of the extreme gradient and rapid flow, copper and lead concentrations at the end of the 15-day dredging period were still many orders of magnitude below their respective chronic criteria. These model results indicate water quality monitoring is best focused on the effects of direct effluent discharge through the outfall (Section 7.5.3.1), rather than diffuse groundwater seepage at the berm face.

7.4.4 Water Quality during Sediment Transport

Dredged sediment will be transported by barge and/or hydraulically through a pipeline from the dredging location to the CDF. Sediment overexcavated beneath the containment berm will be dredged mechanically and transported by barge to the head of Slip 1 for placement. Sediment in Slip 3 will likely be dredged hydraulically with some locations of mechanical dredging.

Collection of field parameters every 6 hours and one laboratory sample to be analyzed by COCs will be the first tier of monitoring. Visual monitoring will occur along the pipeline if the material is hydraulically dredged and at the transfer facility if mechanically offloaded. If a plume of significant duration (one hour) and extent (width of the compliance zone) is observed around the construction operation, then sampling will occur to monitor water quality. Further details are provided in the Water Quality

Monitoring Plan (Appendix D). Appropriate construction BMPs are presented in the Construction Specifications.

7.4.5 Water Quality during Demolition and Pile Removal

Numerous structures and piling will be demolished and removed as part of the Removal Action (see Sections 4.7 and 5.4). Collection of field parameters every 6 hours and one laboratory sample to be analyzed by COCs. Further details are provided in the Water Quality Monitoring Plan (Appendix D). Appropriate construction BMPs are presented in the Construction Specifications (Appendix G).

7.4.6 Water Quality during Marine Structures Construction

Piling will be driven and superstructure constructed as part of the Removal Action for the Berth replacement (see Section 4.9). Collection of field parameters every 6 hours and one laboratory sample to be analyzed by COCs. Further details are provided in the Water Quality Monitoring Plan (Appendix D). Appropriate construction BMPs will be presented in the Construction Specifications (Appendix G).

7.5 Long-term Groundwater Quality at the CDF

7.5.1 Modeling Results

After the CDF is constructed, groundwater will flow through the dredged sediment and containment berm into the river. The quality of the groundwater at the point of discharge to the river was predicted using a numerical groundwater flow and transport model, MODFLOW-2000 and MT3DMS (Harbaugh et al. 2000; Zheng, 1999). A two-dimensional model was set up along the critical flow path through the CDF. Model documentation and results are provided in Appendix I – Contaminant Transport Modeling, and described briefly below.

As an initial model assumption, the CDF was filled to capacity with sediments having the physical and geochemical characteristics of Slip 3 sediments, although in reality, Slip 3 sediments will only fill about 15 percent of the CDF. The model was run 1,000 years into the future to estimate peak concentrations and arrival times of groundwater COCs (including cadmium, copper, lead, arsenic, chrysene, and DDE).

Key model input parameters include the following:

- Structural configuration (dimensions, slopes) and material types of the CDF;
- Hydrogeologic conditions in the adjacent Terminal 4 uplands;
- Hydrologic conditions and return frequencies in the Willamette River (USGS 2006);
- Physical properties measurements on upland soils and river sediments;
- Initial pore-water concentrations in contaminated fill materials derived from maximum PCLT leachate concentrations (see Section 7.4.4);
- Soil-water partitioning coefficients (Kd and Koc) derived from paired observations of bulk sediment and PCLT leachate, supplemented by literature values when necessary (USEPA 2002, 2005).

The model provides an estimate of the dilution and attenuation that contaminants experience as they are transported from the fill materials across the berm to the river, as quantified by a dilution and attenuation factor (DAF; USEPA 2002). The processes that contribute to the DAF, and thus help to reduce contaminant concentrations in groundwater releases to the river, include dispersion, mixing, adsorption, and biodegradation (DDE only). Calculated DAFs range from 12 to greater than 10,000 L/kg, as summarized in Table 16. DAFs are primarily dependent on the soil-water partitioning coefficient—constituents with higher partitioning coefficients (Kd) tend to bind more strongly with matrix materials in the berm, which greatly diminishes their mobility and retards their transport rates. The lowest DAF of 12 would be similar to a conservative tracer that is unaffected by adsorption. Slightly lower DAFs are experienced at an unpaved site because infiltrating rainfall accelerates groundwater movement through the fill.

Model results (contaminant arrival curves) for groundwater COCs are shown on Figures 32A through 32F. None of the COCs are predicted to exceed chronic criteria in 1,000 years. As discussed in Section 7.4.3, if groundwater releases from the CDF are at or below chronic criteria, they are also expected to be protective of human health exposures through bioaccumulation and fish consumption and drinking water consumption.

The groundwater transport model presented in Appendix I and summarized here will also be used to help support the development of sediment acceptance criteria for other prospective Portland Harbor projects requesting to place dredged sediment in the CDF (see Sediment Acceptance Criteria Memo). The fill sequence in the model will continue to be updated as new sediments are identified and placed in the CDF, until the CDF is finally covered and closed.

7.5.2 Berm Material Permeability

The Design Team was asked to evaluate the potential of using finer grained material within the berm to reduce the permeability and potentially further reduce water quality concentrations exiting the berm, even though initial model runs on indicate long term water quality will be in compliance with water quality standards. The selection of the berm material is a balance between finding the lowest permeable material that will not adversely affect the seismic stability of the berm. Finer grained material will have a lower shear strength and hence is less resistant to failure during a seismic event.

A sensitivity analysis was completed on locally available fill materials. Ten different materials from four different suppliers were evaluated to estimate both their permeability and the seismic stability of the containment berm if it were constructed of the material. Figure 33 plots the results of the sensitivity analysis. The y-axis of the graph represents the seismic safety factor for the material. For design purposes, a safety factor greater than 1.1 is acceptable. The x-axis represents the grain size of the material. Specifically, it represents the D_{10}, which is the corresponding grain size that 10 percent of the material is finer by weight. For comparison purposes, a D_{10} of 0.3 mm was used for the modeling described in Appendix I.

As can be seen in Figure 33, finer grained material provides a lower permeability but at the expense of berm stability. Sources C-2 and B-4 on the graph meet the specified grain size for select fill presented in the specifications—it also provides a stable berm and lower permeability material

7.5.3 Solids Retention of Containment Berm

The select fill material specified for the containment berm construction will also serve to retain solids as water flows through the dredged material and into the berm. An analysis was completed to assess the filtering function of the berm to retain the dredged material solids. Two composite samples were collected for the Column Settling Tests. These samples were taken from the Slip 3 dredge prism to represent the anticipated geotechnical conditions of the dredged material. Sieve analysis completed on the two samples indicated that the material to be dredged and placed within the CDF is clayey, very sandy silt to slightly clayey, silty sand. The D_{15} (material size where 15 percent the material is finer by weight) and D_{85} of the sediment varies from 0.008 to 0.0013 mm and 0.36 to 0.6 mm, respectively. The specified gradation for the select fill has a D_{15} varying between 0.18 to 0.7 mm.

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

(D_{15} select fill)/(D_{85} dredged material) < 4 (a)

and

(D_{15} select fill)/(D_{15} dredged material) > 5 (b)

For the select fill specified and the anticipated dredged material being placed within the CDF equation (a) ranges from 0.3 to 1.9 and equation (b) ranges from 23 to 538. This indicates that the select fill used to construct the berm should retain the dredged material placed within the CDF. Section 7.5 discusses the transport of dissolved contaminants through the berm.

The use of a geotextile filter fabric was also evaluated for solids retention. The filter fabric would serve the same function as the select fill (see discussion above). The filter fabric would be anchored towards the top of the berm and rolled down the slope to the toe. Panels would be overlapped 3 feet and not seamed. Underwater diver would likely be required to secure the panels in the portion placed beneath the water. The estimated cost for filter fabric installation would be approximately $150,000. Since the fabric does not improve the solids retention capabilities beyond the retention capability of the 200-foot-thick layer of select fill already does and the cost is relatively high, the use of a filter fabric was not considered further in the design.

8 HABITAT MITIGATION

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

The habitat mitigation components that will be conducted to offset losses of aquatic habitat in Slip 1 from construction of the CDF include the following on-site and off-site activities. These activities are also discussed in the Draft Mitigation Plan.

- Habitat Bench--creation of a habitat bench along the outer edge of the CDF berm face to create 0.38 acres of prime shallow water habitat, 0.42 acres of moderately shallow habitat, and 0.17 acres of deep water habitat. In addition, 2-inch minus material will be placed on the habitat bench to fill in the spaces between the riprap.
- Piling Removal—removal of over 1,800 treated wood piling in areas of Wheeler Bay and Slip 3 covering over 3 acres of habitat
- Capping— creation of 0.08 acres of shallow water habitat and 0.15 acres of moderately shallow water habitat during the capping activities. Additionally, habitat enhancements and improvements will be made in Wheeler Bay as part of the capping activities, including placing a layer of sand and gravel over the cap armor layer (large rock) between + 3.0 feet and -3.5 feet NGVD to improve substrate conditions within the prime shallow water habitat area of the Bay. The Wheeler Bay bank slope will be vegetated as necessary for slope stability.
- Ramsey Refugia, Phase II—creating approximately 2.5 acres of habitat in the Ramsey Wetland Complex in the Columbia Slough by re-establishing hydrologic connectivity to the Lower Columbia Slough to improve floodplain wetland functions and to increase the amount and quality of off-channel rearing and refuge aquatic habitat.

8.1 On-site Mitigation Actions

8.1.1 Habitat Bench

A description of the containment berm, including the habitat bench, is provided in Section 4 of this document.

8.1.2 Piling Removal in Wheeler Bay and Slip 3

Approximately 25 treated wood piles and an old wooden trestle will be removed from Wheeler Bay just upstream from Slip 1 and approximately 1800 treated wood piles will be removed from the south side of Slip 3. Slip 3 contains an actively used pier that consists of Berths 410 and 411. On the south side of Slip 3, an old pile field exists that was once part of Pier 5. The deck has been removed, but the wooden piles remain for the full length of Slip 3. These piles will be cut or broken off at the mudline. The removal of piles will involve in-water work as well as onshore work.

Figure 19 shows the structures and piling to be demolished in Wheeler Bay. Figure 34 shows the piling to be demolished at Pier 5.

Construction quality control procedures to confirm pile removal activities meet the intent of the design are presented in Section 5.6 of this document and the CQAP (Appendix C).

8.1.3 Capping

A description of the capping actions are provided in Section 6 of this document.

8.2 Off-site Mitigation Action—Ramsey Refugia, Phase II

For the off-site Ramsey Refugia, Phase II project, the Port will make a financial contribution to the City of Portland to partially fund the project (i.e., 2.5 acres). Funds would be provided to the City to be used for design, construction, and monitoring of 2.5 acres of the 5-acre project for the Terminal 4 Early Action project mitigation.

No design analysis is provided for the Ramsey Refugia, Phase II project, as the City of Portland will be responsible for all components of the design phase.

9 SUBSTANTIVE REQUIREMENTS OF PERMITS

As described in the EE/CA, CERCLA 121(e) exempts remediation actions conducted entirely onsite from having to comply with administrative requirements such as obtaining permits and meeting reporting and record keeping requirements. Thus, no federal, state, or local permits are required for onsite actions associated with the Removal Action at Terminal 4 [40 CFR 300.400(e)(1)]. The National Contingency Plan (NCP) defines onsite as "the areal extent of contamination and all suitable areas in very close proximity to the contaminants necessary for implementation of the response action." Areal extent of contamination refers to surface area, groundwater beneath the site, and air above the site. Offsite actions (e.g., offsite disposal of hazardous waste) must comply with all legally applicable substantive and administrative requirements, including obtaining permits. The concept of relevant and appropriate is not available to offsite locations.

9.1 Applicable or Relevant and Appropriate Requirements (ARARs)

For onsite actions, USEPA and support agencies must identify the legally applicable or relevant and appropriate requirements that may govern the removal action. Legally applicable requirements include those requirements promulgated under federal or state law or state facility siting law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at Terminal 4. Examples of legally applicable requirements include cleanup standards, standards of control, and other environmental protection requirements, criteria, or limitations. Relevant and appropriate requirements are requirements for environmental protection promulgated under federal or state law that address situations sufficiently similar to the circumstances of the removal action contemplated and are well-suited to Terminal 4 [40 CFR 300.400(g)(1) and (2)].

In addition, to qualify as an ARAR a state requirement must be:

- A state law
- Promulgated under a federal or state environmental or facility siting law
- More stringent than the federal requirement
- Identified by the state in a timely manner
- Consistently applied

9.2 ARARs Classifications

CERCLA actions may have to address several types of requirements. USEPA developed ARARs classifications to provide guidance on how to identify and address ARARs. There are three ARAR classifications:

- Chemical-specific
- Location-specific
- Action-specific

These classifications are defined below.

- Location-specific requirements are restrictions on activities based on the characteristics of a site or its immediate environment. The restrictions on work performed in wetlands or wetland buffers provide an example in which location-specific requirements may require restoration of wetlands.
- Chemical-specific requirements are health- or risk-based concentration limits or ranges for specific hazardous substances, pollutants, or contaminants in various environmental media. An example is the maximum contaminant levels established by USEPA as safe levels in drinking water.
- Action-specific requirements are controls or restrictions on particular types of activities such as hazardous waste management or wastewater treatment. Examples of action-specific requirements are state and federal air emissions standards as applied to an in-situ extraction treatment unit.

USEPA identified location-, chemical- and action-specific ARARs for on-site monitored natural recovery, capping, dredging, and CDF construction activities in the Action Memo (USEPA 2006a). Although these activities do not require federal, state, or local permits, they must comply with the substantive requirements of these permits, as detailed on Table 17.

Federal, state, and local permits are required for any offsite actions. Off-site actions that are a part of the Removal Action include disposal of debris. Additionally, the Ramsey Refugia, Phase II habitat mitigation project will be implemented off-site. The Port's responsibility associated with this project is to provide a portion of the funding to the City of Portland to implement the project. As such, the City of Portland is responsible for obtaining all federal, state, and local permits for this activity.

