LOWER DUWAMISH WATERWAY
SLIP 4 EARLY ACTION AREA

100% DESIGN SUBMITTAL

Design Analysis Report

Submitted to
U.S. Environmental Protection Agency, Region 10
1200 Sixth Avenue
Seattle, WA 98101

Submitted by
City of Seattle
King County

Prepared by
integral
consulting inc.

7900 SE 28th Street, Suite 410
Mercer Island, WA 98040

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ACRONYMS AND ABBREVIATIONS

AOC	administrative order on consent
ARAR	applicable or relevant and appropriate requirement
ARPA	Archaeological Resources Protection Act
ASAOC	Administrative Settlement Agreement and Order on Consent
BA	biological assessment
bgs	below ground surface
bml	below mudline
BMP	best management practice
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CM	construction management
CMP	corrugated metal pipe
COC	chemical of concern
cPAH	carcinogenic polycyclic aromatic hydrocarbon
CQA	construction quality assurance
CQAP	construction quality assurance plan
CQC	contractor quality control plan
Crowley	Crowley Marine Services
CSL	cleanup screening level
CSR	cyclic stress ratio
cy	cubic yards
CWA	Clean Water Act
CZMA	Coastal Zone Management Act
DAR	design analysis report
DO	dissolved oxygen
DOC	dissolved organic carbon
EAA	early action area
Ecology	Washington State Department of Ecology
EE/CA	engineering evaluation/cost analysis
EFH	Essential Fish Habitat
EOF	emergency sewer overflow
ESA	Endangered Species Act
GAC	granulated activated carbon
HWA	HWA Geosciences Inc.
IC	institutional control
ICIP	institutional controls implementation plan
Integral	Integral Consulting Inc.
LDW	Lower Duwamish Waterway

LDWG	Lower Duwamish Waterway Group
LWD	large woody debris
MLLW	mean lower low water
MTCA	Model Toxics Control Act
NAGPRA	Native American Graves Protection and Repatriation Act
NCP	National Contingency Plan
NGVD	National Geodetic Vertical Datum
NHPA	National Historic Preservation Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NTCRA	non-time-critical removal action
OC	organic carbon
OVRA	Olympic View Resource Area
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PSCAA	Puget Sound Clean Air Agency
RA	Removal Area
RAWP	removal action work plan
RCRA	Resource Conservation and Recovery Act
RI/FS	remedial investigation and feasibility study
SAP	sampling and analysis plan
SCL	Seattle City Light
SD	storm drain
SMA	Shoreline Management Act
SMC	Seattle Municipal Code
SMS	sediment management standards
SOW	statement of work
SPT	standard penetration test
SPU	Seattle Public Utilities
SQS	sediment quality standards
TCLP	toxicity characteristic leaching procedure
T/E	threatened or endangered
TOC	total organic carbon
TPH-Dx	extended diesel-range total petroleum hydrocarbon
TPH-G	gasoline-range total petroleum hydrocarbon
TSCA	Toxic Substances Control Act
TSS	total suspended solids
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
WDFW	Washington Department of Fish and Wildlife

WQMP	water quality monitoring plan
WQS	water quality standard

1 INTRODUCTION

This document is the 100% Design Submittal—Design Analysis Report (DAR) for the removal action addressing contaminated marine sediments and immediately adjacent bank areas at the Slip 4 Early Action Area (EAA) of the Lower Duwamish Waterway (LDW) Superfund Site located in Seattle, King County, Washington. The City of Seattle and King County are conducting the Slip 4 sediment removal action for early cleanup of contaminated sediments. This design documentation will be used to implement U.S. Environmental Protection Agency's (EPA) decision for a selected cleanup alternative for Slip 4, as documented in Action Memorandum for a Non-Time-Critical Removal Action at the Slip 4 Early Action Area of the Lower Duwamish Waterway Superfund Site, Seattle, Washington (Action Memorandum) (USEPA 2006a).

