DESIGN ANALYSIS REPORT
(CONCEPTUAL 30 PERCENT DESIGN DELIVERABLE)

TERMINAL 4 EARLY ACTION
PORT OF PORTLAND, PORTLAND, OREGON

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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

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

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List of Figures

List of Appendices

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 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 1.3 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). The AOC requires the Port to complete a conceptual remedial design of the selected Removal Action. Figure 2 shows the components of the Removal Action.

The Statement of Work (SOW) and the EE/CA specify the following be completed as part of the conceptual (30 percent) design:

- Describe dredging areas and determine conceptual cut thicknesses and slope angles (see Section 3)

- Determine and describe general disposal location, handling methods, and transport approaches (see Section 4)
- Describe capping areas and determine conceptual slope and cap designs (see Section 5)
- Prepare an annotated outline of the Conceptual (30 percent) Design Analysis Report (DAR) (this document)
- Prepare an annotated outline of the Confined Disposal Sediment Management Plan (see Appendix B)
- Prepare an annotated outline of plan drawings (see Appendix F)
- Prepare an annotated outline of the design Construction Specifications (see Appendix G)
- Prepare an annotated outline of the Sediment Acceptance Criteria Technical Memorandum (a separate document)
- Prepare Draft Biological Assessment (a separate document)
- Prepare Conceptual Mitigation Plan Proposal (a separate document)

Furthermore, the Action Memorandum outlined a number of USEPA directed modifications to the selected Removal Action as a result of public comment. These areas of modification included:

- Determine CDF Sediment Disposal/Acceptance Criteria. Section 4.9.1 of this document, as well as the separate annotated outline of the Sediment Acceptance Criteria Memorandum, address this directed modification.
- Consider Additional CDF Geotechnical Parameters. Section 4.1 of this document addresses this directed modification.
- Determine MNR Contingency. The Operations Maintenance and Monitoring Plan (OMMP) will address the monitoring program for MNR areas as well as any contingency measures.
- Determine Appropriate Mitigation. The Conceptual Draft Mitigation Plan Proposal, a separate document, addresses this directed modification.

The design process for the Terminal 4 Removal Action is an iterative process between the Port and USEPA. The Port will receive comments on this Conceptual Design from USEPA, address these comments, and produce the Prefinal (60 percent) Design. Because of this iterative process, all of the sections presented in this report will be further developed and refined with the Prefinal (60 percent) Design version. USEPA will review this document and provide comments to the Port. The Final (100 percent) Design will address the comments from USEPA.

The Port is currently beginning the selection process for a construction manager/general contractor (CM/GC) to assist the design team with constructability and implementation of the Removal Action. The CM/GC will likely be selected early during the Prefinal (60 percent) Design.

1.2 Site Description

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 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.

1.3 General Description of Removal Action

The Removal Action objectives (RAOs) established for the RAA are to:

1. Reduce ecological and human health risks associated with sediment contamination within the Removal Action Area 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 Removal Action Area—removal or capping of sediments as well as evaluation of potential ongoing sources.

The Removal Action includes a dredge emphasis with sediment placement in a CDF. The highest risk sediment (characterized by prevalent exceedances of probable effects concentrations [PEC], per MacDonald et al. 2000) was selected for dredging and incorporation into the CDF, and the lowest risk sediment was selected for Monitored Natural Recovery (MNR). Capping will be used in areas with moderate levels of contaminants of concern where immobilization could limit risk to receptors or where it was deemed impractical to dredge.

An at-grade CDF will be constructed in Slip 1 that will have a footprint of approximately 15.3 acres and will contain contaminated sediments dredged from the RAA at Terminal 4 and from other areas owned by the Port or connected with harbor-wide cleanup actions. Dredging, capping, and MNR efforts will be implemented in the RAA consistent with the Action Memorandum (see Figure 2).

Details of the Removal Action by subarea are presented below and illustrated on Figure 2.

1.3.1 Slip 1 – Full At-Grade Confined Disposal Facility

An at-grade CDF will be constructed in Slip 1 and sediment dredged in Slip 3 will be placed in the Slip 1 CDF. Sediments to be placed in the CDF from the RAA include Slip 3 sediments and soft sediments overexcavated 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 annotated outline of the conceptual *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. An earthen 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 4 provides more details on the conceptual design of the CDF.

1.3.2 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.

1.3.3 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.

1.3.4 North of Berth 414 – Monitored Natural Recovery

Similar to Wheeler Bay, low surface contaminant concentrations were found in the subarea north of Berth 414 subarea. Therefore, MNR will be used north of Berth 414. However, high polynuclear aromatic compound (PAH) concentrations were reported in two historical samples from a part of this area; the Port is currently analyzing additional data collected in July 2006 to determine if elevated PAHs are present and to what extent.

The information will be used to determine whether any additional actions may be warranted in this subarea.

1.3.5 Berth 401 – Monitored Natural Recovery and Capping

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

1.4 Organization of this Document

The remainder of this document is organized as follows:

- Section 2 summarizes the existing conditions
- Section 3 provides the conceptual dredge plan in Slip 3
- Section 4 provides the conceptual CDF design
- Section 5 provides the conceptual cap design
- Section 6 discusses predicted water quality with the different removal action elements
- Section 7 provides the basis for the habitat mitigation design (this will be completed as part of the Prefinal [60 percent] Design)
- Section 8 discusses the substantive requirements of permits
- Section 9 provides the engineering cost estimate (this will be completed as part of the Prefinal [60 percent] Design)
- Section 10 provides the project construction schedule and sequencing
- Section 11 provides a discussion of access and easement requirements
- Section 12 provides the institutional controls required for the project
- Section 13 provides the references used in the document

The appendices provide the following information:

- Appendix A provides a conceptual geotechnical design of the containment berm
- Appendix B provides the annotated outline of the Confined Disposal Sediment Management Plan

- Appendix C provides a placeholder for the Construction Quality Assurance Plan (CQAP) to be completed as part of the Prefinal (60 percent) Design
- Appendix D provides a placeholder for the Water Quality Monitoring Plan to be completed as part of the Prefinal (60 percent) Design
- Appendix E provides a placeholder for the OMMP to be completed as part of the Final 100 percent Design
- Appendix F provides the drawings
- Appendix G provides the outline of the Construction Specifications
- Appendix H provides a placeholder for the engineering cost estimate to be completed as part of the Prefinal (60 percent) Design

2 EXISTING CONDITIONS

Existing conditions within the RAA will be 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), supplemented with additional pre-construction data that is currently being analyzed (see Section 2.4.2 below). Section 4 of the Terminal 4 Characterization Report (BBL 2004a) summarizes the results of tests and analyses conducted in the field and by the subcontracted laboratories, including:

- Chemical analysis of 32 surface sediment, 14 underpier sediment, 167 subsurface sediment, and eight sediment trap samples
- Forty-two grain size analyses on discrete samples and three on composite samples
- Geotechnical borings, standard penetration tests (SPTs), and cone penetrometer tests (CPTs)
- Twenty-five Atterberg limits tests
- Three consolidation tests
- Triaxial compression tests on two samples
- Shear strength tests on four discrete samples and three composite samples
- Specialty testing of composite sediment samples to be used in determining dredged sediment quality and the suitability of dredged sediment for on-site placement or off-site disposal during evaluation of the Removal Action alternatives

This information will be used throughout the remainder of this section to describe the existing conditions in the RAA.