10 CONSTRUCTION SCHEDULE AND SEQUENCING

The Terminal 4 Early Action will be completed in three main stages as summarized below:

- **Stage 1** –construction of the CDF containment berm and remediation of the Terminal 4 sediments.
- **Stage 2** – filling of the CDF with contaminated sediments from other Portland Harbor Superfund Sites.
- **Stage 3** – completion of the CDF cover.

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

10.1 Stage 1 – CDF Containment Berm Construction and Remediation of Terminal 4 Sediments

This stage of the project will occur over a two year period. The first year (2007) will be preparation of Slip 1 for filling as well as constructing the containment berm at the mouth of the slip and capping of sediments at Berth 401 and the shoreline of Wheeler Bay. The second year of construction (2008) will include dredging of Slip 3 and Berth 414, sediment placement into the Slip 1 CDF, and capping of impacted sediments within the Terminal 4 facility. The construction elements associated with Stage 1 include the following:

- Slip 1 Preparation
  - IRM relocation
  - Demolition
  - Replacement berth construction
- Stormwater outfall rerouting (note that this may or may not occur as part of berm construction)
- Containment Berm Construction

- Dredging of Slip 3 and Berth 414
- In situ Capping of Terminal 4 sediments (Berth 401, Wheeler Bay, Slip 3 and Berth 414)

Stage 1 work will begin in 2007 and be completed in 2008. Figure 35 presents the anticipated duration and sequencing of the different Stage 1 events. The figure also shows the fish closure periods. Each of the elements is described in more detail below.

10.1.1 Slip 1 Preparation

In order to create a CDF in Slip 1, a number of structures need to be demolished and/or relocated. IRM currently imports and exports liquid bulk from Berth 408. The IRM berthing facility will be relocated to the existing Berth 401. Since the work is not in the water, it can be completed at any time and needs to be completed prior to demolition of Berth 408 such that IRM's services are not interrupted. The work is anticipated to take 3 to 4 months to complete.

Both berths 405 and 408 will be demolished to make room for the CDF (see Section 5.7). This work will be completed with predominantly water-based equipment with some support from upland equipment. Because work will be conducted from the water, the construction of the containment berm cannot begin until the demolition is completed. Demolition of Slip 1 piers will begin immediately at the beginning of the in-water work window and will take 5 to 6 weeks. After this work is completed the equipment will move to Pier 5 (Slip 3) and Wheeler Bay for pile demolition in those areas. Due to the limited duration of in-water work windows, the contractor will work 6 days per week for these activities as they will for all of the water based work.

Berth 405 will be replaced with a replacement berth near the containment berm (see Figure 2; see Section 5.9). This work is estimated to take 4 months to complete. The footprint of the new pier is offset from the berm footprint, so work on the two structures can occur concurrently without much schedule impact on the other.

The final element of preparing Slip 1 for filling is the relocation of the stormwater outfalls. As described in Section 5.8, four Port of Portland and one City of Portland outfalls are known to discharge into Slip 1. The rerouting of the outfalls is estimated to take six months of construction. The majority of the work will occur outside of the water so it can be completed outside the in-water work window. The daylighting of the outfalls into the Willamette River will be considered in-water work and can only be completed during the in-water work window. Figure 35 shows the stormwater relocation occurring in 2008. The CDF will be connected to the Willamette River with the weir structure. Therefore, from a technical (hydraulics) perspective the only schedule driver is that relocation needs to occur before the outfalls are covered with fill. Hence, the actual final relocation could even occur after 2008 if so necessary.

10.1.2 Containment Berm Construction

Section 5.2 describes the construction of the containment berm. The first task will be overexcavation of the soft sediments below the berm. Removal of this approximately 25,000 cy will be completed with an 8 cy clamshell bucket and bottom dump barge. The work will be completed in 5 to 9 days. The overexcavation will then be backfilled with select fill. Once the overexcavation is filled to grade, the contractor will start placement of training terraces. The training terraces will be constructed with an 8 cy clamshell bucket or with a skip box. A skip box is a bucket shaped like the bed of a dump truck. Material is placed by lifting one end of the box while moving it over the target area. Once the terraces are constructed on each side of the berm, select fill will be placed in between. The Contractor will use a bottom dump barge as much as possible to place the select fill. The containment berm will require approximately 290,000 tons of select fill and 95,000 tons of rock for training terraces. The amount of training terrace rock and therefore also the select fill will vary depending on the contractor's approach to terrace sizes. The specifications allow the contractor to use terraces ranging in height from 3 to 20 feet.

The total duration of berm construction is anticipated to be 5½ to 6 months. Because of this, the construction of the berm will be completed using two approaches. The lower portion of the berm will be constructed from water until the closure of the in-water work window (October 31). The top elevation of the berm at this date is anticipated to be between 4 to 8 feet NGVD, which is expected to be above the water level. The berm will then be finished in the dry with upland based equipment. This equipment will include trucks hauling in materials, dozers spreading the material and equipment to compact the lifts.

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

10.1.3 Dredging of Slip 3 and Berth 414

Prior to beginning dredging in the 2008 construction season, two preparatory tasks will be completed. First, the sediment offloading facility will be set up at the replacement berth. The offloading facility setup will include installing a dredge pump, piping from the pump to the CDF and a diffuser barge. The dredge pump will be supported by a crane or trackhoe working off of the new pier. This is the facility that will transport mechanically dredged sediments from the haul barges into the CDF. Because this work will not occur in the River, it can be completed at any time. The estimated duration for this task is 1 month. The second task is setting up the hydraulic dredging pipeline from Slip 3 to the CDF assuming upland routing. This work can also be completed at any time since the work is not in the River. Mobilization of the pipeline and construction of the diffuser barge is estimated to take 1 to 2 months. Both of these tasks need to be completed before July 1st so that dredging can begin upon opening of the in-water work window.

The first task will be mechanically dredging the sediments immediately adjacent to the sheetpile wall. Removal of this 15,900 cy will be completed with an 8 cy clamshell bucket and haul barge. The work will be completed in about 4 days—the contractor will likely dredge 24 hours a day, seven days per week to complete the Slip 3 dredging work. The offloading facility at the replacement berth will need to be sized to handle this production rate or additional barges will be required for storage.

When the mechanical dredging is completed the dredge will complete two days of debris sweeping in Slip 3. After one day of debris sweeping the hydraulic dredge will begin removing the 79,200 cy of dredged material from Slip 3. The Contractor will likely use a 17-inch hydraulic dredge. The dredge will work 24 hours per day, seven days per week to complete the dredging. The hydraulic dredging is estimated to take about 10 days to complete.

Post-dredge samples will be collected from Slip 3. Additional time is anticipated to address residuals that may be found during the sampling.

The total time for dredging in Slip 3 is estimated to be 15 days. This total duration will fluctuate depending on the amount of residuals that are encountered.

Once the mechanical dredge has completed the debris sweep in Slip 3, it will be moved to Berth 414 to complete dredging. The dredging of the 2,500 cy at Berth 414 will take 1 to 2 days.

10.1.4 Capping

Two of the cap areas will likely be constructed in 2007. The Wheeler Bay shoreline cap and the Berth 401 cap. Each are anticipated to require about 8 days to complete and will be completed with a combination of upland and in-water equipment.

The remaining caps will be completed in 2008 once all of the dredging is completed. Two equipment and labor crews will complete the capping. The first crew will consist of a clamshell derrick with a 5 to 8 cy bucket. This crew will work one shift, 6 days per week. They will place 100 to 140 tons/hour of capping and armor material. The crew will work sequentially on the caps at Wheeler Bay aquatic, the head of Slip 3, Pier 5 and Berth 414. The estimated durations of these caps are about 20, 3, 40 and 6 days, respectively.

A second crew consisting of a barge with a conveyor or chute will work the underpier cap at Berth 411. This crew will work around the vessels at Berth 410/411. The estimated duration to place the 8,200 tons of cap and armor under the pier is 20 working days; however, since the berth will be occupied by tenant vessels roughly 2/3 of the time, the duration of this work from start to completion may be in the order of 60 days.

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

The CDF can confine an additional estimated 545,800 cy of contaminated sediments after the Terminal 4 sediments are placed. Additional material (up to 300,000 cy) beyond that volume may also be placed for confinement depending on the amount of settlement that occurs. The speed at which the material is placed within the CDF is a function of two factors: 1) how fast the material can be physically offloaded from barges and pumped into the CDF; 2) how available the material is. The offloading facility to be located at the replacement berth would likely be sized to offload 2,000 to 4,000 cy per day assuming a 10- to 12-inch diameter hydraulic dredge pump, respectively. Assuming there are 100 working days per in-water work season (6 days per week between July 1st and October 31st) the maximum quantity of material that could reasonably be offloaded would be 200,000 to 400,000 cy.

Therefore, the shortest duration for filling the additional capacity for contaminated sediments would be 1½ to 2½ seasons. However, it is not anticipated that contaminated sediments would become available this quickly. A longer duration is anticipated for the Stage 2 work.

10.3 Stage 3 – Placement of the CDF Cover

The CDF cover consists of two main layers (see Figure 14). The lower level located above the dredged sediment for confinement is the import fill layer. The volume of this layer is approximately 464,000 cy. The majority of this material is anticipated to be clean dredged material brought to the site on haul barges. The offloading facility described in Section 11.2 will be used for offloading the material. As with the contaminated sediment the rate of placement will be a function of the supply rate. At a minimum the filling would require 1 to 2 seasons to complete.

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

11 ACCESS AND EASEMENT REQUIREMENTS

As stated in Section IX (Access and Institutional Controls) of the AOC (USEPA 2003b), the Port shall provide USEPA and its representatives, including contractors, with access at all reasonable times to the Terminal 4 Removal Action Area for the purpose of conducting any activity related to the AOC. The AOC further states that if any portion of the Terminal 4 Removal Action Area, or any other riparian property where access is needed to implement the Order, is owned by or in the control of someone other than the Port, Port shall use best efforts to obtain all necessary access for performing and overseeing the work required to be done in the SOW.

The Port owns a majority of the uplands adjacent to the Removal Action Area and leases some areas to its tenants. As stated previously in this document, current tenants at Terminal 4 are Cereal Food Processors, IRM, Rogers Terminal, and KMBT. As necessary, the Port will develop agreements with Port tenants to coordinate the work for the Removal Action. Additionally, the City of Portland (Fire Bureau) owns a small piece of upland property that will be capped and stabilized in Wheeler Bay. Access to the City-owned parcel will be coordinated with the City.

Currently, both the Port and the Oregon DSL own the submerged and submersible lands within the RAA. The Port is in the process of acquiring the land from the State of Oregon that would be necessary to implement the Removal Action. The Port submitted a Land Sale Application Form to the DSL in May 2005, which was presented and approved for negotiations at the June 2006 State Land Board. The Port is currently in negotiations with DSL to obtain all submerged and submersible lands within the RAA that will be capped and used for the CDF. Institutional controls will also be required to ensure the integrity of the cap and CDF are maintained (See Section 11 for details on the Institutional Controls). This land transaction is expected to occur in April 2007 prior to the first Removal Action construction season.

12 INSTITUTIONAL CONTROLS

Section IX (Access and Institutional Controls) of the AOC states that "If after the Removal Action is complete, restrictions on the use of the Port's property, including the beds or banks of the slips or Willamette River, is necessary to maintain the Removal Action or avoid exposure to hazardous substances, pollutants, or contaminants, the Port shall take any and all actions to establish, implement, and maintain the necessary institutional controls." To meet this requirement, this section describes the institutional controls that will be implemented after the Removal Action.

The overall protectiveness of the Removal Action will be further enhanced by implementation of institutional controls for areas where contaminated sediment is contained in place with caps and for the CDF. The primary objectives for the institutional controls include the following:

- Protect the integrity of the CDF berm and capped surfaces such that the underlying isolated sediments remain isolated.
- Protect the integrity of the CDF such that the contained contaminated sediments are not exposed and do not re-enter the river.

Additional details on specific institutional controls that will be implemented to meet each objective are provided below.

12.1 Protect the Integrity of the CDF Berm and Capped Surfaces

As stated previously, one objective for implementing institutional controls is to protect the integrity of the CDF berm and capped surfaces such that the underlying isolated sediments remain isolated. To meet this objective, regulated navigation areas will be established in capped areas and in the footprint of the CDF berm. These areas will also be identified on the Port-maintained Terminal 4 base-map that is used for construction/redevelopment activities. Notification to the Port's tenants alerting them to the location of the capped areas will also be implemented to protect the integrity of the capped surfaces. Finally, a property record notice regarding the cap areas will be placed to ensure that future property owners are aware of the capped areas and long-term maintenance and monitoring requirements.

Regulated Navigation Areas. Regulated navigation area (RNA) requests for CDF berm and the capped areas will be submitted to the US Coast Guard and/or NOAA after the berm is constructed and the capping portion of the Removal Action is complete. An RNA designation will prohibit activities such as anchoring, dragging, trawling, or other activities that may disrupt the function or effect the integrity of the CDF berm or caps. The CDF berm will be able to handle pile driving and removal within its footprint.

Update the Terminal 4 Base-map. The location of the capped areas and the footprint of the CDF berm will be placed on the Terminal 4 base-map to alert personnel conducting future construction activities that the integrity of the capped areas and CDF berm must be maintained. Additionally, a statement requiring coordination with the Port's Marine Environmental prior to conducting any construction activities within the footprint of the capped areas will also be placed on the base-map.

Notification to Port Tenants. Written notification will be given to the Port's tenants about the presence of the capped areas, which will include the following:

- Instructions and maps that show areas where boat and ship traffic should be minimized and anchoring prohibited
- Direction that all proposed work in the vicinity of a cap should be cleared with the Port prior to starting work
- Direction that excavation and/or purposeful sediment disturbance shall not be conducted in the capped areas
- Direction that the Port shall be notified in the event of any possible damage to a capped area

Additionally, lease language protecting the integrity of the capped areas will be provided for any new tenants that occupy Port property at Terminal 4.

Property Record Notice. A notice will be placed in the property record documenting the cap locations and the long term monitoring requirements as stated in the LTMRP.