The 100% design package received EPA approval in 2007. This package has been updated in 2010 in preparation for construction in 2011 /2012. The Slip 4 EAA removal area boundary was determined by the distribution of polychlorinated biphenyls (PCBs) which are the chemicals of concern (CoC) with the greatest aerial extent. The EAA boundary encompasses the distributions of other CoCs within the site. The defined removal boundaries encompass approximately 3.83 acres. The primary objective of the removal action is to reduce the concentrations of contaminants in post-cleanup surface sediments (biologically active zone [0–10 cm]) to below the Washington State Sediment Quality Standards (SQS) for PCBs and other chemicals. The sediment removal action will significantly reduce unacceptable risks to the aquatic environment resulting from potential exposure to contaminants in sediments in the slip. This cleanup will also reduce potential human health risks associated with PCBs in sediment within the LDW.
This DAR is a component of the 100% design package, which also includes:

- Design Drawings
- Technical Specifications
- Construction Quality Assurance Plan (CQAP)
- Water Quality Monitoring Plan (WQMP).

A biological assessment (BA) is being submitted concurrently with this design. This DAR provides the basis of the design for dredging, excavation, capping and disposal of contaminated sediments, pier removal, and associated construction and monitoring activities. This report was prepared and submitted by Integral Consulting Inc. (Integral) on behalf of the City of Seattle and King County.

1.1 PROJECT BACKGROUND

The LDW was added to the EPA's National Priorities List (Superfund) in September 2001 because of chemical contaminants in sediments. The key parties involved in the LDW site are the Lower Duwamish Waterway Group (LDWG) (composed of the City of Seattle, King County, the Port of Seattle, and The Boeing Company), EPA, and Washington Department of Ecology (Ecology). EPA is the lead regulatory agency for the sediment investigation and cleanup work under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA); Ecology is the lead regulatory agency for source control work. The LDWG is voluntarily conducting the LDW remedial investigation and feasibility study (RI/FS) under an Administrative Order on Consent (AOC). The City of Seattle and King County performed the Slip 4 characterization and engineering evaluation / cost analysis (EE/CA) under Tasks 9 and 10 of the LDWG AOC and associated Statement of Work (SOW), and per requirements of the Slip 4 Revised Work Plan (Integral 2004b). The design, construction, and post construction activities are being conducted as a non-time-critical removal action under the Administrative Settlement Agreement and Order on Consent (ASAOC) and associated SOW for the removal action in Slip 4.

Slip 4 was identified as a candidate early action site within the LDW by EPA and Ecology (Windward 2003a) based primarily on elevated concentrations of PCBs. EPA determined that Slip 4 meets the criteria for initiating a removal action under CERCLA and that this removal is non-time-critical. The process used by EPA and Ecology to identify early action sites followed both the National Contingency Plan (NCP), which requires that threats to human or animal populations, sensitive ecosystems, or other significant factors affecting the health or welfare of the public or environment be considered when identifying removal actions (40 CFR§300.415), and the Washington State Model Toxics Control Act (MTCA). MTCA defines interim actions as "a remedial action that is technically necessary to reduce a threat to human health or the environment by eliminating or substantially reducing one or more pathways for exposure to a hazardous substance at a facility" (WAC 173-340-430) (Windward 2003a).

On February 10, 2006, the City of Seattle and King County submitted the EE/CA to EPA (Integral 2006a). The EE/CA summarized environmental data and source control activities and identified removal action objectives. Removal action boundaries were clearly established. As per EPA guidance, the report evaluated alternative removal actions based on effectiveness, implementability, and cost. The City of Seattle and King County recommended an alternative that represented the best balance between all criteria.

EPA held a public meeting on March 7, 2006 and received formal public comment.