2.1 Physical Conditions

This section will summarize the following physical conditions at Terminal 4:

- Bathymetry and topography
- Existing structures, including piers, piling, bulkheads, etc.
- Typical vessels that call at Terminal 4
- River currents
- Wind/wave characteristics

Figure 3 summarizes the physical conditions of the RAA. Additional figures and tables will be prepared as part of the Prefinal (60 percent) Design that will summarize vessel, river, and wind characteristics of the RAA.

2.2 Hydrogeologic and Geotechnical Conditions

This section will summarize the following hydrogeologic and geotechnical conditions:

- Existing subsurface geotechnical conditions in Slip 1. This summary will provide the basis for the CDF containment berm stability and long-term CDF settlement analyses as described in Section 4.1 and 4.3.
- Existing geotechnical conditions at Berth 405 pier relocation. This summary will provide the basis for the foundation support analysis of the new pier as described in Section 4.9.
- Existing geotechnical conditions of sediment to be dredged in Slip 3. This summary will provide the basis for the dredgeability assessment, settling characteristics, and self weight consolidation of the Slip 3 sediments as described in Sections 3 and 4.
- Existing geotechnical conditions of sediments to be capped at Terminal 4. This summary will provide the basis for the cap placement and stability analysis as described in Section 5.
- Existing hydrogeologic conditions in Slip 1 and the vicinity as it relates to the CDF. This summary will provide the basis for the contaminant transport analysis of the CDF as described in Section 6.7.
- Existing hydrogeologic conditions at the different capping areas. This summary will provide the basis for the contaminant transport analysis of the different caps as described in Section 5.3.

In addition to the text described above, a number of figures will be created as part of the Prefinal (60 percent) Design to show the subsurface geotechnical and hydrogeologic conditions of the RAA.

2.3 Hydrodynamic Characteristics

This section will summarize the hydrodynamic characteristics of Terminal 4. Pertinent characteristics will include currents, directions, and tidal influences. These parameters will be used for designing the armor layer on RAA caps and assessing water quality impacts from the different Removal Action measures as discussed below in Section 6.

2.4 Sediment Quality

Sediment quality information, including sediment chemistry data in the EE/CA database supplemented with additional pre-construction data (currently being analyzed), will be used to guide the design of the Removal Action. 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 will be used in the design of the Removal Action and a description of the pre-construction sampling data, which is currently being evaluated and will be incorporated into the existing database, is provided in the following sections.

2.4.1 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 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 EE/CA.

The primary source of sediment chemistry data that will be 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 will also be 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 below along with their maximum PEC enrichment ratios (i.e., maximum concentration divided by PEC value):

Constituent	Max PEC Enrichment Ratio
Key Polynuclear Aromatic Hydrocarbons (PAHs)	
Benzo(a)anthracene	77
Pyrene	72
Benzo(a)pyrene	65
Phenanthrene	63
Chrysene	61
Fluoranthene	58
Lead	9.1
Zinc	2.9
DDD	2.9
DDE	1.4
PCBs	1.5

These identified COCs will be used to guide the design of the Removal Action.

2.4.2 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 2006), the objectives of the pre-construction sampling event, included:

- Specialty testing of composite sediment samples (column settling tests [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 up to 80 surface and 72 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

Collected samples are currently being analyzed and results will be presented in a Technical Memorandum submitted after receipt of the final laboratory data. Results will be incorporated into the existing sediment quality dataset for use in the design of the Removal Action.

In addition to the pre-construction data, recent post-dredge sampling results collected by the Port following maintenance dredging activities at Berth 410 will also be incorporated into the dataset used for the design of the Removal Action.

2.5 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.
- **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 temporarily 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.

2.6 Source Control

This section will describe 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 sediment**s. 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.
- **Stormwater Outfalls**. Rerouting of storm lines to the Willamette River and installation of stormwater treatment systems will be accomplished as part of the CDF construction. In addition, other storm drain improvements are being implemented in conjunction with a railroad realignment project on the south side of Slip 1.

The effect of upstream sources will be discussed as part of the Prefinal (60 percent) Design. Potential upstream sources include:

- 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.)

2.7 Sediment Quality Objectives

Sediment quality objectives are necessary to guide the delineation and design of dredging, capping, and MNR areas at Terminal 4. Although sediment quality objectives 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 Record of Decision (ROD). Therefore, some conservative assumptions are necessary at this early stage of design 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.

As mentioned previously, sediment quality criteria are in the process of being developed for the Portland Harbor Superfund Site. Although draft criteria have been proposed (Windward et al. 2006), they are currently in agency review and it is not known when these criteria may be approved and finalized. As a result, these draft criteria will be considered in the design of the Removal Action, but will not be used strictly or exclusively as Removal Action levels.

PEC values will be used as a primary consideration in delineating and designing the Removal Action. The Terminal 4 data collected during the EE/CA characterization effort will be compared to the sediment quality guidelines presented in MacDonald et al. 2000, specifically PEC values, to delineate and design the Removal Action. The USEPA Action Memorandum (USEPA 2006a) defines the sediment selected for dredging at Slip 3 and placement in the adjacent Slip 1 CDF as "that sediment with prevalent PEC exceedances." Hence, the MacDonald et al. PEC values have been recognized as appropriate for use in guiding Removal Action decisions on this project. It is also important to note that PEC values for key chemicals of concern at Slip 3 (PAHs, lead, zinc, and DDTs) are at or below the draft sediment quality values recently developed using Portland Harbor bioassay data (Windward et al. 2006). Therefore, it is likely that designing a Removal Action to meet PEC values will also comply with the Portland Harbor sediment quality values when they are eventually finalized.

Although PEC values will be a primary consideration in delineating and designing the Terminal 4 RAA, other modifying criteria will also be considered, including the following:

- **Depth to Native Contact**. Native material is generally represented by clean sand (low percent fines) whereas overlying contaminated material is often darker (higher organic content) and has a higher silt content. In Slip 3, the contact between native sediments and overlying contaminated sediments is often very sharp, and dredging down to the native contact can be accomplished in many areas with only minimal additional overdepth compared to dredging down to below PEC values.

- **Deepest Historical Dredge Depths**. The deepest historical dredge depths in Slip 3 will be compiled, mapped, and compared to the depth of contamination 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).
- **Engineering Design Considerations**. The dredge design process must translate a contour surface of the depth of contamination or depth to native contact into a rectilinear and constructable dredge plan. Similarly, the lateral extent of the capping areas must translate into a rectilinear and constructable cap plan. The designs must also consider stable slope requirements, waterfront structures, waves and currents, utilities, obstructions, navigation requirements, and other constraints.
- **Dredging and Capping Constructability**. The means and methods by which contractors complete dredging and capping operations will also influence the extent (more specifically, the elevations, slopes, and overdepth requirements) of the Removal Action.

3 DREDGE PLAN

As part of the Removal Action, dredging is required in a majority of Slip 3 (see Figure 2). This section presents the approach used to design a dredge plan, specifics about each component of the design process including development of the dredge design surface and neatline dredge prism, as a discussion of volume estimates, a discussion of equipment selection, and an assessment of dredging residuals.

This conceptual design will be refined in subsequent design documents following receipt of additional sediment quality characterization data obtained during the pre-construction sampling event in July 2006.

3.1 Design Approach

The process to develop the dredge plan includes several key steps, as illustrated on Figure 4:

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 (IDW) interpolation technique.
2. Identify the depth to native alluvium in all sediment cores. Develop an elevation contour surface on the native contact using IDW 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 constructable 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. Develop a Construction Quality Assurance Plan to minimize the potential for short-term water quality effects during construction and to verify the target contaminated sediments have been effectively removed.