12.2 Protect the Integrity of the CDF

To protect the integrity of the CDF and prevent the contained contaminated sediments from being exposed and re-entering the river, the following actions will be implemented:

- Update the Terminal 4 base-map to include the CDF footprint
- Review construction activities
- Place restrictive covenant and property record notice

Update Terminal 4 Base-map. The footprint of the CDF will be placed on the Port maintained Terminal 4 Base-map along with a statement requiring coordination with the Port's Marine Environmental prior to conducting any construction activities within the footprint of the CDF.

Review Construction Activities. The contaminated sediments will be located 22 feet below the ground surface within the footprint of the CDF. Therefore, to ensure the integrity of the CDF, any construction activities that will occur within the footprint of the CDF below ground surface will be reviewed by Marine Environmental at the Port. Routine maintenance of existing structures will not require additional review.

Additionally, specific lease language for future tenants who may occupy the land above the CDF will be provided notifying them that any construction activities that will occur within the footprint of the CDF below ground surface will be reviewed by Marine Environmental at the Port to ensure the integrity of the CDF.

Restrictive Covenant and Property Record Notice. A restrictive covenant or other means will be placed in property record to prohibit the installation of potable water production wells or intake pipes on submerged lands adjacent to the CDF berm. In addition, a notice will be placed in the property record documenting the CDF location and the long term monitoring and maintenance requirements as described in the LTMRP.

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TABLES

Table 2
Summary of Monitoring Activities Associated with the Terminal 4 Early Action

Construction Activity	Type of Sampling/Monitoring	Activity	Document and/or Section where Details are Provided
Short-term Construction			
Pile/Structure Demolition	Water Quality Monitoring	Laboratory Parameters	Section 3.2 of the Water Quality Monitoring Plan (WQMP)
		Conventional Field Parameters	Section 3.2 of the WQMP
	Archeological Monitoring	Monitoring for activities occurring within the archeologically sensitive areas according to the Archeological Monitoring Protocol	Attachment C-1 of the Construction Quality Assurance Plan (CQAP)
	Construction Performance Criteria Monitoring and Verification	Verify Removal of Specified Structure/Pile	Section 4.1.3.1 of the CQAP
		Settlement Monitoring to Verify Protection of Remaining Structures	Section 4.1.3.1 of the CQAP
		Waste-Tracking Program to Verify Appropriate Disposal/Recycling of Demolition Materials	Section 4.1.3.2 of the CQAP
		Soil Sampling to Verify No Off-site Tracking of Contaminants Occurred During Transport of Disposal Materials	Section 4.1.3.3 of the CQAP
Containment Berm Construction	Water Quality	Laboratory Parameters	Section 3.4 of the WQMP
		Conventional Field Parameters	Section 3.4 of the WQMP
	Archeological Monitoring	Monitoring for activities occurring within the archeologically sensitive areas according to the Archeological Monitoring Protocol	Attachment C-1 of the CQAP
	Construction Performance Criteria Monitoring and Verification	Bathymetric/Topographic Surveys to Verify Specified Grades and Extents	Section 4.2.3.1 of the CQAP
		Verify Stability of the Containment Berm	Section 4.2.3.2 of the CQAP
		Verify Import Material Quality	Section 4.2.3.3 of the CQAP
Dredging (Berm Key, Slip 3, Berth 414)	Water Quality	Laboratory Parameters	Section 3.3 (Berm Key); Section 3.1 (Slip 3 and Berth 414) of the WQMP
		Conventional Field Parameters	Section 3.3 (Berm Key); Section 3.1 (Slip 3 and Berth 414) of the WQMP
	Archeological Monitoring	Monitoring for activities occurring within the archeologically sensitive areas according to the Archeological Monitoring Protocol	Attachment C-1 of the CQAP
	Construction Performance Criteria Monitoring and Verification	Hydrographic Surveys to Verify Dredging Depths and Extents	Section 4.3.3.1 of the CQAP
		Hydrographic Surveys to Verify Placement of Material at the Head of Slip 1	Section 4.3.3.3 of the CQAP
		Settlement Monitoring to Verify Protection of Structures	Section 4.3.3.4 of the CQAP
		Post-Dredge Confirmation Sampling to Verify Sediment Quality Performance	Section 4.3.3.5 of the CQAP
		Soil Sampling (pre and post) to Verify No Off-site Tracking of Contaminants Occurred During Transport of Disposal Materials for Demolition Activities	Section 4.3.3.6 of the CQAP
Capping (Berth 401, Wheeler Bay, Slip 3, Berth 414)	Water Quality	Laboratory Parameters	Section 3.6 of the WQMP
		Conventional Field Parameters	Section 3.6 of the WQMP
	Construction Performance Criteria Monitoring and Verification	Verify Import Material Quality	Section 4.4.3.1 of the CQAP
		Bathymetric/Topographic Surveys to Verify Specified Grades and Extents	Section 4.4.3.2 of the CQAP
		Settlement Monitoring to Verify Protection of Remaining Structures	Section 4.4.3.3 of the CQAP
New Structure/Outfall/Piping Construction	Water Quality	Laboratory Parameters	Section 3.5 of the WQMP
		Conventional Field Parameters	Section 3.5 of the WQMP
	Archeological Monitoring	Monitoring for activities occurring within the archeologically sensitive areas according to the Archeological Monitoring Protocol	Attachment C-1 of the CQAP
	Construction Performance Criteria Monitoring and Verification	Verify Construction Material	Section 4.5.3.1 of the CQAP
		Surveys to Verify Specified Grades and Dimensions	Section 4.5.3.2 of the CQAP
		Hydrostatic and/or Air Testing to Verify Watertightness of Pipes	Section 4.5.3.3 of the CQAP
		Mandrel Tests to Verify Pipe Loading	Section 4.5.3.4 of the CQAP
		Field Nuclear Gage Testing (or equivalent) to Verify Compaction	Section 4.5.3.5 of the CQAP
		Use of Bubble Curtain (or other type of sound attenuation device) to Protect Aquatic Species During Installation of Pipe Piles with an Impact Hammer	Section 4.5.3.6 of the CQAP
Terminal 4 CDF Filling	Water Quality	Laboratory and Conventional Field Parameters for Ponded Water Release Through Berm Face	Section 3.7 of the WQMP
		Laboratory and Conventional Field Parameters for CDF Effluent Release (including sample to be taken within CDF as early warning)	Section 3.8 of the WQMP
		Laboratory and Conventional Field Parameters for Ponded Water Release Through Berm Face	Section 3.7 of the WQMP
		Laboratory and Conventional Field Parameters to Confirm No Release of Material During Transport of Dredged Material to CDF (mechanical dredging)	Section 3.1 of the WQMP and Section 4.6.3.2 of the CQAP
		Pipe Testing and Visual Inspections to Confirm No Release of Dredged Material During Hydraulic Transport	Section 4.6.3.3 of the CQAP

Table 2
Summary of Monitoring Activities Associated with the Terminal 4 Early Action

Construction Activity	Type of Sampling/Monitoring	Activity	Document and/or Section where Details are Provided
	Construction Performance Criteria Monitoring and Verification	Sediment Sampling (Pre and Post) to Confirm No Spillage of Material at the Transfer/Offload Facility for mechanical dredging	Section 4.6.3.4 of the CQAP
		Bathymetric Surveys to Verify Specified Material Placement Elevations	Section 4.6.3.5 of the CQAP
		Settlement Monitoring to Verify CDF Consolidation	Section 4.6.3.6 of the CQAP
Habitat Mitigation	Construction Performance Criteria Monitoring and Verification (On-Site Activities)	Bathymetric/Topographic Surveys to Verify Specified Grades and Extents of Habitat Bench	Section 5.1.1.1 of the Draft Mitigation Plan
		Verify Removal of Specified Piles in Wheeler Bay and Slip 3	Section 5.2.1.1 of the Draft Mitigation Plan
		Bathymetric/Topographic Surveys to Confirm Cap Thickness and Extent	Section 5.3.1.1 of the Draft Mitigation Plan
	Construction Performance Criteria Monitoring and Verification (Off-Site Activity)	Bathymetric/Topographic Surveys to Verify Target Elevations Achieved	Section 5.3.1.1 of the Draft Mitigation Plan
		Vegetation and LWD Surveys to Verify Vegetation Planted where Specified	Section 5.4.1.2 of the Draft Mitigation Plan
Post Terminal 4 CDF Filling			
CDF Filling With Non-Terminal 4 Contaminated Sediment	Water Quality	Laboratory and Conventional Field Parameters for CDF Effluent Release (including sample to be taken within CDF as early warning)	Section 3.8 of the WQMP
		Laboratory and Conventional Field Parameters for Ponded Water Release Through Berm Face	Section 3.7 of the WQMP
		Laboratory and Conventional Field Parameters to Confirm No Release of Material During Transport of Dredged Material to CDF (mechanical dredging)	Section 3.1 of the WQMP and Section 4.6.3.2 of the CQAP
	Sediment Acceptance Criteria	Bulk Sediment Chemistry Testing	Section 5.2.1 of the SACM
		Bulk Physical Properties (TOC, Grain Size, Atterberg Limits)	Section 5.2.2 of the SACM
		TCLP (Hazardous Waste Designation)	Section 5.2.3 of the SACM
		PCLT (Sediment Leachability)	Section 5.2.4 of the SACM
		Other Testing Requirements (Possible MET and CST Testing)	Section 5.2.5 of the SACM
	Construction Performance Criteria Monitoring and Verification	Pipe Testing and Visual Inspections to Confirm No Release of Dredged Material During Hydraulic Transport	Section 4.6.3.3 of the CQAP
		Sediment Sampling (Pre and Post) to Confirm No Spillage of Material at the Transfer/Offload Facility for mechanical dredging	Section 4.6.3.4 of the CQAP
		Bathymetric Surveys to Verify Specified Material Placement Elevations	Section 4.6.3.5 of the CQAP
		Settlement Monitoring to Verify CDF Consolidation	Section 4.6.3.6 of the CQAP
	Interim Filling Monitoring	Bathymetric Surveys and Visual Inspections of the Containment Berm After a Filling Season or Post Design-Level Flood or Earthquake	Section 2.1 of the Confined Disposal Sediment Management Plan (CDSMP)
		Bathymetric and/or Topographic Surveys of Placed Material	Section 2.2 of the CDSMP
		Placement of a Thin-Layer Cap to Protect Wildlife	Section 2.3 of the CDSMP
CDF Covering	Construction Performance Criteria Monitoring and Verification	Verify Import Material Quality	Section 4.7.2.1 of the CQAP
		Surveys to Verify Specified Cover, Thickness, and Extent	Section 4.7.2.2 of the CQAP
Long Term Monitoring			
Capping (Berth 401, Wheeler Bay, Slip 3, Berth 414)	Cap Monitoring	To be determined during 100% Design	Section 2.0 of the Long-Term Monitoring and Reporting Plan (LTMRP)
Monitored Natural Recovery	MNR Monitoring	To be determined during 100% Design	Section 3.0 of the LTMRP
CDF	Physical Monitoring	To be determined during 100% Design	Section 4.0 of the LTMRP
	Groundwater Quality Monitoring	To be determined during 100% Design	Section 5.0 of the LTMRP
Habitat Mitigation	Habitat Mitigation Monitoring	Bathymetric/Topographic Surveys to Confirm Target Elevations are being Reasonably Maintained	Section 5.4.1.1 of the Draft Mitigation Plan
		Vegetation Surveys to Confirm Planted Vegetation is Growing and Surviving	Section 5.4.1.2 of the Draft Mitigation Plan
		Evaluate Stream Gage and Velocity Data to Confirm that Hydrologic Connectivity between Ramsey Lake Complex and Lower Columbia Slough has been Achieved	Section 5.4.2.1 of the Draft Mitigation Plan
		Fish Surveys to Evaluate Fish Presence/Absence	Section 5.4.2.2 of the Draft Mitigation Plan
		Wildlife Surveys	Section 5.4.2.3 of the Draft Mitigation Plan

Table 3
Terminal 4 Sediment Quality Guidelines

Substance	PEC	TEC	Draft Portland Harbor Screening (Level 2)
Conventionals (in mg/kg)			
Ammonia	---	---	170
Sulfides	---	---	32
Metals (in mg/kg)			
Arsenic	33	9.79	24
Cadmium	4.98	0.99	2.6
Chromium	111	43.4	---
Copper	149	31.6	562
Lead	128	35.8	---
Silver	---	---	32
Mercury	1.06	0.18	0.63
Nickel	48.6	22.7	---
Zinc	459	121	---
Polycyclic aromatic hydrocarbons (in ug/kg DW)			
Anthracene	845	57.2	---
Fluorene	536	77.4	---
Naphthalene	561	176	---
Phenanthrene	1,170	204	---
Benzo(a)anthracene	1,050	108	---
Benzo(a)pyrene	1,450	150	---
Chrysene	1,290	166	---
Dibenzo(a,h)anthracene	---	33	---
Fluoranthene	2,230	423	---
Pyrene	1,520	195	---
Total PAHs	22,800	1,610	1,270,000
TPH - Diesel Range	---	---	340,000
TPH - Residual Range	---	---	2,700,000
Polychlorinated biphenyls (in ug/kg DW)			
Total PCBs	676	59.8	1,400
Organochlorine pesticides (in ug/kg DW)			
Chlordane	17.6	3.24	---
Dieldrin	61.8	1.9	21.5
Sum DDD	28	4.88	---
Sum DDE	31.3	3.16	---
Sum DDT	62.9	4.16	---
Total DDTs	572	5.28	1,000
Endrin	207	2.22	---
Heptachlor Epoxide	16	2.47	---
Lindane (gamma-BHC)	4.99	2.37	---
beta-Hexachlorocyclohexane	---	---	9.6