In May 2006, EPA issued their Action Memorandum representing their decision for a selected cleanup alternative for Slip 4 (USEPA 2006a). The selected alternative includes dredging and excavation of contaminated soils, sediments, and debris, and capping of the entire Slip 4 removal area. The selected alternative is described in detail in Section 1.4.

1.2 SITE DESCRIPTION

1.2.1 Location

The Duwamish River flows 13 miles from the confluence of the Black and Green rivers to Elliott Bay. The LDW includes the lower reach of the river, extending from the upper turning basin (Turning Basin 3) to the southern tip of Harbor Island. The East and West waterways, discharging to Elliott Bay, are not part of the LDW Superfund site.

Slip 4 is located on the east bank of the LDW, approximately 2.8 miles from the southern end of Harbor Island (see Figure 1-1). The slip is approximately 1,400 ft long, with an average width of 200 ft. The slip encompasses approximately 6.4 acres, from the head of the slip to the confluence with the LDW main channel. The removal action boundaries include approximately 3.83 acres at the head of the slip.

1.2.2 Physical Characteristics

All elevations in this report are based on the U.S. Survey mean lower low water (MLLW) vertical datum and are given in feet. Table 1-1 presents the relationship between various datum planes and tidal stages at Slip 4.

1.2.2.1 Bathymetry and Topography

The slip is relatively shallow, with surface elevations ranging from +5 ft MLLW at the head of the slip to approximately -20 ft MLLW at the mouth (Figure 1-2). The shallowest depths occur at the head and along the eastern shoreline where the bottom relief gradually slopes to the current and historical dredging boundary located approximately halfway across the slip. At low tide, bottom sediments are exposed at the head and along the eastern shoreline.

The top of bank elevation ranges from about +12 to +18 ft MLLW. Much of the bank is within the tidal range (the extreme low tide is approximately -4 ft MLLW; extreme high tide is approximately +13 ft MLLW; the mean higher high tide is +11.1 ft MLLW). The bank on the west side of the slip under the Crowley Marine Services (Crowley) pier includes steeply sloped riprap next to a vertical bulkhead, with sediment deposits under the outer edge of the pier. The bank slope is nearly vertical at the bulkheads located on the eastern shoreline at First South Properties, and steeply sloping at the head of Slip 4. The southern portion of the eastern shoreline on the Boeing property is steeply sloped and armored with riprap.

The upland areas adjacent to Slip 4 are mostly flat. A small manmade hill is located near the mouth of the slip in the landscaped park area at Boeing.

Tidal effects primarily control the water elevation in the Duwamish Waterway (King County 1999). Tidal elevations at Slip 4 range from extreme lows of approximately -4 ft MLLW to extreme highs of approximately +13 ft MLLW. River discharge (controlled by releases from the Howard Hanson Dam on the Green River) has a lesser influence on water elevations in the lower Duwamish.

1.2.2.2 Structures and Debris

Crowley's pier and berthing area are situated along the western shoreline. The berthing area was dredged in 1981 to facilitate pier construction, and a portion of the berthing area was dredged again in 1996 (USACE 1981, 1996). The pier is comprised of a concrete deck that extends over the water, supported by concrete piling. The berthing areas at the mouth of Slip 4 are currently used for barge loading and unloading. There are no other docks in Slip 4. Additional structures, including buildings and outfalls, in and adjacent to Slip 4 are shown in Figure 1-3.

Portions of the east shoreline at First South Properties and, the bank at the head of the slip are lined with discontinuous segments of dilapidated timber piles and wood-lagging-supported bulkheads and cinderblock bulkheads. Parts of a derelict wooden loading structure remain on the western shoreline between the Crowley pier and the head of the slip.

There is a considerable amount of concrete debris and partially buried logs and piling near the toe of the banks and around the head of the slip. There is also a series of large timber skids at the head of the slip, in the northwest corner. The skids are mostly buried by sediment. Debris may exist throughout the removal area.

Appendix A presents a complete summary of the estimated quantities and types of debris within the removal area. Section 4 describes how this debris will be managed during construction.