3.2 Dredge Design Surface

3.2.1 Depth of Contamination (DOC) Surface

The depth and elevation of contamination in Slip 3 sediments will be determined based on a core-by-core analysis of PEC exceedances (Section 2.4). The USEPA Action Memorandum (USEPA 2006a) defines the sediment selected for dredging at Slip 3 as "that sediment with prevalent PEC exceedances." The DOC will be determined for each core location using compaction-corrected sampling intervals and chemical analytical results. A statistical interpolation model will then be used to create an elevation contour surface of the DOC. The interpolation model will be an IDW algorithm (power of 2) with a quadrant search structure. The dataset is not large enough to allow more complex geostatistical treatments 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 depositon, 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 will be subtracted from the current bathymetric surface to estimate a contaminated sediment thickness and volume. The current estimate of the DOC elevation surface is shown on Figure 5. This figure will be revised for the Prefinal (60 percent) Design based on the results of the pre-construction sampling that occurred in July 2006.

3.2.2 Depth to Native Surface

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

The elevation of the native surface will be interpolated using the IDW technique and the same or similar interpolation parameters that were used to develop the DOC elevation map. The current estimate of the elevation of the native surface is shown on Figure 6. As with Figure 5, this figure will be revised for the Prefinal (60 percent) Design based on the results of the pre-construction sampling that occurred in July 2006.

In areas where the elevation of the native alluvium is close to (i.e., slightly deeper than) the elevation of the contaminated sediments (based on PEC exceedances), the dredge prism will be adjusted downward to the native contact. The side graphic on Figure 4 illustrates the concept of taking the dredge surface deeper down to the native contact. Terminating the dredge cut in native sediments will minimize the potential for dredging residuals and also minimize the need for contingency response actions (e.g., thin capping or second-pass dredging) to address dredging residuals (see Section 3.6).

3.3 Neatline Dredge Prism

Once the dredge design surface is completed based on the DOC surface and adjusted as appropriate to reach native alluvium, the neatline dredge prism will be prepared. The dredge design surface will be sectioned into sediment management units with either a constant dredging elevation or a constant slope based on engineering constraints. The dredge prism within each sediment management unit will be set at or below the deepest point of contamination within a given area. Therefore, the neatline dredge prism must include removal of variable amounts of uncontaminated sediment (i.e., sediment that does not exceed the PEC) to ensure complete removal of the target contaminated sediment.

During the development of the neatline dredge prism, other engineering constraints will now be incorporated in the design, for example, slope stability requirements to avoid oversteepening and failure of cut surfaces or impacts to waterfront structures (see Section 3.4 below), underwater debris, utilities, navigation requirements, and other considerations.

Finally, an allowable overdepth thickness will be added to the neatline dredge prism based on dredging equipment tolerances and other constructability considerations. Based on past experience with environmental dredging projects, the expansion of the dredge prism volume over and above the target contaminated sediment volume, as a result of the design and construction factors described above, may be as high as 30 percent or more.

3.4 Volumes

Once the dredge plan is developed, and the contaminated sediment surface has been divided into sediment management units, the neatline dredge prism volume will be calculated. Because of dredging accuracies, the actual volume dredged will be somewhat higher than this neatline volume. This allowable overdredge volume will be computed by taking the spatial footprint of the dredge prism and multiplying that area by a 6- to 12-inch allowable overdepth. The neatline dredge prism volume plus the allowable overdredge volume will equal the total estimated dredging volume.

Estimated Neatline Dredge Prism Volume	XX,000 cy
Allowable Overdredge Volume	XX,000 cy
Total Estimated Dredge Volume	XXX,000 cy

These volumes will be estimated during the Prefinal (60 percent) Design after the design surfaces have been updated with the pre-construction sediment sampling results.

3.5 Equipment Selection

The selection of appropriate dredging equipment will ultimately be based on multiple criteria, and will seek 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 to consider when selecting appropriate equipment include:

- Availability and types of equipment
- 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

- Maximizing environmental effectiveness
- CDF capacity and management of hydraulically dredged sediment and water
- Accessibility of equipment

These elements will be presented and discussed in the Prefinal (60 percent) Design with a recommendation for equipment selection. It is currently anticipated that hydraulic dredging will be the primary dredging technique with mechanical dredging specified in certain appropriate areas.

3.6 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. Although the dredge plan will be designed to minimize the potential for residuals, the presence of some amount of residual contamination is expected 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 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:

1. Dredging down to native alluvium where practicable to reduce the potential for residual generation.
2. Specifying appropriate construction best management practices (BMPs) to minimize the loss of sediments and contaminants during dredging operations. BMPs will be outlined in the Construction Specifications in the Prefinal (60 percent) Design.
3. Employing a post-dredge verification sampling program to characterize and, if necessary, adaptively manage any significant residual contamination after the completion of dredging. Management may include MNR, thin covers, thick capping, and/or additional dredging passes. The adaptive management plan will consider a number of factors including elevation of the dredge surface (i.e., limitations on

navigation), chemical concentrations in the residual layer (i.e., suitability for MNR, thin covers, etc.) and the location and extent of any residual deposits within Slip 3. The post-dredge verification sampling program will be outlined in the CQAP as part of the Prefinal (60 Percent) Design.

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

- 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; typically, this is accomplished by sequencing the dredging activities from more contaminated to less contaminated areas.

4 CONFINED DISPOSAL FACILITY DESIGN

4.1 Design Approach

As part of the Removal Action, a CDF will be constructed in Slip 1. Figure 7 shows the conceptual layout of the CDF. The CDF will consist of three main components:

1. **CDF containment berm**. The containment berm will be constructed near the mouth of Slip 1 (see Figure 7). Figure 8 shows a cross section through the berm.
2. **Dredged fill**. The dredged fill will consist of contaminated dredged sediments placed in the saturated zone and fill material placed above. Contaminated dredged sediments will include material from Slip 3 and other sites within the Portland Harbor Superfund Site. Figure 8 shows the conceptual thickness of the different dredged sediments.
3. **CDF 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 8 shows the conceptual thickness of the surface layer.

A number of other activities will be required in order to construct the CDF. Existing structures within Slip 1 will need to be demolished and properly disposed and replacement berths located elsewhere. Outfalls currently discharging into Slip 1 will need to be rerouted to the Willamette River.

The USACE's Confined Disposal of Dredged Material manual (USACE 1987) will be used as guidance for a majority of the design. Design 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, will also be used for design guidance.

The remainder of this section describes the design process for the different elements required for construction of the CDF, including:

- Containment berm stability under static and seismic loading conditions
- Containment berm stability against erosion from river currents, waves, or propeller wash
- Consolidation and settlement of the dredged material placed within the CDF

- CDF surface layer thickness and gradation determinations
- Weir and outfall size and location necessary to handle elutriate leaving the CDF during filling
- Assessment of potential impacts from the CDF on the Willamette River flood stage
- Demolition of Slip 1 structures
- Relocating or stormwater outfalls from Slip 1 to the Willamette River
- Construction of new waterfront structures to replace those demolished in Slip 1

The section concludes with a description of the volumes associated with each unit, how the CDF will be managed during the filling operation, and anticipated equipment to be used for the CDF construction.

4.2 Containment Berm Stability

Appendix A presents a detailed summary of the conceptual level CDF containment berm geotechnical design. Figure 8 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 bench between elevations -3.2 to 2.8 feet NGVD and will be sloped at 5H:1V. The crest of the structure will be constructed to elevation 33.24 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 dikes consisting of quarry spalls or riprap will be placed at both ends of each 3-foot-lift during construction.