Table 4
Terminal 4 Enrichment Rations by Remediation Area

Remediation Area: Slip 3

Constituent	Maximum Concentration	PEC	TEC	Maximum PEC Enrichment Ratio	Maximum TEC Enrichment Ratio
Key Polycyclic Aromatic Hydrocarbons (PAHs) (ug/kg)					
Anthracene	15000	845	57.2	17.75	262.24
Fluorene	14000	536	77.4	26.12	180.88
Napthalene	11000	561	176	19.61	62.50
Phenanthrene	74000	1170	204	63.25	362.75
Benz(a)anthracene	81000	1050	108	77.14	750.00
Benzo(a)pyrene	94000	1450	150	64.83	626.67
Chrysene	78000	1290	166	60.47	469.88
Dibenz(a,h)anthracene	25000	---	33	---	757.58
Fluoranthene	130000	2230	423	58.30	307.33
Pyrene	110000	1520	195	72.37	564.10
Total PAHs	868000	22800	1610	38.07	539.13
Key Metals (mg/kg)					
Cadmium	10.1	4.98	0.99	2.03	10.20
Lead	1670	128	35.8	13.05	46.65
Zinc	2050	459	121	4.47	16.94
Other Key Constituents (ug/kg)					
Sum DDD	80	28	4.88	2.86	16.39
Sum DDE	17	31.3	3.16	0.54	5.38
Sum DDT	90	62.9	4.16	1.43	21.63
Total DDTs	158	572	5.28	0.28	29.92
Total PCBs	1000	676	59.8	1.48	16.72

Remediation Area: Berth 414

Constituent	Maximum Concentration	PEC	TEC	Maximum PEC Enrichment Ratio	Maximum TEC Enrichment Ratio
Key Polycyclic Aromatic Hydrocarbons (PAHs) (ug/kg)					
Anthracene	11000	845	57.2	13.02	192.31
Fluorene	9800	536	77.4	18.28	126.61
Napthalene	1100	561	176	1.96	6.25
Phenanthrene	60000	1170	204	51.28	294.12
Benz(a)anthracene	46000	1050	108	43.81	425.93
Benzo(a)pyrene	54000	1450	150	37.24	360.00
Chrysene	60000	1290	166	46.51	361.45
Dibenz(a,h)anthracene	15000	---	33	---	454.55
Fluoranthene	97000	2230	423	43.50	229.31
Pyrene	67000	1520	195	44.08	343.59
Total PAHs	620900	22800	1610	27.23	385.65
Key Metals (mg/kg)					
Cadmium	1.61	4.98	0.99	0.32	1.63
Lead	171	128	35.8	1.34	4.78
Zinc	579	459	121	1.26	4.79
Other Key Constituents (ug/kg)					
Sum DDD	22	28	4.88	0.79	4.51
Sum DDE	15	31.3	3.16	0.48	4.75
Sum DDT	10.5	62.9	4.16	0.17	2.52
Total DDTs	32.2	572	5.28	0.06	6.10
Total PCBs	169	676	59.8	0.25	2.83

Table 4
Terminal 4 Enrichment Rations by Remediation Area

Remediation Area: Wheeler Bay

Constituent	Maximum Concentration	PEC	TEC	Maximum PEC Enrichment Ratio	Maximum TEC Enrichment Ratio
Key Polycyclic Aromatic Hydrocarbons (PAHs) (ug/kg)					
Anthracene	2000	845	57.2	2.37	34.97
Fluorene	890	536	77.4	1.66	11.50
Napthalene	660	561	176	1.18	3.75
Phenanthrene	10000	1170	204	8.55	49.02
Benz(a)anthracene	20000	1050	108	19.05	185.19
Benzo(a)pyrene	24000	1450	150	16.55	160.00
Chrysene	19000	1290	166	14.73	114.46
Dibenz(a,h)anthracene	4000	---	33	---	118.18
Fluoranthene	27000	2230	423	12.11	63.83
Pyrene	24000	1520	195	15.79	123.08
Total PAHs	208000	22800	1610	9.12	129.19
Key Metals (mg/kg)					
Cadmium	1.03	4.98	0.99	0.21	1.04
Lead	3130	128	35.8	24.45	87.43
Zinc	271	459	121	0.59	2.24
Other Key Constituents (ug/kg)					
Sum DDD	16.4	28	4.88	0.59	3.36
Sum DDE	14	31.3	3.16	0.45	4.43
Sum DDT	31	62.9	4.16	0.49	7.45
Total DDTs	35.9	572	5.28	0.06	6.80
Total PCBs	270	676	59.8	0.40	4.52

Remediation Area: Berth 401

Constituent	Maximum Concentration	PEC	TEC	Maximum PEC Enrichment Ratio	Maximum TEC Enrichment Ratio
Key Polycyclic Aromatic Hydrocarbons (PAHs) (ug/kg)					
Anthracene	130	845	57.2	0.15	2.27
Fluorene	77	536	77.4	0.14	0.99
Napthalene	90	561	176	0.16	0.51
Phenanthrene	690	1170	204	0.59	3.38
Benz(a)anthracene	320	1050	108	0.30	2.96
Benzo(a)pyrene	400	1450	150	0.28	2.67
Chrysene	450	1290	166	0.35	2.71
Dibenz(a,h)anthracene	38	---	33	---	1.15
Fluoranthene	900	2230	423	0.40	2.13
Pyrene	1300	1520	195	0.86	6.67
Total PAHs	5812	22800	1610	0.25	3.61
Key Metals (mg/kg)					
Cadmium	0.54	4.98	0.99	0.11	0.55
Lead	31.9	128	35.8	0.25	0.89
Zinc	151	459	121	0.33	1.25
Other Key Constituents (ug/kg)					
Sum DDD	6.2	28	4.88	0.22	1.27
Sum DDE	7.15	31.3	3.16	0.23	2.26
Sum DDT	17.1	62.9	4.16	0.27	4.11
Total DDTs	23.7	572	5.28	0.04	4.49
Total PCBs	250	676	59.8	0.37	4.18

Table 4
Terminal 4 Enrichment Rations by Remediation Area

Remediation Area: North MNR Area

Constituent	Maximum Concentration	PEC	TEC	Maximum PEC Enrichment Ratio	Maximum TEC Enrichment Ratio
Key Polycyclic Aromatic Hydrocarbons (PAHs) (ug/kg)					
Anthracene	280	845	57.2	0.33	4.90
Fluorene	180	536	77.4	0.34	2.33
Napthalene	580	561	176	1.03	3.30
Phenanthrene	1600	1170	204	1.37	7.84
Benz(a)anthracene	730	1050	108	0.70	6.76
Benzo(a)pyrene	1000	1450	150	0.69	6.67
Chrysene	970	1290	166	0.75	5.84
Dibenz(a,h)anthracene	78	---	33	---	2.36
Fluoranthene	2100	2230	423	0.94	4.96
Pyrene	3300	1520	195	2.17	16.92
Total PAHs	14254	22800	1610	0.63	8.85
Key Metals (mg/kg)					
Cadmium	0.62	4.98	0.99	0.12	0.63
Lead	33.7	128	35.8	0.26	0.94
Zinc	566	459	121	1.23	4.68
Other Key Constituents (ug/kg)					
Sum DDD	73	28	4.88	2.61	14.96
Sum DDE	25	31.3	3.16	0.80	7.91
Sum DDT	18.7	62.9	4.16	0.30	4.50
Total DDTs	76.2	572	5.28	0.13	14.43
Total PCBs	193	676	59.8	0.29	3.23

Remediation Area: Berm Key Area

Constituent	Maximum Concentration	PEC	TEC	Maximum PEC Enrichment Ratio	Maximum TEC Enrichment Ratio
Key Polycyclic Aromatic Hydrocarbons (PAHs) (ug/kg)					
Anthracene	640	845	57.2	0.76	11.19
Fluorene	1000	536	77.4	1.87	12.92
Napthalene	360	561	176	0.64	2.05
Phenanthrene	4900	1170	204	4.19	24.02
Benz(a)anthracene	4000	1050	108	3.81	37.04
Benzo(a)pyrene	6300	1450	150	4.34	42.00
Chrysene	4900	1290	166	3.80	29.52
Dibenz(a,h)anthracene	1100	---	33	---	33.33
Fluoranthene	9700	2230	423	4.35	22.93
Pyrene	7200	1520	195	4.74	36.92
Total PAHs	60322	22800	1610	2.65	37.47
Key Metals (mg/kg)					
Cadmium	0.713	4.98	0.99	0.14	0.72
Lead	53.3	128	35.8	0.42	1.49
Zinc	172	459	121	0.37	1.42
Other Key Constituents (ug/kg)					
Sum DDD	15.1	28	4.88	0.54	3.09
Sum DDE	18	31.3	3.16	0.58	5.70
Sum DDT	13	62.9	4.16	0.21	3.13
Total DDTs	31.6	572	5.28	0.06	5.98
Total PCBs	96	676	59.8	0.14	1.61

Table 4
Terminal 4 Enrichment Rations by Remediation Area

Remediation Area: Slip 3

Constituent	Maximum Concentration	PEC	TEC	Maximum PEC Enrichment Ratio	Maximum TEC Enrichment Ratio
Key Polycyclic Aromatic Hydrocarbons (PAHs) (ug/kg)					
Anthracene	15000	845	57.2	17.75	262.24
Fluorene	14000	536	77.4	26.12	180.88
Napthalene	11000	561	176	19.61	62.50
Phenanthrene	74000	1170	204	63.25	362.75
Benz(a)anthracene	81000	1050	108	77.14	750.00
Benzo(a)pyrene	94000	1450	150	64.83	626.67
Chrysene	78000	1290	166	60.47	469.88
Dibenz(a,h)anthracene	25000	---	33	---	757.58
Fluoranthene	130000	2230	423	58.30	307.33
Pyrene	110000	1520	195	72.37	564.10
Total PAHs	868000	22800	1610	38.07	539.13
Key Metals (mg/kg)					
Cadmium	10.1	4.98	0.99	2.03	10.20
Lead	1670	128	35.8	13.05	46.65
Zinc	2050	459	121	4.47	16.94
Other Key Constituents (ug/kg)					
Sum DDD	80	28	4.88	2.86	16.39
Sum DDE	17	31.3	3.16	0.54	5.38
Sum DDT	90	62.9	4.16	1.43	21.63
Total DDTs	158	572	5.28	0.28	29.92
Total PCBs	1000	676	59.8	1.48	16.72

Remediation Area: Berth 414

Constituent	Maximum Concentration	PEC	TEC	Maximum PEC Enrichment Ratio	Maximum TEC Enrichment Ratio
Key Polycyclic Aromatic Hydrocarbons (PAHs) (ug/kg)					
Anthracene	11000	845	57.2	13.02	192.31
Fluorene	9800	536	77.4	18.28	126.61
Napthalene	1100	561	176	1.96	6.25
Phenanthrene	60000	1170	204	51.28	294.12
Benz(a)anthracene	46000	1050	108	43.81	425.93
Benzo(a)pyrene	54000	1450	150	37.24	360.00
Chrysene	60000	1290	166	46.51	361.45
Dibenz(a,h)anthracene	15000	---	33	---	454.55
Fluoranthene	97000	2230	423	43.50	229.31
Pyrene	67000	1520	195	44.08	343.59
Total PAHs	620900	22800	1610	27.23	385.65
Key Metals (mg/kg)					
Cadmium	1.61	4.98	0.99	0.32	1.63
Lead	171	128	35.8	1.34	4.78
Zinc	579	459	121	1.26	4.79
Other Key Constituents (ug/kg)					
Sum DDD	22	28	4.88	0.79	4.51
Sum DDE	15	31.3	3.16	0.48	4.75
Sum DDT	10.5	62.9	4.16	0.17	2.52
Total DDTs	32.2	572	5.28	0.06	6.10
Total PCBs	169	676	59.8	0.25	2.83

Table 4
Terminal 4 Enrichment Rations by Remediation Area

Remediation Area: Wheeler Bay

Constituent	Maximum Concentration	PEC	TEC	Maximum PEC Enrichment Ratio	Maximum TEC Enrichment Ratio
Key Polycyclic Aromatic Hydrocarbons (PAHs) (ug/kg)					
Anthracene	2000	845	57.2	2.37	34.97
Fluorene	890	536	77.4	1.66	11.50
Napthalene	660	561	176	1.18	3.75
Phenanthrene	10000	1170	204	8.55	49.02
Benz(a)anthracene	20000	1050	108	19.05	185.19
Benzo(a)pyrene	24000	1450	150	16.55	160.00
Chrysene	19000	1290	166	14.73	114.46
Dibenz(a,h)anthracene	4000	---	33	---	118.18
Fluoranthene	27000	2230	423	12.11	63.83
Pyrene	24000	1520	195	15.79	123.08
Total PAHs	208000	22800	1610	9.12	129.19
Key Metals (mg/kg)					
Cadmium	1.03	4.98	0.99	0.21	1.04
Lead	3130	128	35.8	24.45	87.43
Zinc	271	459	121	0.59	2.24
Other Key Constituents (ug/kg)					
Sum DDD	16.4	28	4.88	0.59	3.36
Sum DDE	14	31.3	3.16	0.45	4.43
Sum DDT	31	62.9	4.16	0.49	7.45
Total DDTs	35.9	572	5.28	0.06	6.80
Total PCBs	270	676	59.8	0.40	4.52

Remediation Area: Berth 401

Constituent	Maximum Concentration	PEC	TEC	Maximum PEC Enrichment Ratio	Maximum TEC Enrichment Ratio
Key Polycyclic Aromatic Hydrocarbons (PAHs) (ug/kg)					
Anthracene	130	845	57.2	0.15	2.27
Fluorene	77	536	77.4	0.14	0.99
Napthalene	90	561	176	0.16	0.51
Phenanthrene	690	1170	204	0.59	3.38
Benz(a)anthracene	320	1050	108	0.30	2.96
Benzo(a)pyrene	400	1450	150	0.28	2.67
Chrysene	450	1290	166	0.35	2.71
Dibenz(a,h)anthracene	38	---	33	---	1.15
Fluoranthene	900	2230	423	0.40	2.13
Pyrene	1300	1520	195	0.86	6.67
Total PAHs	5812	22800	1610	0.25	3.61
Key Metals (mg/kg)					
Cadmium	0.54	4.98	0.99	0.11	0.55
Lead	31.9	128	35.8	0.25	0.89
Zinc	151	459	121	0.33	1.25
Other Key Constituents (ug/kg)					
Sum DDD	6.2	28	4.88	0.22	1.27
Sum DDE	7.15	31.3	3.16	0.23	2.26
Sum DDT	17.1	62.9	4.16	0.27	4.11
Total DDTs	23.7	572	5.28	0.04	4.49
Total PCBs	250	676	59.8	0.37	4.18