1.2.2.3 Outfalls

The following public outfalls, including storm drains and emergency sewer overflows (EOFs), are located at the head of Slip 4 (see Figure 1-3):

- I-5 storm drain (SD)
- King County Airport SD #3/ PS44 EOF
- North Boeing Field SD
- East Marginal Way PS EOF

- Georgetown flume.

There are also numerous private storm drains and piped outfalls located along the Slip 4 shoreline (Figure 1-3). Additional information on discharges from the Slip 4 outfalls and associated source control activities is provided in Section 2.6 and Appendix B of the Slip 4 EE/CA (Integral 2006a). Outfall characteristics relevant to the design are summarized in Table 1-2, including the peak discharge characteristics (from Appendix C of this document). The dredging and capping elements are configured to protect the existing outfalls and resist erosion from outfall flows. The Georgetown flume outfall has been modified (under a separate design) as described in Section 2.

1.2.2.4 Utility Crossings

Other than storm drainage/EOF pipes, no other utility crossings in Slip 4 have been identified within the removal action area.

1.2.3 Land Use and Ownership

Properties immediately adjacent to Slip 4 are currently owned by Crowley Marine Services (Crowley), First South Properties, King County, and The Boeing Company. Crowley currently owns the majority of the submerged land (i.e., sediments) within the Slip 4 EAA and the bank along the First South Properties' shoreline (Figure 1-3). The City jhas purchased the portion of Crowley's land affected by the removal action (Figure 1-3).

Certain construction elements will require access through or construction on the adjacent lands outside City ownership. Also, portions of the sediment cap will be constructed on adjacent lands. Easement and access requirements for these elements are discussed in Section 8.

1.2.4 Sediment Characteristics

1.2.4.1 Chemical Characteristics

Previous Investigations

A summary of sediment quality data can be found in the EE/CA (Integral 2006a). PCBs are the primary chemical of concern (CoC) in Slip 4 sediments. Existing sediment quality data provided the basis for determining the removal action boundary. Historical data (1990–1999) were compiled, and additional data were collected in 2004 to fill data gaps. All chemical data were compared to the Washington State Sediment Management Standards (SMS) which include the SQS (which for total PCBs is 12 mg/kg organic carbon normalized [OC]) and cleanup screening levels (CSL) (which for total PCBs is 65 mg/kg OC) (WAC 173-204).

Detected surface sediment PCB concentrations in samples collected in 2004 exceeded the SQS at six stations; the remaining 20 stations were below SQS (see p.21 of the EE/CA) (Integral 2006a). Carbon-normalized PCB concentrations ranged from undetected to 201 mg/kg OC.

Of the 11 stations where subsurface cores were collected in 2004, samples from nine stations were analyzed by either the City of Seattle/King County or The Boeing Company. Six of the nine cores that were analyzed contained one or more intervals with PCBs greater than the CSL. Carbon-normalized PCB concentrations ranged from undetected to 1,549 mg/kg OC.

Concentrations of PCBs bank samples ranged from below the SQS to above the CSL, and as high as 402 mg/kg OC. As presented in the EE/CA, Emerald Services, the current First South Properties tenant, performed an analysis of bank soil samples in 2005 (Integral 2006a). Concentrations of PCBs in surface soils along the top of the banks ranged from undetected to 6.2 mg/kg OC, below the SQS.

A small drainage swale formerly existed on the eastern bank of Slip 4. If PCB concentrations in surface soil from the drainage area are normalized to organic carbon for comparison to sediment standards, PCBs in the two samples ranged from 23 mg/kg OC to 810 mg/kg OC respectively (the first greater than the SQS and the second greater than the CSL). In September 2006, Emerald Services removed the affected soil and collected samples to confirm that the affected soil was removed. Documentation of this removal is provided in Appendix H.