For the purpose of the design process, it is assumed that in the future the channel outside of the berm will be dredged to a maximum elevation of -46 feet NGVD.

Behind the berm, contaminated dredged sediments will be placed to elevation 12 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 8).

4.2.1 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.

Preliminary 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 static (Section 4.2.2)
- Long-term (post-filling) static (Section 4.2.3)
- Long-term (post-filling) seismic (Section 4.2.4)
- Long-term post earthquake static (section (4.2.4.2)

For each case, the slope stability factor based on a random search of 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.

4.2.2 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 1.43. The factor of safety for slope stability for a deep slope movement that would intersect the dredged sediments was 1.88. These values indicate that the berm would be stable during hydraulic filling. Note that the condition modeled is not anticipated to occur during the filling operation.

4.2.3 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 1.61. The factor of safety for deep slope movements was 2.25. These values indicate that the berm will be stable under normal operating conditions.

4.2.4 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 substantial deformation, 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:

1. 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
2. Development of input ground motions from seismic sources considering site-specific geotechnical considerations
3. 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
4. Evaluation of slope stability and deformation for both pseudo-static and post-earthquake conditions
5. 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, we have defined the two primary seismic sources considered for design purposes 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).

4.2.4.1 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 0.91. The factor of safety for deep shear surfaces that intersect the dredged sediments was 1.17. 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 dredged material.

4.2.4.2 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 on 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 less than 1. The factor of safety for the deep shear surfaces that potentially intersect the dredged sediments was 1.64. This indicates the potential exists for displacement of the berm toe after a design level earthquake. However, the remaining berm possesses sufficient residual strength to contain the contaminated dredged sediments behind the containment berm.

A more detailed seismic deformation study will be completed as part of the Prefinal (60 percent) Design. As has been done with the design of other Region 10 CDF containment berms, a Newmark analysis will be used to model permanent slope deformation after a seismic event.

4.2.5 Discussion 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. To improve the berm stability, the foundation of the berm will be overexcavated and backfilled with structural fill. For the majority of the berm structure, 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 10 feet will be removed below the outer toe of the berm. 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 permanent deformations along shallow surfaces under 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.

4.3 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 including river currents, waves, and propeller wash. The conceptual design of the berm face includes quarry spalls or riprap for erosion protection (see Figure 8). The analyses applied to the cap design for erosion resistance in Section 5.3.2 will be applied to the armoring along the face of the containment berm as part of the Prefinal (60 percent) Design.

It was determined as part of the EE/CA, that while some sections of the channel may experience velocities faster and slower than the average during a flood event, velocities above the average are typically located in the deeper parts of the mid-channel sections, and not along the banks affecting the CDF. Velocities induced by propeller wash are anticipated to be more significant than velocities the berm would experience during a flood.

4.4 Consolidation and Settlement

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 sediments consolidate due to the additional weight. Predicting the duration and amount of the settlement is needed to properly design the CDF surface layer.

The CDF will settle due to two factors: (1) the self-weight consolidation of the dredged sediment placed within the CDF; and (2) the consolidation of the sediments below the CDF. Geotechnical information on dredged sediment and subsurface soil samples will be used with computer models to estimate the total amount and duration of the settlement. Procedures outlined in USACE's Confined Disposal of Dredged Material (1987) will be used along with constitutive models that use laboratory-derived relations between void ratio and applied stress to predict the amount and duration of sediment settlement (Stark 1996; Znidarcic et al 1992). The rate of filling will impact the duration of settlement. As part of the Prefinal (60 percent) Design, the consolidation and settlement of the CDF will be determined (data collected in July 2006 will be used for this analysis).

4.5 CDF Surface Layer

The last stage of the CDF construction is the placement of the CDF surface layer (see Figure 8). The CDF surface layer is constructed of imported granular materials that provide a structural layer above the underlying materials. This layer will provide a foundation for future surface activities at Terminal 4. Surface drainage structures will also likely be constructed within this layer.

The CDF surface layer design will consider both the potential long-term site uses as well as requirements for surface water management based on the contaminant transport modeling. Design procedures for this layer will depend on the anticipated surface uses. For instance, if pavement for parking is anticipated, standard pavement design procedures will be followed. As part of the Prefinal (60 percent) Design, this section will present both the analysis and the final design of the surface layer.

The new surface layer will require a stormwater collection system. As part of the Prefinal (60 percent) Design, this section will present the analysis and design for the stormwater system.

4.6 CDF Filling Procedure and Weir and Outfall Design

Following construction of the containment berm, the CDF will be filled with dredged sediments. It is currently anticipated that the filling of the CDF will occur with hydraulic dredging equipment. For Slip 3 dredging, the sediment will be pumped hydraulically from Slip 3 to a diffuser barge located within the CDF. The diffuser barge will reduce the energy of the dredge slurry allowing the dredged sediment to settle out. The diffuser barge will likely be moved in different locations during filling depending on the material being placed.

The location of the dredge pipeline between the dredge and the CDF will either be in the water or over the upland. Figure 7 shows a possible location of the upland alignment of the dredge line. Contaminated dredged sediment brought from other Portland Harbor Superfund Site locations will either be brought to the CDF via a pipeline or haul barge. If the material is brought by haul barge, the sediments would likely be offloaded with a high solids pump into the CDF.

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 out an outfall into the river. During dredging, the water within the CDF will contain some suspended sediments. The total suspended solids (TSS) concentration in the water that goes over the weir needs to be controlled so that water quality standards are met (see Section 6). The TSS concentration at the weir is influenced by several factors, including filling or dredge production rate, solids concentration of influent, size of CDF and ponding depth, dredging volume, and sediment settling characteristics. Due to the size of the CDF and that this Early Action will consume only a portion of the total capacity of the CDF, it is likely that during the dredging of the Slip 3 sediments, no water will need to be discharged through the weir.

Figure 7 shows the conceptual location of the drop-inlet spillway structure and drain. The USACE's Confined Disposal of Dredged Material (1987) will be used to size the CDF and design the weir structure. As part of the Prefinal (60 percent) Design, the size, location, and operational configurations of the weir and outfall structures will be further developed.

4.7 Assessment of Potential 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), will be confirmed with the existing CDF configuration as part of the Prefinal (60 percent) Design using the same models and process.

4.8 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 conceptual plan anticipates that the structures will be removed with a combination of water-based and land-based construction equipment. Because of this, the demolition work will need 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 fully removed. The grain offloading structure located at Berth 405 is currently planned to be relocated to Terminal 2.

Figure 9 shows the extent of demolition in Slip 1 required for the CDF construction.

4.9 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 the property of the City of Portland. When Slip 1 is filled, these discharge points will be buried; therefore, these pipes must be relocated to provide a suitable point of discharge into the Willamette River. Two separate and parallel trunk lines will be required—one for the combined flows from the Port storm drains and a second for the rerouted flow from the City storm drain. The two trunk lines will outfall to the river in the same general area at the end of the peninsula between Slip 1 and Wheeler Bay.

Preliminary computations indicate that a 36-inch-diameter main is required for both 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 minimum slope of 0.35 percent is used in the preliminary design. Preliminary 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 would 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.

Since new construction at Berth 401 is planned, layout of the stormwater reroute system would begin by intercepting Outfall STSOUT255, flowing south along the eastern side of Slip 1. Here, all the outfalls along this side could be intercepted and flow directed along the southern side of Slip 1, eventually discharging into the Willamette River. Further design will occur to ensure that the Berth 401 construction is considered.