Table 4
Terminal 4 Enrichment Rations by Remediation Area

Remediation Area: North MNR Area

Constituent	Maximum Concentration	PEC	TEC	Maximum PEC Enrichment Ratio	Maximum TEC Enrichment Ratio
Key Polycyclic Aromatic Hydrocarbons (PAHs) (ug/kg)					
Anthracene	280	845	57.2	0.33	4.90
Fluorene	180	536	77.4	0.34	2.33
Napthalene	580	561	176	1.03	3.30
Phenanthrene	1600	1170	204	1.37	7.84
Benz(a)anthracene	730	1050	108	0.70	6.76
Benzo(a)pyrene	1000	1450	150	0.69	6.67
Chrysene	970	1290	166	0.75	5.84
Dibenz(a,h)anthracene	78	---	33	---	2.36
Fluoranthene	2100	2230	423	0.94	4.96
Pyrene	3300	1520	195	2.17	16.92
Total PAHs	14254	22800	1610	0.63	8.85
Key Metals (mg/kg)					
Cadmium	0.62	4.98	0.99	0.12	0.63
Lead	33.7	128	35.8	0.26	0.94
Zinc	566	459	121	1.23	4.68
Other Key Constituents (ug/kg)					
Sum DDD	73	28	4.88	2.61	14.96
Sum DDE	25	31.3	3.16	0.80	7.91
Sum DDT	18.7	62.9	4.16	0.30	4.50
Total DDTs	76.2	572	5.28	0.13	14.43
Total PCBs	193	676	59.8	0.29	3.23

Remediation Area: Berm Key Area

Constituent	Maximum Concentration	PEC	TEC	Maximum PEC Enrichment Ratio	Maximum TEC Enrichment Ratio
Key Polycyclic Aromatic Hydrocarbons (PAHs) (ug/kg)					
Anthracene	640	845	57.2	0.76	11.19
Fluorene	1000	536	77.4	1.87	12.92
Napthalene	360	561	176	0.64	2.05
Phenanthrene	4900	1170	204	4.19	24.02
Benz(a)anthracene	4000	1050	108	3.81	37.04
Benzo(a)pyrene	6300	1450	150	4.34	42.00
Chrysene	4900	1290	166	3.80	29.52
Dibenz(a,h)anthracene	1100	---	33	---	33.33
Fluoranthene	9700	2230	423	4.35	22.93
Pyrene	7200	1520	195	4.74	36.92
Total PAHs	60322	22800	1610	2.65	37.47
Key Metals (mg/kg)					
Cadmium	0.713	4.98	0.99	0.14	0.72
Lead	53.3	128	35.8	0.42	1.49
Zinc	172	459	121	0.37	1.42
Other Key Constituents (ug/kg)					
Sum DDD	15.1	28	4.88	0.54	3.09
Sum DDE	18	31.3	3.16	0.58	5.70
Sum DDT	13	62.9	4.16	0.21	3.13
Total DDTs	31.6	572	5.28	0.06	5.98
Total PCBs	96	676	59.8	0.14	1.61

Table 6
Water Quality Criteria and Guidelines

PARAMETER		Units	Narrative Standard[1]	Narrative Guidance Value[1]	Acute WQC[2]	Chronic WQC[3]	Willamette River BG[4]	Acute Guidance Value[5]	Chronic Guidance Value[5]
Field Parameters									
	Turbidity	NTU	BG <50 NTU: BG + 5 NTU BG >50 NTU: BG + 5%						
	Total Suspended Solids	mg/L	--	BG + 5%					
	Dissolved Oxygen	mg/L	> 6.5						
Metals[6]									
	Cadmium	µg/L			0.5	0.09	0.05		
	Lead	µg/L			14	0.54	0.14		
	Zinc	µg/L			36	36	TBD		
Polycyclic Aromatic Hydrocarbons (PAHs)									
	Naphthalene	µg/L			--	--	TBD	807	194
	Acenaphthylene	µg/L			--	--	TBD	1277	307
	Acenaphthene	µg/L			--	--	TBD	233	56
	Fluorene	µg/L			--	--	TBD	162	39
	Phenanthrene	µg/L			--	--	TBD	79	19
	Anthracene	µg/L			--	--	TBD	87	21
	Fluoranthene	µg/L			--	--	TBD	30	7.1
	Pyrene	µg/L			--	--	TBD	42	10
	Benzo(a)anthracene	µg/L			--	--	TBD	9.2	2.2
	Chrysene	µg/L			--	--	TBD	8.3	2.0
	Benzo(b)fluoranthene	µg/L			--	--	TBD	2.8	0.68
	Benzo(k)fluoranthene	µg/L			--	--	TBD	2.7	0.64
	Benzo(a)pyrene	µg/L			--	--	TBD	4.0	0.96
	Indeno(1,2,3-cd)pyrene	µg/L			--	--	TBD	1.2	0.28
	Dibenzo(a,h)anthracene	µg/L			--	--	TBD	1.2	0.28
	Benzo(g,h,i)perylene	µg/L			--	--	TBD	1.8	0.44
Chlorinated Organic Compounds[7]									
	4,4'-DDT	µg/L			1.1	0.001	TBD		
	Total PCBs	µg/L			--	0.014	TBD		

Notes:
[1] Applies to all construction activities
[2] Applies to dredging and capping activities, and CDF effluent discharges of less than four days in duration
[3] Applies to CDF effluent discharges greater than four days in duration
[4] Initial values determined from USGS Station #14211720; to be updated with pre-construction and ongoing measurmements at Terminal 4
[5] Final Acute Values and Final Chronic Values from EPA 2003
[6] Based on Willamette River hardness of 25 mg/L
[7] COCs of limited extent; applies to construction activities in vicinity of T4-VC17, southeast corner of Slip 3
TBD = To be determined

Table 7
Ambient Background Concentrations WIlliamette River Portland

		Median	Mean	90th Percentile
Conventionals				
Turbidity (NTU)	[1]	4.6	10	27
TSS (mg/L)	[1]	12	24	49
Metals (ug/L)				
Arsenic	[2]	0.4	0.4	0.5
Cadmium	[2]	<0.04	<0.04	0.05
Copper	[2]	0.9	1.0	1.5
Lead	[2]	0.07	0.08	0.14

Notes:

[1] 1974-2000, USGS Station #14211720

[2] 2004-2005, USGS Station #14211720

Table 8
Groundwater Release Criteria for Fish and Drinking Water Consumption

Darcy Flux[1]	3.20E-06	m/s
Ambient Current[2]	0.05	m/s

BIOACCUMULATIVE CHEMICAL OF CONCERN [BCOC]	Water Quality Criteria (µg/L)				Receiving Water Concentration (µg/L)	
					Distance above berm (m)	
	BCOC Groundwater Criteria	Fish Consumption Criteria	Willamette River Backgrd[3]	Chronic Criteria	0.1	1
ARSENIC[4]	160	0.14	0.4	150	0.50	0.41
MERCURY	230	0.15	0	0.77	0.15	0.01
BENZO(A)PYRENE	28	0.018	0	0.96	0.018	0.002
CHRYSENE	28	0.018	0	2.0	0.018	0.002
DDT	0.35	2.2E-04	0	0.001	2.2E-04	2.2E-05

DRINKING WATER CHEMICAL OF CONCERN [DCOC]	Water Quality Criteria (µg/L)					Receiving Water Conc. (µg/L)
						Distance (m)
	DCOC Groundwater Criteria	Water Solubility[5]	Region 9 Tap Water PRG	Drinking Water MCL	Willamette River Backgrd[3]	10
ARSENIC[4]	15,000	N/A	0.045	10	0.4	0.50
CADMIUM	770,000	N/A	18	5	0.04	5.0
LEAD	2,330,000	N/A	--	15	0.08	15.0
MERCURY	312,000	N/A	11	2	0	2.0
BENZO(A)PYRENE	1,430	2	0.0092	0.2	0	0.0092
CHRYSENE	1,430,000	2	9.2	--	0	9.2
DDT	31,000	25	0.2	--	0	0.20

Notes:

[1] From MODFLOW results; see Appendix I
[2] From BBL 2005
[3] From USGS, 2006
[4] Defaults to Willamette River background (90th percentile = 0.5 µg/L)
[5] USEPA 2002; Syracuse Research Corporation Online Database

Most stringent criteria for drinking water exposure

Table 9
DRET Elutriate Chemistry Results

Sample ID / Lab ID / Date Sampled	Acute Water Quality Value	T4-CM1-Dret K2402978-004 04/20/2004		T4-CM2-Dret K2403382-001 05/05/2004	
Metals (ug/L)					
Arsenic	340	0.9		0.8	
Cadmium	0.5	0.02	U	0.04	U
Chromium	183	1.11		1.77	
Copper	3.6	5.08		4.25	
Lead	14	1.63		1.86	
Mercury	1.4	0.2	U	0.2	U
Nickel	145	1.3		1.65	
Selenium		0.7	U	0.4	B
Silver	0.3	0.03	U	0.03	
Zinc	36	5.62		6.7	
Semivolatile Organics (ug/L)					
Naphthalene	807	0.40	U	0.39	U
2-Methylnaphthalene	300	0.40	U	0.39	U
1-Methylnaphthalene	312	0.40	U	0.39	U
Biphenyl		0.40	U	0.39	U
2,6-Dimethylnaphthalene	108	0.40	U	0.39	U
Acenaphthylene	1,277	0.40	U	0.099	J
Acenaphthene	233	0.40	U	0.19	J
2,3,5-Trimethylnaphthalene	41	0.40	U	0.027	J
Fluorene	162	0.40	U	0.096	J
Phenanthrene	79	0.40	U	0.13	J
Anthracene	87	0.40	U	0.39	U
1-Methylphenanthrene	31	0.40	U	0.39	U
Fluoranthene	30	0.40	U	0.092	J
Pyrene	42	0.075	J	0.13	J
Benz(a)anthracene	9.2	0.40	U	0.39	U
Chrysene	8.3	0.40	U	0.39	U
Benzo(b)fluoranthene	2.8	0.40	U	0.39	U
Benzo(k)fluoranthene	2.7	0.40	U	0.39	U
Benzo(e)pyrene	3.7	0.40	U	0.39	U
Benzo(a)pyrene	4.0	0.40	U	0.39	U
Perylene	3.7	0.40	U	0.39	U
Indeno(1,2,3-cd)pyrene	1.2	0.40	U	0.39	U
Dibenz(a,h)anthracene	1.2	0.40	U	0.39	U
Benzo(g,h,i)perylene	1.8	0.40	U	0.39	U
Dimethyl phthalate		9.9	U	9.6	UJ
Diethyl phthalate		9.9	U	9.6	U
Di-n-butyl phthalate		9.9	U	9.6	U
Butylbenzyl phthalate		9.9	U	9.6	U
Bis(2-ethylhexyl) phthalate		9.9	U	9.6	U
Di-n-octyl phthalate		9.9	U	9.6	U
Total PAHs (a,b)		0.075	J	0.737	J
Pesticides (ug/L)					
4,4'-DDE		0.099	U	0.097	U
4,4'-DDD		0.099	U	0.097	U
4,4'-DDT	1.1	0.099	U	0.097	U
2,4'-DDE		0.099	U	0.097	U
2,4'-DDD		0.099	U	0.097	U
2,4'-DDT		0.099	U	0.097	U

Table 9
DRET Elutriate Chemistry Results

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

Notes:

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

Table 10
MET Elutriate Chemistry Results (from BBL 2005)

Sample ID Lab ID Date Sampled	Acute WQC	Chronic WQC	T4-CM2-Met-T K2403058-001 04/23/2004		T4-CM2-Met-D K2403058-002 04/23/2004	
Metals (ug/L)						
Arsenic	340	150	15.5		2.6	
Cadmium	0.5	0.09	2.05		0.06	U
Chromium	183	24	118		3.37	
Copper	3.6	2.7	250		15.9	
Lead	14	0.54	178		4.72	
Mercury	1.4	0.77	0.6		0.05	U
Nickel	145	16	88.9		2.6	
Selenium			4.3	B	1.7	U
Silver	0.3		1.96		0.15	
Zinc	36	36	573		12.8	
Semivolatile Organics (ug/L)						
Naphthalene	807	194	0.39	UJ	0.39	U
2-Methylnaphthalene	300	72	0.39	UJ	0.39	U
1-Methylnaphthalene	312	75	0.39	UJ	0.39	U
Biphenyl			0.11	UJ	0.39	U
2,6-Dimethylnaphthalene	108	26	0.39	UJ	0.39	U
Acenaphthylene	1,277	307	0.092	J	0.11	J
Acenaphthene	233	56	0.096	J	0.43	
2,3,5-Trimethylnaphthalene	41	9.8	0.024	J	0.041	J
Fluorene	162	39	0.39	J	0.11	J
Phenanthrene	79	19	0.27	J	0.39	U
Anthracene	87	21	0.047	J	0.39	U
1-Methylphenanthrene	31	7.5	0.39	UJ	0.39	U
Fluoranthene	30	7.1	0.46	J	0.17	J
Pyrene	42	10	0.85	J	0.10	J
Benz(a)anthracene	9.2	2.2	0.11	J	0.39	U
Chrysene	8.3	2.0	0.17	J	0.39	U
Benzo(b)fluoranthene	2.8	0.68	0.39	J	0.39	U
Benzo(k)fluoranthene	2.7	0.64	0.092	J	0.39	U
Benzo(e)pyrene	3.7	0.90	0.39	J	0.39	U
Benzo(a)pyrene	4.0	0.96	0.39	J	0.39	U
Perylene	3.7	0.90	0.064	J	0.39	U
Indeno(1,2,3-cd)pyrene	1.2	0.28	0.39	UJ	0.39	U
Dibenz(a,h)anthracene	1.2	0.28	0.39	UJ	0.39	U
Benzo(g,h,i)perylene	1.8	0.44	0.39	UJ	0.39	U
Dimethyl phthalate			9.6	UJ	9.6	U
Diethyl phthalate			9.6	UJ	9.6	U
Di-n-butyl phthalate			9.6	UJ	9.6	U
Butylbenzyl phthalate			9.6	UJ	9.6	U
Bis(2-ethylhexyl) phthalate			9.6	UJ	9.6	U
Di-n-octyl phthalate			9.6	UJ	9.6	U
Total PAHs (a,b)			2.6	J	0.92	
Pesticides (ug/L)						
4,4'-DDE			0.015	J	0.002	J
4,4'-DDD			0.011	J	0.096	U
4,4'-DDT	1.1	0.001	0.007	J	0.096	U
2,4'-DDE			0.002	J	0.096	U
2,4'-DDD			0.011	J	0.096	U
2,4'-DDT			0.003	J	0.096	U