Pre-Design Investigations

HWA Geosciences Inc. (HWA) performed a Phase II Environmental Site Assessment for Seattle City Light (SCL) at the Slip 4 upland area to further characterize upland soil and groundwater conditions within the City purchase area (HWA 2006). HWA collected subsurface soil samples at the soil-ground water interface (typically at 12 to 16 ft bgs) from seven borings near the head of Slip 4 (Figure 1-4). Summary information from the HWA investigation is reproduced in Appendix I.

A total of 10 subsurface soil samples and five groundwater samples were analyzed for chemical constituents. One of 10 soil samples analyzed contained petroleum hydrocarbon concentrations exceeding MTCA cleanup levels. Six soil samples contained total carcinogenic polycyclic aromatic hydrocarbons (cPAHs) exceeding the MTCA Method A cleanup levels. Two soil samples contained PCB concentrations exceeding MTCA cleanup levels. One soil sample contained an arsenic concentration at the cleanup level. Two groundwater samples from HWA-B6 and HWA-B7 contained lube-oil-range petroleum hydrocarbon concentrations above MTCA cleanup levels. Based on these results, there is a potential that PCBs, PAHs, and petroleum hydrocarbons in existing subsurface soils may exceed MTCA cleanup levels and/or SMS criteria on the excavated banks of shoreline zones 2 and 3 (shoreline zones 1 through 5 are shown on Figure 1-6). The design includes engineered caps on these banks to contain these chemicals should the affected soils be exposed in bank excavations.

To support removal action design, Integral performed a pre-design investigation of surface sediment, subsurface sediment, bank soil and seep water between June 19 and June 23, 2006. The complete report of this investigation can be found in Appendix A.

A total of six seep water samples collected from five seeps located on the east side of Slip 4 were analyzed for dissolved PCB Aroclors and dissolved organic carbon (DOC). Aroclors were detected in two samples. Aroclor 1248 was detected at SP04 at 0.02 µg/L, below the State marine chronic water quality standard (WQS) of 0.03 µg/L. Aroclor 1254 was detected at SP01 at 0.1 µg/L, exceeding the State WQS of 0.03 µg/L. DOC ranged from 1.75 to 7.13 mg/L in the seep samples.

Integral collected sediment and soil samples at 23 locations within the Slip 4 Early Action Area (Appendix A, Figure 2-1). Four intertidal surface sediment samples (0–10 cm) were collected near the removal boundary on Boeing riprap and analyzed for total organic carbon (TOC) and PCBs Aroclors. Carbon-normalized total PCB concentrations ranged from 9.2 to 22.4 mg/kg OC. Three of the four intertidal surface sediment samples (SG30, SG32, and SG33) exceeded the state SMS of 12 mg/kg OC. Because the riprap where these samples were collected had few deposits of sediment that could be sampled, the two exceedances of the SMS represent very small, localized deposits. Based on these results, no adjustments to the removal boundaries defined in the EE/CA are warranted.

To determine the disposal requirements for the mudflat sediment to be dredged, one composite sample representing the total lengths of three cores (SC12, SC13, and SC16 combined) was collected. Similarly, two bank soil samples were composited from three sampling stations located on the banks of Slip 4 (soils from SB 21 formed composite sample SL4-SB21, and soils from SB22 and SB23 were composited to form composite sample SL4-SB22). The composite samples were analyzed for PCBs, semivolatile organic compounds (SVOCs), metals, chlorinated pesticides, extended diesel-range total petroleum hydrocarbons (TPH-Dx), gasoline-range TPH (TPH-G), and TOC (see Appendix A, Table 5-4a). As discussed in Appendix A, the results of these analyses indicate that none of the bulk (dry-weight) concentrations exceed 20 times the toxicity characteristic leaching procedure (TCLP) extract criteria of 40 CFR Part 261 or WAC 173-303-090. Therefore, the bank soil or mudflat sediments do not exhibit the toxicity characteristic under the Resource Conservation and Recovery Act (RCRA) or the State Dangerous Waste Regulations.