Stormwater improvements will also be incorporated into the design. Figure 10 shows the proposed location of the new stormwater lines.

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

The new Berth 405 replacement 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 will be 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.

The dock platform will be a reinforced 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. The piles will be driven to the depth of the Troutdale Formation, which is a large gravel layer beneath the river deposited sand that makes up the majority of site soil. Steel pipe piles were chosen for their ease of installation in this soil layer.

The platform will be connected to the shore by a one-lane vehicle access steel trestle structure capable of supporting an American Association of State Highway and Transportation Officials (AASHTO) rated H25 truck. In addition, a number of 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 reinforced concrete pile bents, and installation of steel walkway and an access trestle. It is anticipated that precast concrete deck panels will be placed by a crane-loaded barge, as will prefabricated steel or aluminum access catwalks and the vehicle access steel trestle.

The IRM berthing facility is to be temporarily 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.

Figure 11 presents the conceptual plan of the new Berth 405 relocation structure.

4.11 Volumes

The CDF will contain over 700,000 cubic yards (cy) of contaminated sediment, 275,000 cy of fill, and 275,000 cy of surface layer material.

4.12 Management of CDF during Filling

After the Slip 3 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.

4.12.1 Acceptance Criteria for Non-Terminal 4 Material

This section will summarize the Sediment Acceptance Criteria Memorandum as it relates to acceptable characteristics for contaminated sediments placed below the water table, as well as criteria for imported fill material for placement above the water table.

4.12.2 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 annotated outline of the Confined Disposal Sediment Management Plan.

This section will summarize Appendix B, describing the management of the Terminal 4 CDF activities from the point in time *after* the Slip 3 sediments are dredged and placed in the CDF though construction of the surface layer. The plan will:

- Describe the CDF design elements
- Describe Port and USEPA administration of CDF management
- Describe management of future filling events and between future filling events
- Describe management of the fill placement necessary to raise the site to the level of the CDF surficial layer

Long term management activities will be addressed in the OMMP that will be included as part of the Final (100 percent) Design.

4.13 Equipment Selection

The selection of appropriate dredging equipment will also be linked to the appropriate method for placement of dredged sediments into the CDF. The selection of equipment will ultimately be based on multiple criteria and will seek 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 to consider when selecting appropriate equipment include:

- Availability and types of equipment
- Production rate capability
- How the post-Slip 3 sediments are brought to the CDF (hydraulic versus mechanical)
- CDF properties (i.e., water depths, surface area, etc.)
- Geotechnical properties of sediment targeted for removal and underlying materials
- Presence of significant debris
- Minimization of short-term water quality impacts
- Accessibility of equipment

These elements will be presented and discussed in the Prefinal (60 percent) Design with a recommendation for equipment selection. It is currently anticipated that hydraulic dredging will be the primary dredging technique, with mechanical dredging specified in certain appropriate areas.

5 CAPPING PLAN

5.1 Design Approach

The cap design will follow appropriate USEPA and USACE guidance, including *ARCS Program Guidance for In-Situ Subaqueous Capping of Contaminated Sediments* (Palermo et al. 1998). Based on this approach, the thicknesses of the in situ caps for the Removal Action are based on the following five components (from Palermo et al. 1998):

- Chemical isolation of contaminants (T_i)
- Bioturbation (T_b)
- Consolidation (T_c)
- Erosion (T_e)
- Operational considerations (i.e., placement inaccuracies and other pertinent processes) (T_o)

An appropriate thickness of cap will be determined individually for each component based on site-specific design parameters as summarized below. The individual component thicknesses contribute 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 will be a concurrent thickness, rather than independent thickness requirements. That is, a set thickness of an armor layer can serve to resist erosion as well as accommodate bioturbation.

There are five different cap areas requiring cap design:

- Berth 401
- Wheeler Bay
    - Shoreline cap
    - Aquatic cap
- Berth 411 Underpier
- Head of Slip 3
    - Cap behind the sheet pile bulkhead

  - Cap in front of the timber bulkhead
- Pier 5 area

Figure 12 shows the five cap areas. The boundaries of the five cap areas are conceptual and will be refined based on the July 2006 pre-construction sampling data and additional data to be collected as part of the Prefinal (60 percent) 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 biota and the environment. Section 5.3.1 presents the chemical isolation component for the five different 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 5.3.2 presents the erosion component for the five different areas.

As part of the Prefinal (60 percent) Design, cap designs will be prepared for the five different capping areas based on the analyses presented below. The designs will include gradations and thickness of each layer. Figures 13 and 14 show the conceptual level cap design sections for each area.

5.2 Source Material

Sources for capping material will most likely be upland site quarries. Physical and chemical specifications will be developed for the different cap material types. Sources will be identified, if possible, as part of the Prefinal (60 percent) Design.

5.3 In-Situ Cap Design

5.3.1 Chemical Isolation Component

A series of calculations will be performed using location-specific conditions (contaminant concentrations, vertical groundwater velocity, sediment total organic carbon [TOC], etc.) to evaluate the chemical isolation component of a subaqueous cap for containment. Chemical isolation modeling will include the use of 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) will be used to estimate chemical concentrations in the surficial (bioturbation) sediment layers of the cap once steady state conditions are achieved.

5.3.2 Erosion Component

Erosive forces that can potentially act on a cap surface include the following:

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

This section will present an analysis of each of these components. Each erosive component will produce a unique design level bed shear velocity. As part of the Prefinal (60 percent) Design, bed velocities from the four conditions analyzed below will be used to determine the necessary armor layer grain size required to resist the erosion. The armor layer gradation will be developed based on these requirements for the five different capping areas.

5.3.2.1 Wind-Induced Wave Analysis

A nearshore spectral wind wave model will be used to simulate wind-generated waves for various meteorological conditions at the Terminal 4 RAA. Bottom shear stresses resulting from extreme wind-generated waves will be predicted. The maximum predicted shear stresses from the wind waves are anticipated to be significantly less than the maximum predicted shear stresses during the reasonable worst-case hydrodynamic condition, confirming that wind-wave forces are less of a concern for cap design than flood and tidal forces.

5.3.2.2 Vessel-Induced Waves Analysis

Bottom shear stresses resulting from waves induced by vessels will also be predicted. These shear stresses are anticipated to be less of a concern for cap design than river currents.

5.3.2.3 Currents

The hydrodynamic and sediment transport (EFDC) model of the Lower Willamette River used by the Lower Willamette Group will be 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. It has been preliminarily calibrated to demonstrate to the LWG and regulatory agencies (including USEPA and DEQ) that such a model would be adequate for LWG study purposes, once calibration is finalized following additional data collected in 2005 and early 2006.

The river-wide EFDC model, as it currently exists and is calibrated, will have the grid refined to provide increased resolution in the vicinity of the slips. These modifications will be made to the grid used to simulate the 100-year flood in the Lower Willamette River. The model will predict bed shear velocities at the different caps under the design level flood event.

5.3.2.4 Propeller Wash

Predictive equations will be used to estimate the bottom velocity of several design vessels operating within the Terminal 4 facility (Palermo et al. 1998; Verhey 1983; and Blaauw and van de Kaa 1978). These predictive equations will be developed for large (ocean-going) vessels, as well as support vessels such as tug boats, in a maneuvering operation (i.e., mooring or un-mooring where vessel speed is essentially zero) and require adaptation to address moving conditions. The Prefinal (60 percent) Design will include a listing of design vessels, the vessels' physical properties, and their operating conditions. Based on these conditions, bed shear velocities will be predicted.