Table 10
MET Elutriate Chemistry Results (from BBL 2005)

Sample ID Lab ID Date Sampled	Acute WQC	Chronic WQC	T4-CM2-Met-T K2403058-001 04/23/2004	T4-CM2-Met-D K2403058-002 04/23/2004
Total DDD			0.022 J	0.096 U
Total DDE			0.017 J	0.002 J
Total DDT			0.010 J	0.096 U
ΣDDTs (a)			0.049 J	0.002 J
PCBs (ug/L)				
Aroclor 1016			0.096 U	0.096 U
Aroclor 1221			0.096 U	0.096 U
Aroclor 1232			0.096 U	0.096 U
Aroclor 1242			0.096 U	0.096 U
Aroclor 1248			0.096 U	0.096 U
Aroclor 1254			0.098 U	0.096 U
Aroclor 1260			0.082 J	0.096 U
Aroclor 1262			0.096 U	0.096 U
Aroclor 1268			0.096 U	0.096 U
Total PCBs (a)	2	0.014	0.082 J	0.096 U
Conventionals (mg/L)				
Total suspended solids			3300	5 U

Notes:

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

Table 11
Slip 3 CST Results (from Anchor 2006)

	Depth from Top of Settling Column (ft)									
	0.4	0.9	1.4	1.9	2.4	2.9	3.4	3.9	4.4	5.4
Time	Port F	Port G	Port H	Port I	Port J	Port K	Port L	Port M	Port N	Port P
Turbidity (NTU)										
0		28,000		28,000		28,000		31,000		29,000
1	11,200	11,000	11,300	11,400	12,200	10,800	11,600			
2	9,600	9,600	9,800	10,600	9,600	9,900	9,500	9,600		
4	8,250	8,400	8,100	8,450	8,400	8,150	7,950	8,200	8,050	
6	7,200	8,350	8,300	7,700	7,900	7,550	7,750	7,650	7,700	
8		7,300	7,300	7,050	7,200	7,150	7,300	7,400	7,400	
11		6,750	6,800	6,800	6,700	6,750	6,900	6,850	6,750	12,000
24		5,500	5,900	5,850	6,250	5,850	5,800	5,750	6,050	6,050
48		4,360	5,160	5,120	6,000	4,920	4,880	4,960	5,200	4,920
97			3,200	3,440	3,660	3,520	3,580	3,560	3,620	3,560
132[1]			2,628	2,927	3,137	3,135	3,156	3,175	3,226	3,304
168			2,040	2,400	2,600	2,740	2,720	2,780	2,820	3,040
265			620	1,600	1,880	2,000	2,100	2,160	2,200	2,280
Total Suspended Solids (mg/L)										
0		96,000		115,000		105,000		204,000		103,000
1	15,800	16,500	19,300	18,700	25,200	17,600	21,500			
2	11,900	12,900	13,900	13,400	13,700	13,700	13,600	14,000		
4	11,100	12,100	10,900	11,900	10,900	11,000	11,100	11,000	11,000	
6	8,100	12,600	12,100	10,000	9,800	10,300	10,200	10,100	9,500	
8		8,900	9,000	8,700	9,600	9,000	9,300	9,200	9,000	
11		8,100	7,900	8,300	8,300	8,100	8,300	7,000	8,200	23,500
24		6,150	6,950	5,850	7,350	6,900	6,300	5,900	6,100	6,850
48		3,760	5,100	5,567	6,700	5,100	4,700	5,100	5,733	4,800
97			2,360	2,880	3,460	3,240	2,960	2,580	2,980	3,280
132[1]			1,941	2,185	2,454	2,570	2,354	2,255	2,413	2,812
168			1,510	1,470	1,420	1,880	1,730	1,920	1,830	2,330
265			60	470	683	1,195	1,305	910	1,035	1,390

Notes:

[1] Mean retention time = 132 hours; turbidity and TSS values are interpolated from measurements at 97 and 168 hours.

Table 12
PCLT Leachate Results (from BBL 2005)

Metals (µg/L)

Sample ID:	T4 CM2-3	T4 CM2-6	T4-CM2-9	T4-CM2-12	T4-CM2-15	T4-CM2-18	T4-CM2-21	T4-CM2-24	Water Quality Criteria	
Lab ID:	K2403293-001	K2403768-001	K2404308-001	K2404838-001	K2405298-001	K2405675-001	K2405932-002	K2406359-001		
Date Sampled:	05/02/2004	05/19/2004	06/08/2004	06/30/2004	07/19/2004	07/27/2004	08/06/2004	08/22/2004	Acute	Chronic
Arsenic	**3.2**	**2.4**	**3.8**	**4.1**	**2.3**	**2.4**	**2.5**	**2.6**	340	150
Cadmium	**0.21**	**0.07**	**0.11**	**0.11**	**0.06**	**0.1**	**0.13**	**0.1**	0.5	0.09
Chromium	**4.3**	**3.2**	**4.0**	**4.2**	**1.9**	**2.1**	**2.2**	**2.4**	183	24
Copper	**3.8** J	**3.7**	**6.6**	**13.3**	**5.6**	**6.6**	**7.4**	**6.8**	3.6	2.7
Lead	**0.67**	**1.2**	**2.5**	**5.8**	**2.4**	**3.0**	**3.2**	**2.9**	14	0.54
Mercury	0.2 U	0.2 U	0.2 U	0.2 U	0.2 UJ	0.2 U	0.2 UJ	0.2 U	1.4	0.77
Nickel	**7.5**	**2.9**	**3.0**	**2.4**	**0.9** J	**1.3**	1.4 U	**1.5**	145	16
Selenium	**0.4** B	**0.2** B	1 UJ	1 U	1 U	1 U	1 U	1 U		
Silver	**0.02** B	**0.03**	0.06 U	**0.09**	0.07 U	0.08 U	0.08 U	**0.05**	0.3	
Zinc	**3.9**	**3.2**	**4.5**	**10.2**	**4.0**	**6.2**	**6.3**	**6.4**	36	36

Semivolatile Organics (µg/L)

Sample ID:	T4-CM2-1	T4CM2-4	T4-CM2-7	T4-CM2-10	T4-CM2-13	T4-CM2-16	T4-CM2-19	T4-CM2-22	Water Quality Criteria	
Lab ID:	K2402978-006	K2403459-001	K2403995-001	K2404410-001	K2405086-001	K2405510-001	K2405739-001	K2406120-001		
Date Sampled:	04/07/2004	05/08/2004	05/25/2004	06/14/2004	07/08/2004	07/23/2004	08/03/2004	08/14/2004	Acute	Chronic
Naphthalene	0.40 UJ	**0.13 J**	**0.14 J**	**0.15 J**	0.43 U	0.49 U	**0.12 J**	0.40 U	807	194
2-Methylnaphthalene	0.40 UJ	0.40 U	0.39 UJ	0.066 J	0.43 U	0.49 U	**0.068 J**	0.40 U	300	72
1-Methylnaphthalene	**0.14 J**	**0.32 J**	**0.25 J**	**0.43**	0.43 U	**0.12 J**	**0.23 J**	0.40 U	312	75
Biphenyl	0.40 UJ	0.40 U	0.39 UJ	0.41 U	**0.11 J**	0.49 U	0.40 U	0.40 U		
2,6-Dimethylnaphthalene	0.40 UJ	**0.065 J**	**0.051 J**	**0.096 J**	0.43 U	0.49 U	**0.074 J**	0.40 U	108	26
Acenaphthylene	0.40 UJ	0.40 U	0.39 UJ	0.41 U	0.43 U	0.049 J	0.40 U	0.40 U	1,277	307
Acenaphthene	**0.33 J**	**0.62**	**0.46 J**	**0.78**	0.43 U	**0.39 J**	**0.50**	**0.21 J**	233	56
2,3,5-Trimethylnaphthalene	0.40 UJ	**0.072 J**	0.39 UJ	**0.077 J**	0.43 U	0.49 U	**0.064 J**	0.40 U	41	9.8
Fluorene	0.40 UJ	**0.20 J**	**0.15 J**	**0.24 J**	0.43 U	**0.098 J**	**0.19 J**	0.40 U	162	39
Phenanthrene	0.40 UJ	**0.28 J**	**0.22 J**	**0.29 J**	0.43 U	0.49 U	**0.36 J**	0.40 U	79	19
Anthracene	0.40 UJ	**0.024 J**	0.39 UJ	**0.033 J**	0.43 U	0.49 U	0.40 U	0.40 U	87	21
1-Methylphenanthrene	0.40 UJ	0.40 U	0.39 UJ	0.41 U	0.43 U	0.49 U	0.40 U	0.40 U	31	7.5
Fluoranthene	0.40 UJ	**0.057 J**	**0.060 J**	0.41 UJ	0.43 U	**0.20 J**	0.40 U	0.40 U	30	7.1
Pyrene	0.40 UJ	**0.069 J**	**0.064 J**	**0.096 J**	0.43 U	**0.096 J**	0.40 U	0.40 U	42	10
Benz(a)anthracene	0.40 UJ	0.40 U	0.39 UJ	0.41 U	0.43 U	0.49 U	0.40 U	0.40 U	9.2	2.2
Chrysene	0.40 UJ	0.40 U	0.39 UJ	0.41 U	0.43 U	**0.034 J**	0.40 U	0.40 U	8.3	2.0
Benzo(b)fluoranthene	0.40 UJ	0.40 U	0.39 UJ	0.41 U	0.43 U	0.49 U	0.40 U	0.40 U	2.8	0.68
Benzo(k)fluoranthene	0.40 UJ	0.40 U	0.39 UJ	0.41 U	0.43 U	0.49 U	0.40 U	0.40 U	2.7	0.64
Benzo(e)pyrene	0.40 UJ	0.40 U	0.39 UJ	0.41 U	0.43 U	0.49 U	0.40 U	0.40 U	3.7	0.90
Benzo(a)pyrene	0.40 UJ	0.40 U	0.39 UJ	0.41 U	0.43 U	0.49 U	0.40 U	0.40 U	4.0	0.96
Perylene	0.40 UJ	0.40 U	0.39 UJ	0.41 U	0.43 U	0.49 U	0.40 U	0.40 U	3.7	0.90
Indeno(1,2,3-cd)pyrene	0.40 UJ	0.40 U	0.39 UJ	0.41 U	0.43 U	0.49 U	0.40 U	0.40 U	1.2	0.28
Dibenz(a,h)anthracene	0.40 UJ	0.40 U	0.39 UJ	0.41 U	0.43 U	0.49 UJ	0.40 UJ	0.40 U	1.2	0.28
Benzo(g,h,i)perylene	0.40 UJ	0.40 U	0.39 UJ	0.41 U	0.43 U	0.49 U	0.40 U	0.40 U	1.8	0.44
Dimethyl phthalate	10 UJ	9.9 U	9.6 UJ	11 U	11 U	13 U	10 U	10 U		
Diethyl phthalate	**0.51 J**	9.9 U	9.6 UJ	11 U	11 U	13 U	10 U	10 U		
Di-n-butyl phthalate	10 UJ	9.9 U	9.6 UJ	11 U	11 U	13 U	10 U	10 U		
Butylbenzyl phthalate	10 UJ	9.9 U	9.6 UJ	11 U	11 U	13 U	10 U	10 U		
Bis(2-ethylhexyl) phthalate	10 UJ	9.9 U	9.6 UJ	11 U	11 U	13 U	10 U	10 U		
Di-n-octyl phthalate	10 UJ	9.9 U	9.6 UJ	11 U	11 U	13 U	3.9 J	10 U		
Total PAHs (a,b)	**0.33 J**	**1.4**	**1.1 J**	**1.6**	0.43 U	**0.87 J**	**1.2**	**0.21 J**		

Table 12
PCLT Leachate Results (from BBL 2005)

Pesticides and PCBs (µg/L)