To determine the Toxic Substances Control Act (TSCA) disposal requirements for the mudflat sediment to be dredged, five, 5-ft composite samples representing the total lengths of five cores (SC14, SC15, SC16, SC 17, and SC18) were collected. These samples were submitted for PCB analyses (Appendix A, Table 5-4a). Detected total PCB concentrations ranged from 1.5 to 5.9 mg/kg. All samples were substantially below 50 mg/kg PCBs, indicating that the dredged material does not need to be managed at a TSCA-permitted landfill and is suitable for Subtitle D landfills.

1.2.4.2 Geotechnical Characteristics

Previous Investigations

Grain-size data for Slip 4 sediments were collected in both historic and recent investigations. Surface sediments sampled in 2004 ranged from less than 10% to over 80% fine material (i.e., clay and silt). The coarsest sediment was found along the east side and at the head of the slip—these are areas that have not been dredged or are located near outfalls. Subsurface sediment grain size also varied widely, ranging from 2% to 91% fines (Integral 2004a).

Pre-Design Investigations

As part of Integral’s June 2006 pre-design investigation, load-bearing and consolidation properties (bulk density, consolidation, UU triaxial shear test) of the sediment were analyzed at three stations. In addition, samples of sediment and bank soil from cores used to determine disposal requirements were analyzed for geotechnical parameters. Sediment core intervals were submitted for water content, specific gravity, grain-size distribution, Atterberg limits, and TOC (Appendix A, Tables 5-4a through 5-6).

In general, the slip is characterized by a top layer (0–3 ft) of sandy and clayey silts underlain by interbeded silts and sands and a thicker sand unit (approximately 5–15 ft thick). The banks are predominantly fill material consisting of sands and gravels. Refer to Appendix A, Table 5-6, for a complete summary of all geotechnical parameters used in design analyses.

1.2.5 Sensitive Ecosystems

Slip 4 is located in a highly developed commercial-industrial area, and the shoreline and surrounding upland areas have been substantially modified and developed. Except for a small park that was created in the 1990s, most upland habitat has been eliminated. The park is partially landscaped with ornamental and native flowers, shrubs, grasses, and trees. Species characteristic of disturbed areas (e.g., blackberries) are present along the shoreline, slope, and paths.

Nearly all of the Slip 4 shoreline has been highly modified and includes berths and a pier, riprap (some mixed with sand and gravel), exposed geotextile material, bulkheads, and miscellaneous fill (Figure 1-5). The small areas of unarmored shoreline are generally steep, eroded slopes, vegetated by mixed grasses and shrubs. There is little overhanging vegetation.

Two basic aquatic habitat types can be identified at Slip 4 based on depth, sediment grain size, and general topography (Figure 1-5). The first is sandy mud or muddy shallow subtidal habitat. These areas are found along the center and northwest sides of Slip 4 at depths of -10 to -17 ft MLLW, and are over 60% fine-grained material. The second is intertidal mudflat at the head and on the southeast side of the slip, composed primarily of 30–60% fine-grained material. There are also hard structures such as pilings and riprap. The existing aquatic habitat in Slip 4 supports populations of benthic and epibenthic invertebrates, likely provides habitat for migratory and resident fishes, and may provide feeding and resting areas for shorebirds, waterfowl, and marine birds. Additional information on onsite uses is described in greater detail in Section 2.1.8.2 of the EE/CA (Integral 2006a).

1.3 REMOVAL ACTION OBJECTIVES

Within the Slip 4 EAA, the primary COC in the contaminated sediments is PCBs. The primary removal action objective for sediments in the Slip 4 EAA is to reduce the concentrations of contaminants in post-cleanup surface sediments (biologically active zone [0–10 cm]) to below the Washington State Sediment Quality Standards (SQS) for PCBs and other chemicals of interest (USEPA 2006a).