5.3.3 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).

5.3.4 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.

5.3.5 Slope Stability Component

As part of the Prefinal (60 percent) Design, slope stability analysis will be completed for caps to be constructed on slopes in Wheeler Bay, at Berth 401, Head of Slip 3, and Pier 5. Stability analyses comparable to that described in Section 4 for the containment berm assessment will be completed.

5.3.6 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 vary between 0 to 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.

5.4 Wheeler Bay and Slip 3 Pile Removal

Before capping can occur, wooden piles and an old wooden trestle are also to be removed in Wheeler Bay just upstream from Slip 1 as well as a large pile field on the south side of Slip 3.

Slip 3 of Terminal 4 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 9 shows the structures and piling to be demolished in Wheeler Bay. Figure 15 shows the piling to be demolished at Pier 5.

As part of the Prefinal (60 percent) Design, this section will describe how the piling will be removed.

5.5 Volumes

As part of the Prefinal (60 percent) Design, the volumes of the different cap section components in the five different cap areas will be tabulated. Anticipated overplacement allowances will also be discussed in this section and the associated overplacement volumes will be presented.

5.6 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

These elements will be presented and discussed in the Prefinal (60 percent) Design with a recommendation for equipment selection. It is currently anticipated that the method for placing the open water caps is anticipated to be by mechanical equipment such as a clamshell. The cap placed under the pier at Berth 410 will utilize either a conveyor-type or a hydraulic system.

6 WATER QUALITY

This section will present the water quality standards to be met, results of contaminant mobility testing to date, 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 best management practices (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.

6.1 Water Quality Criteria

Short-term and long-term water quality effects associated with the Terminal 4 Removal Action will be evaluated. Short-term effects include temporary and transient water column effects associated with construction activities, both at the point of construction (i.e., at the site of dredging, capping, or pile pulling) and at the point of discharge (i.e., discharge of return water over the weir at the CDF). Long-term effects include those associated with more continuous movement of groundwater through the CDF berm and into the river. Water quality criteria used to regulate these various activities will be consistent with the conditions of other recent cleanup projects in Region 10, including Commencement Bay and Portland Harbor.

6.1.1 Short-Term Water Quality Effects

Short-term water quality effects include those associated with in-water construction activities (dredging, capping, and pile-pulling) and those associated with overflow discharges from the CDF weir, if overflow occurs during this first phase of placement activity in the CDF. Water quality monitoring associated with these short-term activities will be specified in the Section 401 Water Quality Certification (WQC). It is anticipated that a single WQC will be issued for the Slip 1 CDF and will be used to regulate all filling activities, including placement of Terminal 4 material, external material from other Portland Harbor Superfund Site locations, and imported fill.

Recommendations for appropriate WQC conditions will be presented in this section. These recommendations are consistent with WQCs that have been issued in recent years for sediment dredging and CDF projects in the Pacific Northwest, including the following:

- Blair Slip 1 CDF (Commencement Bay)
- Thea Foss Waterway/St. Paul CDF (Commencement Bay)
- Middle Waterway (Commencement Bay)
- NW Natural Gasco Site (Portland Harbor)

6.1.1.1 Short-Term Water Quality Criteria

Compliance criteria will be based on the State of Oregon water quality standard for turbidity, which will be met at the edge of the construction zone for in-water construction activities and the edge of the mixing zone for CDF return flows (see Sections 6.1.1.2 and 6.1.1.3, respectively).

For toxic constituents, the most recent updates to the National Recommended Water Quality Criteria (USEPA 2006b; http://www.epa.gov/waterscience/criteria/wqcriteria.html) are appropriate for use on this project. The short-term, construction-related discharges described in this section are transient, intermittent, and constantly moving within the construction area; therefore, water quality at the point of construction and point of CDF overflow are appropriately regulated by acute water quality criteria at the edge of the in-water construction zone and CDF effluent mixing zone, respectively (USEPA and USACE 1994).

Based on the results of contaminant mobility testing on Terminal 4 sediments (see Section 6.2 below), turbidity will serve as a reliable surrogate for water quality conditions during dredging, capping, CDF filling, and other activities. By controlling releases of turbidity during construction, releases of sediment-associated contaminants will also be controlled. Should TSS monitoring exceed the applicable standards noted above, then a tiered approach to monitoring that includes chemical analyses compared to acute criteria will be implemented.

Visual observations of turbidity will be conducted during pile pulling/cutting, demolition activities, and new pier construction. If a significant (i.e., length of mixing zone) and persistent (i.e., one hour or more) turbidity plume is evident, monitoring of water quality parameters would be triggered.

6.1.1.2 Construction Zone Configuration

A construction zone of 100 meters, to be authorized around in-water construction activities, is appropriate for the width, depth, and flow of the Willamette River, and is consistent with several recent WQCs issued for contaminated sediment projects in the Pacific Northwest of similar size (see Section 6.1.1). Water quality standards will be met at the edge of the construction zone and waived within the construction zone. The construction zone will extend 100 meters radially from the point of the activity (dredging, capping, etc.). During removal of sediment to place the berm foundation and subsequent construction of the berm, the construction zone will extend 100 meters radially from the point of activity.

6.1.1.3 CDF Mixing Zone Configuration

A mixing zone will be established around the CDF overflow outfall pipe from the weir structure in the CDF. When the berm is closed and Slip 1 is no longer connected to the river, the mixing zone will extend radially from the CDF overflow outfall pipe. The size of the CDF mixing zone will be determined during the Prefinal (60 percent) Design.

6.1.1.4 Pre-Construction Background Survey

Background water quality will be determined with a pre-construction survey of ambient conditions in the RAA over a range of flow, tide, and weather conditions that are representative of the conditions expected to occur during the Removal Action. The background value for turbidity will be calculated as the 90^{th} percentile value of the ambient pre-construction data. A background reference station will also be established and 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 may nevertheless exceed the range of measurements in the pre-construction survey.

6.1.2 Long-Term Water Quality Effects

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 6.1.1, which are regulated under the project WQC, the monitoring of long-term water quality will be described in the Operations, Maintenance, and Monitoring Plan (OMMP) to be submitted as part of the Final (100 percent) Design.

Consistent with the monitoring requirements of other recently built CDFs in the Pacific Northwest, the evaluation of long-term water quality will include a comparison of modeled groundwater concentrations to chronic water quality criteria or ambient water quality (whichever is greater) in the receiving water adjacent to the CDF berm. For most constituents, the chronic criteria published in the most recent updates to the National Recommended Water Quality Criteria (USEPA 2006b; http://www.epa.gov/waterscience/criteria/wqcriteria.html) are appropriate for use on this project. National recommended chronic criteria for PAHs have not yet been formally established. However, chronic water quality criteria for PAHs have been developed in accordance with National Water Quality Criteria guidelines to facilitate derivation of equilibrium partitioning-based sediment benchmarks (USEPA 2003); these PAH criteria will be used in this evaluation.

6.2 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 impacts associated with the different actions.