Sample ID:	T4-CM2-2	T4-CM2-5	T4-CM2-8	T4-CM2-11	T4-CM2-14	T4-CM2-17	T4-CM2-20	T4-CM2-23	Water Quality Criteria	
Lab ID:	K2402978-007	K2403657-001	K2404064-001	K2404715-001	K2405177-001	K2405532-001	K2405932-001	K2406266-001		
Date Sampled:	04/20/2004	05/14/2004	06/01/2004	06/24/2004	07/13/2004	07/27/2004	08/06/2004	08/18/2004	Acute	Chronic
Pesticides (µg/L)										
4,4'-DDE	0.10 U	0.10 U	**0.0054 J**	0.12 U	0.11 U	0.10 U	0.098 U	0.11 U		
4,4'-DDD	0.10 U	0.10 U	0.10 U	0.12 U	0.11 U	0.10 U	0.098 U	0.11 U		
4,4'-DDT	0.10 U	0.10 U	0.10 U	0.12 U	0.11 U	0.10 U	0.098 U	0.11 U	1.1	0.0010
2,4'-DDE	0.10 U	0.10 U	0.10 U	0.12 U	0.11 U	0.10 U	0.098 U	0.11 U		
2,4'-DDD	0.10 U	0.10 U	0.10 U	0.12 U	**0.0013 J**	**0.00084 J**	0.098 U	0.11 U		
2,4'-DDT	0.10 U	0.10 U	0.10 U	0.12 U	0.11 U	0.10 U	0.098 U	0.11 U		
Total DDD	0.10 U	0.10 U	0.10 U	0.12 U	**0.0013 J**	**0.00084 J**	0.098 U	0.11 U		
Total DDE	0.10 U	0.10 U	**0.0054 J**	0.12 U	0.11 U	0.10 U	0.098 U	0.11 U		
Total DDT	0.10 U	0.10 U	0.10 U	0.12 U	0.11 U	0.10 U	0.098 U	0.11 U		
ΣDDTs (a)	0.10 U	0.10 U	**0.0054 J**	0.12 U	**0.0013 J**	**0.00084 J**	0.098 U	0.11 U	1.1	0.0010
PCBs (µg/L)										
Aroclor 1016	0.10 U	0.10 U	0.10 U	0.12 U	0.22 U	0.10 U	0.20 U	0.11 U		
Aroclor 1221	0.10 U	0.10 U	0.10 U	0.12 U	0.43 U	0.10 U	0.39 U	0.11 U		
Aroclor 1232	0.10 U	0.10 U	0.10 U	0.12 U	0.22 U	0.10 U	0.20 U	0.11 U		
Aroclor 1242	0.10 U	0.10 U	0.10 U	0.12 U	0.22 U	0.10 U	0.20 U	0.11 U		
Aroclor 1248	0.10 U	0.10 U	0.10 U	0.12 U	0.22 U	0.10 U	0.20 U	0.11 U		
Aroclor 1254	0.10 U	0.10 U	0.10 U	0.12 U	0.22 U	0.10 U	0.20 U	0.11 U		
Aroclor 1260	0.10 U	0.10 U	0.10 UJ	0.12 U	0.22 U	0.10 U	0.20 U	0.11 U		
Aroclor 1262	0.10 U	0.10 U	0.10 U	0.12 U	0.22 U	0.10 U	0.20 U	0.11 U		
Aroclor 1268	0.10 U	0.10 U	0.10 U	0.12 U	0.22 U	0.10 U	0.20 U	0.11 U		
Total PCBs (a)	0.10 U	0.10 U	0.10 U	0.12 U	0.43 U	0.10 U	0.39 U	0.11 U	2	0.014

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

Table 13
DREDGE Model Input Parameters

	Tupical	Worst Case	Units	Data Sources/References
Dredging Parameters				
Hydraulic Scenario				
Cutterhead				Source: Manson
Cutterhead diameter	0.432	0.432	m	Source: Manson
Cutterhead length	1.22	1.22	m	Source: Manson
Thickness of cut	0.914	0.914	m	Source: Manson
Swing velocity at cutterhead	0.8	0.8	m/sec	Source: Manson
In-situ dry density	700	700	kg/m3	Source: Typical for recently deposited sediments
Mechanical Scenario				
Open Bucket Size	6.2	6.2	m3	Source: Manson
Cycle Time	150	150	sec	Source: Manson (average cycle time)
(Average) Settling Velocity	0.00423	0.00423		Calculated by model based on particle sizes
In-situ dry density	700	700	kg/m3	Source: Typical for recently deposited sediments
Near-field TSS Model				
User Estimate (Hydraulic)	0.50	2.00	% loss	Hayes and Wu, 2001; Anchor, 2003
User Estimate (Mechanical)	5.00	10.00	% loss	Hayes and Wu, 2001; Anchor, 2003
Far-field TSS Models				
Kuo's Model				
Lateral diffusion coefficient	100000	100000	cm2/s	Model default value
Vertical diffusion coefficent	10	10	cm2/s	Model default value
(Average) settling velocity	0.00423	0.00423	m/s	Calculated by model based on particle sizes
Downstream locations (for output)	150	150	m	To determine TSS at point of compiance
Downstream step	5	5	m	
Lateral locations (for output)	100	100	m	
Lateral step	5	5	m	
Desired water depth (for output)	0	0	m	
Site Characteristics				
Water depth (Hydraulic dredge areas)	14	14	m	Typical dredge depth in Slip 3
Water depth (Mechanical dredge areas)	3.5	3.5	m	Shallowest dredge depth in Berth 414
Ambient Water Velocity (Hydraulic)	0.01	0.05	m/s	Source: EE/CA Figure G-1. Head (0.01) and mouth (0.05) of Slip 3.
Ambient Water Velocity (Mechanical)	0.01	0.15	m/s	Source: EE/CA Figure G-1. From head of Slip 3 (0.01) to Harbor line (0.15).
Mean particle size	74	74	um	Source: (review of geotech data)
Specific gravity of sediment	2.64	2.64	g/cm3	Source: Used Values from COMP-2
Fraction of particles < 74um	0.667	0.667	%	Source: Used Values from COMP-2
Fraction of particles < 5um	0.331	0.331	%	Source: Used Values from COMP-2

Table 14
PLUMES Model Input Parameters

Parameter	Input	Units	Reference/Notes
Outfall/ Effluent Conditions			
Number of Ports	1		Assume 1 Port is adequate
Port Diameters	17	In	Preliminary engineering estimate (I.D.)
Port Elevation	1.5	Ft	Elevation from river bottom to port centerlines (30 ft water depth)
Port Depth	28.5	Ft	Submerged depth from the surface to port centerlines
Vertical Angle	8	Deg	Ports are inclined slightly to prevent impingement of ZID on bottom
Horizontal Angle	90	Deg	Port discharges are perpendicular to river flow direction
Effluent Flow	7.6	MGD	One dredge - discharge rate of 7,630 gpm
Effluent Density	1000	Kg/m^3	Assume 2^{o} F rise in river temperature during settling/transport
Effluent Concentration	100	Percent	Generic "tracer" concentration for dilution calculations
Ambient Conditions			
Current Speed	0.5	ft/s	Current speed under relatively low flow condition
Ambient Density	1000.1	Kg/m^3	Approx. density at ambient river temperature (59 *F)
Density Stratification	None		Assume turbulent and well-mixed profile
Background Concentration	0	Percent	For generic dilution calculations

Table 15
Predicted Effluent Dilution Factors

	Matrix	Zone of Initial Dilution[1]	Compliance Boundary[2]
Predicted Dilution (PLUMES Model)[3]			
		37	39
Required Dilution (CST and MET)			
TSS[4]	TOT	NA	36[2]
Copper	DIS	4.4	5.9
Lead	DIS	0	8.7
PAHs	TOT	0	0
PCB	TOT	0	5.9
PCB	DIS	ND	ND
DDT	TOT	0	7.2
DDT	DIS	ND	ND

Notes:

[1] Compliance evaluated with acute water quality criteria

[2] Compliance evaluated with narrative and chronic water quality criteria

[3] PLUMES does not model sedimentation processes;
Additional reductions expected in total fractions due to sedimentation

[4] Interpolated value from CST based on mean retention time of CDF

TOT = Total fraction (dissolved & particulate)

DIS = Dissolved fraction only

NA = Not Applicable

ND = Not Detected

Table 16
Predicted Groundwater Dilution and Attenuation Factors (DAF)

	Minimum Kd	Average Kd	Ref	Minimum Estimated DAF	Average Estimated DAF
Metals					
Arsenic	610	880	[3]	12	14
Cadmium	1,430	2,880	[3]	20	45
Copper	1,730	3,690	[3]	25	63
Lead	4,021	10,100	[3]	68	130
Organic Compounds					
Chrysene[1]	3,180	20,300	[4]	51	1,236
DDE[2]	390	35,800	[4]	>10,000	>>10,000

Notes:

[1] Does not include biodegradation

[2] Includes biodegradation half life = 1,620 days (4.4 years); EPA 2000

[3] Kd dervied from PCLT test data

[4] Kd dervied from PCLT test data and EPA 2002

Table 17
ARARs for Monitored Natural Attenuation, Capping, Dredging, and Confined Disposal Facility

Regulation			
Federal ARARs			
Clean Water Act, Section 404	33 USC 1344 33 CFR Parts 320-323 40 CFR 230	Regulates discharge of dredged and fill material into waters of the United States. Action specific—potentially applicable to dredging, covering, capping, and construction of in-water disposal facility and in-water filling activities in the Willamette River.	Appendix Q of the EE/CA provides a preliminary draft 404(b)(1) evaluation and concludes there is a need for compensatory mitigation due to the permanent loss of aquatic habitat. Conceptual Compensatory Mitigation Plan and Draft Mitigation Plan identify mitigation actions to offset losses of aquatic habitat. Biological Assessment and Water Quality Monitoring Plan (WQMP, Appendix D of the DAR) address action-specific BMPs to minimize short-term water quality impacts due to discharges.
Clean Water Act, Ambient Water Quality Criteria	33 USC 1313, 1314 40 CFR Part 131	Provides minimum standards for water quality programs established by states. Two kinds of water quality criteria exist: one for protection of human health, and one for protection of aquatic life. Chemical-specific; action-specific—potentially relevant and appropriate to activities that may result in a discharge or affect waters of the State resulting from the implementation of the Removal Action and as performance standards for the CDF's containment of hazardous substances only if more stringent than promulgated state criteria.	Section 6.0 of the DAR, Water Quality addresses water quality details related to the Removal Action. The WQMP details water quality monitoring activities by construction action and details ambient water quality criteria as exceedance triggers. The WQMP will be consistent with the Water Quality Monitoring and Compliance Conditions Plan that will be issued by EPA prior to Removal Action construction. The Sediment Acceptance Criteria Technical Memorandum provides process for accepting material for placement into the CDF based on contaminant transport modeling through the berm. Ambient water quality criteria are the basis of the model evaluation. Biological Assessment and WQMP address action-specific BMPs to minimize short-term water quality impacts due to Removal Action construction activities.
Clean Water Act, Section 401	33 USC 1341 40 CFR Section 121.2(a)(3) and (4)	Applies to any federally authorized activity that may result in any discharge into navigable waters and requires that such discharge comply with applicable provisions of sections 1311, 1312, 1313, 1316, and 1317 of the CWA. Action-specific—potentially applicable to discharges into the river (i.e., during dredging and capping activities and during in-water disposal activities) resulting from	Section 6.0 of the DAR, Water Quality addresses water quality details related to the Removal Action. The WQMP details water quality monitoring activities by construction action and identifies criteria that must be met during construction. The WQMP will be consistent with the Water Quality Monitoring and Compliance Conditions Plan that will be issued by EPA prior to Removal Action construction. This EPA-issued document is analogous to a CWA Section 401 Water Quality Certification.

Table 17
ARARs for Monitored Natural Attenuation, Capping, Dredging, and Confined Disposal Facility

Regulation	Citation	Criterion/Standard and Applicability	Compliance Reference
		implementation of the Removal Action.	
Safe Drinking Water Act	42 USC 3000f	Established national drinking water standards to protect human health from contaminants in drinking water. Chemical-specific—Potentially relevant and appropriate to surface water designated as a potential drinking water supply for performance criteria for the CDF's containment of hazardous substances.	The Sediment Acceptance Criteria Technical Memorandum, Section 6.0, Water Quality of the DAR, and Water Quality Monitoring Plan (Appendix D of the DAR) address performance criteria for the CDF and includes drinking water MCLs. (Note: aquatic life standards are more stringent for most analytes.) The Operation, Maintenance, and Monitoring Plan will address long-term performance criteria related to the CDF.
Resource Conservation and Recovery Act	40 CFR 260, 261	Establishes identification and management standards for solid and hazardous waste. Action-specific—Potentially applicable to characterizing wastes generated from the action and designated for off-site disposal; potentially relevant and appropriate for use in identifying acceptance criteria for CDF.	The Sediment Acceptance Criteria Technical Memorandum details sediment exclusions, including characteristic hazardous waste as defined by hazardous waste criteria listed in 40 CFR 261.24
Fish and Wildlife Coordination Act Requirements	16 USC 662, 663 40 CFR 6.302(g)	Requires federal agencies to consider effects on fish and wildlife from projects that may alter a body of water and mitigate or compensate for project-related losses. Action-specific—Potentially applicable to determining appropriate mitigation for effects on fish and wildlife from performance of the removal action.	The Biological Assessment details potential impacts of the Removal Action on ESA-listed fish and wildlife species and construction BMPs and conservation measures that will be implemented to minimize potential impacts. Conceptual Mitigation Plan Proposal and Draft Mitigation Plan details permanent habitat losses at Terminal 4 due to the Removal Action and summarizes mitigation actions to off-set those losses.
Magnuson-Stevens Fishery Conservation and Management Act	50 CFR Part 600	Evaluation of impacts to Essential Fish Habitat (EFH) is necessary for activities that may aversely affect EFH. Location-specific—Potentially applicable if the Removal Action may adversely affect EFH.	The Biological Assessment provides an evaluation of EFH impacts related to Removal Action construction activities.
National Historic Preservation Act	16 USC 470 <u>et seq.</u> 36 CFR Part 800	Requires the identification of historic properties potentially affected by the agency undertaking, and assessment of the effects on the historic property and seek ways to avoid, minimize or mitigate such effects. Historic property is any district, site, building,	The Archeological Monitoring Protocol for the Terminal 4 site is provided as an appendix to the CQAP (Appendix C of the DAR) and details process for identifying whether or not existing structures identified for demolition are historic properties and protocol to follow for compliance with this act.

Table 17
ARARs for Monitored Natural Attenuation, Capping, Dredging, and Confined Disposal Facility

Regulation	Citation	Criterion/Standard and Applicability	Compliance Reference
		structure, or object included in or eligible for the National Register of Historic Places, including artifacts, records, and material remains related to such a property. Action-specific—potentially applicable if historic properties are potentially affected by the Removal Action.	
Archeological and Historic Preservation Act	16 USC 469a-1	Provides for the preservation of historical and archeological data that may be irreparably lost as a result of a federally-approved project and mandates only preservation of the data Action-specific—potentially applicable if historical and archeological data may be irreparably lost by implementation of the Removal Action.	The Archeological Monitoring Protocol for the Terminal 4 site is provided as an appendix to the CQAP (Appendix C of the DAR) and details protocol for conducting ground disturbing activities in archeologically sensitive areas of Terminal 4. Given the highly disturbed condition of the RAA from prior excavation, dredging and filling, removal actions and sampling, it is not expected that historical and archeological resources will be encountered.
Native American Graves Protection and Reparation Act	25 USC 3001-3013 43 CFR 10	Requires Federal agencies and museums which have possession of or control over Native American cultural items (including human remains associated and unassociated funerary items, sacred objects and objects of cultural patrimony) to compile an inventory of such items. Prescribes when such Federal agencies and museums must return Native American cultural items. "Museums" are defined as any institution or State or local government agency that received Federal funds and has possession of, or control over, Native American cultural items. Location-specific; Action-specific—if Native American cultural items are present on property belonging to the Oregon Department of State Lands that is a part of the RAA, this requirement is potentially applicable. If Native American cultural items are collected by an entity which is either a	The Archeological Monitoring Protocol for the Terminal 4 site is provided as an appendix to the CQAP (Appendix C of the DAR) and details protocol for conducting ground disturbing activities in archeologically sensitive areas of Terminal 4. Given the highly disturbed condition of the RAA from prior excavation, dredging and filling, removal actions and sampling, it is not expected that historical and archeological resources will be encountered.

Table 17
ARARs for Monitored Natural Attenuation, Capping, Dredging, and Confined Disposal Facility

Regulation	Citation	Criterion/Standard and Applicability	Compliance Reference
		federal agency or museum, then the requirements of the law are potentially applicable.	
Endangered Species Act	16 USC 1531 et seq.	Actions authorized, funded, or carried out by federal agencies may not jeopardize the continued existence of endangered or threatened species or adversely modify or destroy their critical habitats. Agencies are to avoid jeopardy or take appropriate mitigation measures to avoid jeopardy. Potentially applicable due to potential impacts the Removal Action may have on endangered or threatened species or critical habitat present at the site or that may be affected by the action.	The Biological Assessment details potential impacts of the Removal Action on ESA-listed fish and wildlife species and designated critical habitat. The assessment also details construction BMPs, conservation measures, and mitigation actions that will be implemented to minimize potential impacts such that the Removal Action activities do no jeopardize the continued existence of endangered or threatened species or adversely modify or destroy their critical habitats.
Executive Order for Wetlands Protection	Executive Order 11990 (1977) 40 CFR 6.302 (a) 40 CFR Part 6, App. A	Requires measures to avoid adversely impacting wetlands whenever possible, minimize wetland destruction, and preserve the value of wetlands. Location-specific—potentially relevant and appropriate in assessing impacts to wetlands, if any, from the Removal Action and for developing appropriate compensatory mitigation for the project.	No wetlands will be affected by the Removal Action.
Executive Order for Floodplain Management National Flood Insurance Act and Flood Disaster Protection Act	Exec. Order 11988 (1977) 40 CFR Part 6, App. A 40 CFR 6.302 (b) 42 U.S.C 4001 et seq. 44 CFR National Flood Insurance Program Subpart A Requirements for Flood Plain Management Regulations Areas	Requires measures to reduce the risk of flood loss, minimize impact of floods, and restore and preserve the natural and beneficial values of floodplains. Location-specific—potentially relevant and appropriate for assessing impacts, if any, to the floodplain and flood storage from the Removal Action and developing compensatory mitigation that is beneficial to floodplain values.	Appendix M to the DAR addresses the floodway analysis for the 60% design of the CDF and concludes that the CDF would not impact the floodway or 100-year flood elevations. This analysis was an extension of the floodway and flood storage analysis conducted for the EE/CA and summarized in Appendix K of the EE/CA.

Table 17
ARARs for Monitored Natural Attenuation, Capping, Dredging, and Confined Disposal Facility

Regulation	Citation	Criterion/Standard and Applicability	Compliance Reference
Rivers and Harbors Act	33 USC 403 33 CFR 320-330	Section 10 prohibits the unauthorized obstruction or alteration of any navigable water. Structures or work in, above, or under navigable waters are regulated under Section 10. Action-specific—potentially applicable to capping, construction of the CDF, and construction of the replacement Berth 405.	Appendix Q of the EE/CA contains a Draft 404(b)(1) Analysis Memorandum, which evaluates the Removal Action's potential impact on the aquatic environment. Additionally, the Biological Assessment details potential impacts of the Removal Action on ESA-listed fish and wildlife species and construction BMPs and conservation measures that will be implemented to minimize potential impacts.
Migratory Bird Treaty Act	16 USC 703-702 50 CFR 10.12	Makes it unlawful to take, import, export, possess, buy, sell purchase, or barter any migratory bird. "Take" is defined as pursuing, hunting, shooting, poising, wounding, killing, capturing, trapping and collecting. Action-specific—potentially relevant and appropriate to short-term impacts, if any, on migratory birds from Removal Action activities.	The Biological Assessment addresses potential impacts of the Removal Action to bald eagles. No short-term impacts are expected to other migratory birds from the Removal Action construction activities.
State ARARs			
Hazardous Waste Regulations	ORS 466.005-225, OAR 340-101-0033	Federally authorized state of Oregon hazardous waste identification and management program that operates in lieu of the base federal program. (Oregon: Final Authorization of State Hazardous Waste Management Program – Revision (September 10, 2002), 67 Fed. Reg. 57337). Chemical-specific—Potentially applicable to characterizing wastes generated from the action, and determining appropriate off-site disposal options; potentially relevant and appropriate for use in identifying acceptance criteria for CDF.	TCLP testing will be performed to identify hazardous waste prior to offsite disposal. Although not expected, the Port will comply with generator requirements for any identified hazardous waste. The Sediment Acceptance Criteria Technical Memorandum details sediment exclusions, including characteristic hazardous waste as defined by hazardous waste criteria. TCLP testing will be required for determining hazardous waste designations.
Oregon Hazardous Substance Remedial Action Law and Regulations	ORS 465.200-465.420; OAR 340-122-010 et seq.	Establishes cleanup authority and objectives, and criteria applicable to hazardous substances defined to include oil and other petroleum products. Includes	Design Analysis Report provides cleanup objectives and criteria applicable to hazardous substances as well as the CQAP (Appendix C of the DAR).

Table 17
ARARs for Monitored Natural Attenuation, Capping, Dredging, and Confined Disposal Facility

Regulation	Citation	Criterion/Standard and Applicability	Compliance Reference
		authority and requirements applicable to removal actions that are patterned after CERCLA; enforces criteria very similar to those required by the National Contingency Plan to the extent they are more stringent or broader in scope than CERCLA; ORS 465.315(1)(b)(A) and (1)(e) provide standards for degree of cleanup. Chemical-specific; Action-specific—potentially applicable to extent substantive criteria or requirements are more stringent or broader in scope than federal law.	
State Removal Fill Law and Regulations	ORS 274.040, 0.43,.922, .944 OAR 141-85-0001 et seq; OAR 141-85-0115, 0121, 0126, 0136, 0141, 0151 and 0171	Regulates activities associated with removal and fill operations in state waters, including requirements for wetland mitigation. Action-specific—potentially relevant and appropriate to the dredging, capping, and construction of the CDF.	The Biological Assessment details potential impacts of the Removal Action on ESA-listed fish and wildlife species and construction BMPs and conservation measures that will be implemented to minimize potential impacts. The Water Quality Monitoring Plan (Appendix D of the DAR) addresses action-specific BMPs to minimize short-term water quality impacts due to Removal Action construction activities. The Draft Mitigation Plan details mitigation actions that will be implemented to off-set loss of aquatic habitat from the Removal Action construction activities.
Certification of Compliance with Water Quality Requirements and Standards	ORS 468b.035	Provides that federally-approved activities that may result in a discharge to waters of the State require an evaluation of whether the activity may proceed and meet water quality standards. Certifications may be approved with conditions, which if met, will ensure that water quality standards are met. Chemical-specific—potentially applicable to implementation of the removal action (e.g., dredging, capping, and construction of the CDF) that may result in a discharge to waters of the State.	Section 6.0 of the DAR, Water Quality addresses water quality details related to the Removal Action. The Water Quality Monitoring Plan (WQMP; Appendix D of the DAR) details water quality monitoring activities by construction action and identifies criteria that must be met during construction. The WQMP will be consistent with the Water Quality Monitoring and Compliance Conditions Plan that will be issued by EPA prior to Removal Action construction. Additionally, the WQMP and Biological Assessment address action-specific BMPs to minimize short-term water quality impacts due to Removal Action construction activities.
State Water Quality	ORS 468B.048;	Provides Willamette Basin beneficial uses	Section 6.0 of the DAR, Water Quality addresses water quality

Table 17
ARARs for Monitored Natural Attenuation, Capping, Dredging, and Confined Disposal Facility

Regulation	Citation	Criterion/Standard and Applicability	Compliance Reference
Standards	OAR Ch 340 Div 41	and establishes water quality standards and criteria to protect beneficial uses. Chemical-specific; Action-specific—potentially applicable to actions that may result in a discharge to or affect waters of the State; certain criteria may be potentially relevant and appropriate as performance standards and/or for long-term monitoring of surface water quality in the Removal Action Area.	details related to the Removal Action. The Water Quality Monitoring Plan (WQMP; Appendix D of the DAR) details water quality monitoring activities by construction action and identifies criteria that must be met during construction. The WQMP will be consistent with the Water Quality Monitoring and Compliance Conditions Plan that will be issued by EPA prior to Removal Action construction. Additionally, the WQMP and Biological Assessment address action-specific BMPs to minimize short-term water quality impacts due to Removal Action construction activities. Long-term monitoring activities will be provided in the Operation, Maintenance, and Monitoring Plan (Appendix E of the DAR) as part of the 100% design submittal.
Indian Graves and Protected Objects	ORS 97.740-760	Prohibits willful removal of cairn, burial, human remains, funerary object, sacred object or object of cultural patrimony. Provides for reinterment of human remains or funerary objects under the supervision of the appropriate Indian tribe. Proposed excavation by a professional archeologist of a native Indian cairn or burial requires written notification to the State Historic Preservation Officer and prior written consent of the appropriate Indian tribe. Location-specific; Action-specific—potentially relevant and appropriate if archeological materials encountered.	The Archeological Monitoring Protocol for the Terminal 4 site is provided as an appendix to the CQAP (Appendix C of the DAR) and details protocol for conducting ground disturbing activities in archeologically sensitive areas of Terminal 4, and describes action to be taken if archeological materials are encountered. Given the highly disturbed condition of the RAA from prior excavation, dredging and filling, removal actions and sampling, it is not expected that historical and archeological resources will be encountered.
Archaeological Objects and Sites	ORS 358.905-955	Prohibits persons from excavating, injuring, destroying or damaging archaeological sites or objects on public or private lands unless authorized by permit. Location-specific; Action-specific—Potentially relevant and appropriate if archeological material encountered.	The Archeological Monitoring Protocol for the Terminal 4 site is provided as an appendix to the CQAP (Appendix C of the DAR) and details protocol for conducting ground disturbing activities in archeologically sensitive areas of Terminal 4, and describes action to be taken if archeological materials are encountered. Given the highly disturbed condition of the RAA from prior excavation, dredging and filling, removal actions and sampling, it

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Regulation	Citation	Criterion/Standard and Applicability	Compliance Reference
			is not expected that historical and archeological resources will be encountered.
Requirements regarding Excavation or Removal of Archaeological or Historical Material on Public Lands	ORS 390.235 OAR 736-051-0060 to 736-051-0090	Requires permits and imposes conditions for excavation or removal of archaeological or historical materials. Location-specific; Action-specific—potentially relevant and appropriate if archeological material encountered.	The Archeological Monitoring Protocol for the Terminal 4 site is provided as an appendix to the CQAP (Appendix C of the DAR) and details protocol for conducting ground disturbing activities in archeologically sensitive areas of Terminal 4, and describes action to be taken if archeological materials are encountered. Given the highly disturbed condition of the RAA from prior excavation, dredging and filling, removal actions and sampling, it is not expected that historical and archeological resources will be encountered.
State Air Quality Law and Noise Control	ORS 468A OAR 340-226-0100, OAR 340-035-0035	Provides general emission standards for fugitive emissions of air contaminants and requires the highest and best practicable treatment of control of such emissions. Prohibits any handling, transporting or storage of materials, or use of a road, or any equipment to be operated, without taking reasonable precautions to prevent particulate matter from becoming airborne. Sets noise standards for equipment, facilities, operations, or activities employed in the production, storage, handling, sale purchase, exchange or maintenance of a product, commodity, or service, including the storage or disposal of waste products. Action-specific—potentially relevant and appropriate to certain activities during implementation of the Removal Action	BMPs for emission standards for fugitive emissions of air contaminants are provided in the Construction Specifications.
State Essential Indigenous Salmonid Habitat	ORS 196.810(b) OAR 141-102	Designates Essential Salmonid Habitat and regulates activities affecting such habitat. Location-specific—potentially relevant and appropriate in assessing impacts to salmonid habitat and developing	The Biological Assessment details potential impacts of the Removal Action on ESA-listed salmonid species and construction BMPs and conservation measures that will be implemented to minimize potential impacts. The Draft Mitigation Plan details mitigation actions that will be

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Regulation	Citation	Criterion/Standard and Applicability	Compliance Reference
		compensatory mitigation for the project.	implemented to off-set loss of aquatic habitat from the Removal Action construction activities.
Lower Willamette River Management Plan	ORS 273.045 OAR 141-080-0105	Department of State Lands plan regulating leasing, license, and permit activities in the lower Willamette River. The plan describes allowable activities and conditions for waterway management areas based on state public trust values (fisheries, recreation, and navigation). Location-specific—potentially relevant and appropriate to performance of the Removal Action performed on DSL land, including mitigation sites.	The Port is in the process of purchasing the land from DSL where capping and CDF activities will occur as part of the Removal Action. Once this transaction occurs, no capping or CDF activities will be performed on DSL land.
ODFW Fish Management Plans for the Willamette River.	OAR 635 div 500	Provides basis for in-water work windows in the Willamette River. Action-specific—potentially applicable to implementation of the Removal Action due to presence of protected species at the site.	The Biological Assessment details construction in-water work windows that apply to the in-water components of Removal Action construction.