6.2.1 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 from Slip 3 show that water quality impacts from toxic constituents are unlikely at the point of dredging (Table F-1; BBL 2005). All metals results were well below their respective ambient water quality criteria acute values, with the exception of copper. Although the DRET copper concentration (4.25 μg/L) was slightly above the hardness-adjusted acute criterion (3.6 μg/L, a very stringent criterion considering the low hardness of 25 mg/L in the Willamette River), copper was still below the ambient background concentration in the Willamette River (~5 μg/L dissolved copper; USGS 1995). Only a few PAHs were detected, and the few detected PAHs were two or more orders of magnitude below their acute water quality values according to USEPA 2003. No DDT isomers, PCBs, or petroleum compounds were detected.

6.2.2 Modified Elutriate Test

The modified elutriate test (MET) is used to help predict water quality at the wieir of a CDF. The MET results for the composite dredge prism sample from Slip 3 show that water quality impacts from toxic constituents are unlikely to occur at the point of return flow to the Willamette River during filling of the CDF (Table F-4; BBL 2005). Copper was the only metal in the MET that was detected in the dissolved phase (15.9 μg/L) above its acute criterion, a very stringent criterion considering the low hardness of the Willamette River (see above). However, copper is not a chemical of concern in the sediments at Slip 3, evidenced by the fact that the copper concentration in the composite dredge prism sample (23 mg/kg; Table F-7) 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).

Similar to the DRET, only a few PAHs were detected in the dissolved phase, and the few detected PAHs were two or more orders of magnitude below their acute water quality values according to USEPA 2003. One DDT isomer was detected in the dissolved phase (4,4'-DDE at 0.0024 μg/L) well below its acute water quality criterion (1.1 μg/L; assuming similar toxicity to 4,4'-DDT). No dissolved PCBs were detected. These data indicate COCs, although present in bulk sediment, are not being dissolved in the dredging elutriate water to any significant degree.

Based on the above, little or no dilution of the CDF return flow is needed to alleviate chemical concentrations in the elutriate water during the Terminal 4 Removal Action. Turbidity is a more critical monitoring parameter, as described in Section 6.2.4, and turbidity will serve as a reliable surrogate for water quality conditions associated with the return flow from the CDF.

6.2.3 Pancake Column Leaching Test

The pancake column leaching test (PCLT) is used to help predict long-term water quality leaving the CDF. The PCLT data for the RAA are presented in the EE/CA (Table F-5, BBL 2005). The potential for long-term water quality effects associated with the CDF will be evaluated in consideration of the PCLT data and the subsequent attenuation of constituents that is predicted to occur during groundwater movement through the CDF. The computer model used to estimate the degree of attenuation that occurs during groundwater transport is currently being updated from the EE/CA. An updated analysis of the PCLT data and groundwater attenuation will be provided in the Prefinal (60 percent) Design.

6.2.4 Column Settling Test

The column settling test (CST) is used to help predict the amount of suspended solids at the weir of a CDF. The results of the CST indicate TSS (in mg/L) and turbidity (in NTU) in the CDF elutriate water follow a nearly one-to-one correlation (Table F-3, BBL 2005). After 24 hours of settling, turbidity measurements in the CDF elutriate water are on the order of 2,000 to 4,000 NTU, and TSS concentrations are similarly on the order of 2,000 to 4,000 mg/L. These results are corroborated by the TSS concentration in the MET of 3,300 mg/L after 24 hours of settling. Therefore, turbidity will need to be reduced as discharges from the weir are entrained and mixed with ambient water in the mixing zone to meet ambient background levels in the Willamette River. As a result, turbidity will be the most sensitive monitoring parameter for compliance with water quality standards, and will serve as good sentinel for overall water quality conditions during filling of the Slip 1 CDF during those periods when overflow occurs.

Two additional CSTs are currently being performed on Slip 3 sediments using material collected during the pre-construction sampling event. These data will be presented and incorporated in the evaluation of CDF settling characteristics in the Prefinal (60 percent) Design.

6.3 Water Quality during Dredging Activities

6.3.1 Factors Affecting Water Quality

A number of factors will control the water quality around the dredging operation besides the dredging equipment and methods. These factors include sediment characteristics, hydrodynamic conditions, water depth, and others. Each of these characteristics will be briefly summarized.

6.3.2 Dredging Method

The currently anticipated method of sediment dredging in Slip 3 is hydraulic dredging. More details will be presented on the dredging methods and the potential impacts to water quality during the Prefinal (60 percent) Design.

6.3.3 Water Quality Predictions

The USACE model DREDGE or comparable analytical model that predicts distribution of chemicals around the dredging operation (such as Kuo and Hayes 1991) will be used to simulate and predict water quality at the edge of the mixing zone around the dredging operation. Input parameters to the modeling will include dredging elutriate test (DRET) results, site hydrodynamic characteristics, and anticipated dredging equipment.

Dredging BMPs to control water quality impacts associated with dredging will be presented with the Prefinal (60 percent) Design and incorporated into the Construction Specifications.

6.4 Water Quality during Capping Activities and Berm Construction

6.4.1 Factors Affecting Water Quality

A number of factors will control the water quality around the capping operation besides the capping equipment and methods. These factors include sediment and cap material characteristics, hydrodynamic conditions, water depths, and others. Each of these characteristics will be briefly summarized.

6.4.2 Placement Methods

The capping materials are anticipated to be placed using mechanical equipment such as clamshell bucket. More details will be presented on the placement methods during the Prefinal (60 percent) Design.

6.4.3 Water Quality Predictions

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.) The 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 associated with capping will be presented with the Prefinal (60 percent) Design in the Construction Specifications.

6.5 Water Quality during Dredge 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 isolated locations of mechanical dredging. Non-Terminal 4 sediments would also be dredged either hydraulically or mechanically. If dredged mechanically, they will be transferred by barge to an offloading facility and placed within the CDF.

Visual monitoring for plumes around the transport operations 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 is observed around the operation for a duration to be determined, then sampling will occur to monitor water quality. The Water Quality Monitoring Plan (WQMP) that will be developed as part of the Prefinal (60 percent) Design will detail the tiered water quality program to be followed. BMPs will also be presented in the Construction Specifications to minimize water quality impacts associated with sediment transport.

6.6 Water Quality During Placement in 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 needs to be controlled so that water quality standards are met. The turbidity and TSS concentrations at the weir are influenced by several factors, including filling or dredge production rate, solids concentration of influent, size of CDF and ponding depth, dredging volume, and sediment settling characteristics. It is likely that during the dredging of the Slip 3 sediments, no water will need to be discharged through the weir.

The USACE model SETTLE will be used to simulate and predict water quality of elutriate leaving the CDF (USACE 1987). The model will use the results from the MET and CST and the anticipated dredging equipment to predict effluent quality. Other factors that will be used with the modeling to predict water quality at the mixing zone boundary include hydrodynamic characteristics at the discharge pipe and discharge velocity of the elutriate exiting the pipe.

The configuration of the CDF, as well as the management of filling operations, will be adjusted as required to improve the water quality at the mixing zone boundary. This section will discuss necessary CDF management techniques to meet water quality criteria. The Construction Specifications will detail these CDF management techniques to be followed by the Contractor during construction.

6.7 Long-term Water Quality at the CDF

After the CDF is constructed, groundwater will flow through the dredged sediment and containment berm into the river. The quality of the groundwater moving through the CDF will be predicted and described in this section. The groundwater flow and contaminant transport models (MODFLOW and MT3D) developed in the EE/CA (BBL 2005) will be used to assess long-term water quality at the CDF. The critical flow paths will be identified to focus the contaminant transport evaluation. Bulk attenuation factors will be calculated for use in developing CDF acceptance criteria for candidate dredge sediment from other Portland Harbor sites. Results from site-specific PCLT tests (Section 6.2.3) will be used with the results of the groundwater and contaminant transport modeling to determine whether the geochemical characteristics of the candidate dredge sediment are suitable for placement in the CDF.

6.8 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). Visual monitoring for plumes around the demolition operations will be the first tier of monitoring. If a plume is observed around the operation for a duration to be determined, then sampling will occur to monitor water quality. The WQMP that will be developed as part of the Prefinal (60 percent) Design will detail the tiered water quality program to be followed. BMPs will also be presented in the Construction Specifications to minimize water quality impacts associated with demolition.

6.9 Water Quality During Marine Structures Construction

Piling will be driven and superstructure constructed as part of the Removal Action for the Berth 405 replacement (see Section 4.9). Visual monitoring for plumes around the construction operations will be the first tier of monitoring. If a plume is observed around the operation for a duration to be determined, then sampling will occur to monitor water quality. The WQMP that will be developed as part of the Prefinal (60 percent) Design will detail the tiered water quality program to be followed. BMPs will also be presented in the Construction Specifications to minimize water quality impacts associated with pier construction.

7 HABITAT MITIGATION (PREFINAL 60 PERCENT DESIGN)

8 SUBSTANTIVE REQUIREMENTS OF PERMITS

As part of the Prefinal (60 percent) Design, the substantive requirements of permits required for the implementation of the Removal Action will be presented.

9 ENGINEERING COST ESTIMATE (PREFINAL 60 PERCENT DESIGN)

10 CONSTRUCTION SCHEDULE AND SEQUENCING

The Removal Action can be broken into a number of different construction elements. The sequencing of these different elements will be continuously refined as the design progresses. Factors that will affect the sequencing include:

- Coordination with tenants
- Construction approaches (e.g., water-based versus land-based)
- Production rates
- Availability of materials and equipment
- River stages and currents
- Regulatory construction windows

A brief description of each element is presented below as well as the currently anticipated sequence of construction.

- **Year 1 Activities**
  - **IRM Offloading Pier Construction (Section 4.9)**. The IRM offloading pier, currently at Berth 408 in Slip 1, will be relocated to Berth 401. Piping will be run from the IRM facility, an additional pump will be installed, and minor modifications will be made to the Berth 401 pier.
  - **Overwater Structure and Pile Demolition (Sections 4.7 and 5.4)**. The overwater structures at Berths 405 and 408 will be demolished and recycled and/or disposed of at an acceptable landfill. The Slip 1 structures will need to be demolished before the containment berm is constructed to allow access of water-side equipment. The pile remnants from Pier 5 in Slip 3 and piling and the old fire boat pier in Wheeler Bay will also need to be removed. This work could be completed at any time, as long as it is completed prior to cap construction.
  - **Containment Berm Construction (Section 4.1)**. The containment berm will be constructed across the mouth of Slip 1. Prior to constructing the berm, a small volume of soft sediment will be overexcavated below the berm footprint. The dredged sediment will be placed at the head of Slip 1. After the dredging is completed, the berm will be constructed. Following berm construction, to minimize take of listed fish species, an effort will be employed to remove fish, including listed species, from within Slip 1. Based upon typical juvenile salmonid behavior, efforts

will be focused on shallow water habitat. Fish removal will be more difficult in some areas due to the confined nature of the Slip and existing in-water structures; however, this activity will be conducted in a good-faith effort for the purpose of minimizing impacts on listed fish species.

- **Weir Structure and Outfall Pipe (Section 4.5)**. Concurrent with the containment berm construction and before dredging of Slip 3 sediments, the weir structure and outfall pipe will be installed.
- **Replacement Berth Construction (Section 4.9)**. Berth 405 will be relocated outside of Slip 1 at the face of the containment berm. The majority of the structure and dolphins will be located outside of the containment berm footprint. It is currently anticipated that construction could occur simultaneous with the berm construction.
- **Stormwater and Outfall Structure(s) Relocation (Section 4.8)**. Port outfalls and a City of Portland outfall will be relocated from Slip 1 to the south side of the containment berm.
- **Select Locations of Cap Placement (Section 5)**. Some areas of the RAA may be capped in Year 1. These areas may include the shoreline portions of the Wheeler Bay cap and the Berth 401 cap. Factors that will determine when and where capping will occur in Year 1 include sequencing, proximity to dredge areas, and upland activities.

- **Year 2 Activities**
  - **Slip 3 Dredging (Section 3)**. After the containment berm is constructed, dredging in Slip 3 can commence. It is likely that a debris sweep will be completed to remove debris that may hamper dredging. Dredging will be coordinated with the operations at Berths 410/411 with the objective to minimize any impacts to Port operations.
  - **Cap Placement (Section 5)**. Once the dredging is completed or near completion, the remainder of the cap not placed in Year 1 would be placed.
  - **Dredged Material Offloading Conveyance System Construction (Section 4.11)**. A temporary offloading conveyance system will be constructed to transfer sediments dredged from other Portland Harbor Superfund Site locations into the CDF.
- **Post-Year 2 Activities**

- **Non-Terminal 4 Contaminated Sediment Placement (Section 4.11)**. Sediments dredged from other cleanup areas in the Portland Harbor Superfund Site will be placed within the CDF.
- **CDF Fill Placement (Section 4.11)**. After all of the contaminated sediment is placed in the CDF, a layer of fill will be placed to raise the CDF to grade.
- **CDF Surficial Layer Construction (Section 4.4)**. The surface of the CDF will have a surficial layer sufficient to support the long-term site use activities.
- **Habitat Mitigation Construction (Section 7)**. Off-site habitat constructed as part of mitigation for the Removal Action will be completed. The timing of this element is currently not known and could occur sooner.

As part of the Prefinal (60 percent) Design a detailed construction schedule will be completed for each of these elements.

11 ACCESS AND EASEMENT REQUIREMENTS

As part of the Prefinal (60 percent) Design, the access and easement requirements for the implementation of the Removal Action will be presented.

12 INSTITUTIONAL CONTROLS

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 at the CDF. The primary objective for the institutional controls includes restricting anchor drag through the cap areas or on the berm face.

For cap areas, proposed control mechanisms may include identification of the capped areas as no commercial vessel anchoring zones. These areas would be identified on U.S. Coast Guard navigational maps. Capping areas will be identified on Port maps/plans to ensure that the integrity is not impacted during future potential construction actions.

Proposed institutional controls for the CDF include:

- Notification to current tenants adjacent to the CDF of the CDF construction and any appropriate precautions needed for the CDF's construction.
- Specific lease language for future tenants who would occupy the land above the CDF notifying them of the CDF and any special requirements if they excavate below certain elevations.
- Some form of land use restriction, as necessary, that would limit any compromises to the long-term function of the CDF. Completion of design elements associated with contaminant mobility from the CDF will first be required to further develop this institutional control.

As part of the Prefinal (60 percent) Design, further analysis of the most effective and implementable controls will be presented.

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APPENDIX C

CONSTRUCTION QUALITY ASSURANCE PLAN
(PREFINAL 60 PERCENT DESIGN SUBMITTAL)

APPENDIX D

WATER QUALITY MONITORING PLAN
(PREFINAL 60 PERCENT DESIGN SUBMITTAL)

APPENDIX E

OPERATION, MAINTENANCE AND MONITORING PLAN
(FINAL 100 PERCENT DESIGN SUBMITTAL)

APPENDIX H

ENGINEERING COST ESTIMATE
(PREFINAL 60 PERCENT DESIGN SUBMITTAL)