1.4 SELECTED REMOVAL ALTERNATIVE

The removal actions selected in EPA's Action Memorandum (USEPA 2006a) include a combination of excavating, dredging, and capping of sediments in the slip and in immediately adjacent bank areas; institutional controls; and long-term monitoring to achieve the objectives of the removal action (Figure 1-6). The actions include:

- Removal of contaminated sediments with disposal at an offsite upland commercial disposal facility, followed by capping of remaining sediments, as detailed below:
- Dredge approximately 4,300[1] cubic yards (cy) of contaminated sediment from the head of the slip. This dredging generally targets the near-surface material with the highest concentrations of contaminants.
- Excavate approximately 9,700 cy of bank material along the shore of the Slip 4 in Zones 2, 3, 4, and 5. Excavations in Zones 2 and 3 (covering approximately 250 ft of shoreline) will be extended landward to expand intertidal habitat, creating a

[1] These dredge and excavation quantities are from the Action Memorandum. All quantities have been revised in this design.

shallower slope and approximately 0.08 acres of new aquatic habitat from existing uplands.

- Place engineered sediment caps throughout the entire removal action area to physically and chemically isolate contaminated sediments not removed by dredging or excavation. Specific cap configurations have been determined in consideration of federal guidance, protection of Native American shellfishing treaty rights, and habitat type and functions. All dredged or excavated areas will be capped.
  - Place engineered slope caps on the eastern shore of Slip 4 (Zones 3, 4, and 5). Improve conditions of bank areas in preparation for capping (including improving slope stability, removing debris and failing bulkheads, and preparing a subgrade for cap placement). Post-removal samples would be collected on exposed surfaces to document the nature of the material beneath the cap. It is possible that the action would remove all contaminated material, in which case the final cap may require a lesser degree of long-term monitoring and maintenance. Place slope cover in Zone 2 for slope stabilization.
  - Dispose of excavated and dredged material in a landfill that meets state and federal requirements for disposal of such materials.
  - To accommodate these actions, the City of Seattle is purchasing the land owned by Crowley and subject to this action. The purchase includes a lot line adjustment in the under-pier and nearshore areas so that no capped areas remain in Crowley's ownership.
  - Also to accommodate these actions, a portion of the existing Crowley pier will be removed from within the removal action area. The approach for the pier removal is discussed in Section 3.
- Removal of asphalt, creosote-treated timbers and piles, and other debris present in sediments within the removal action area (estimated 500 tons).
- Sediment accumulations formerly present within the lowest segment of the Georgetown flume (approximately 370 ft of the flume upgradient from the outfall itself) were remediated by the City of Seattle in 2007 under the USAOC. Actions for the Georgetown flume are discussed in Section 2.
- Implementation of institutional controls—Institutional controls will be required because some hazardous substances will remain onsite at levels that do not allow unlimited use and unrestricted exposure in bank slopes and intertidal and subtidal sediment areas. Section 10 of this report presents the Institutional Control Implementation Plan (ICIP). The specific objectives of the institutional controls are to:

- Prevent any uncontrolled excavation or construction that may compromise the cap integrity
- Prevent any current or future land and waterway uses that could compromise the cap integrity
- Require notification of the state and EPA prior to development actions at the site that may damage the cap
- Ensure that these restrictions will run with the land.
- Institutional controls will not preclude the Muckleshoot Tribe from exercising treaty-protected fishing activities in the removal action area in the future.

- Performance of long-term monitoring and reporting—Long-term monitoring and reporting will be performed. The primary purpose of this monitoring is to ensure that the site remains protective of human health and the environment.

1.5 REPORT ORGANIZATION

This DAR is organized into the following sections:

- Section 2 describes the construction and contracting strategies for implementation of the design as well as descriptions of the design and post-construction deliverables.
- Section 3 describes the pier removal action rationale and design.
- Section 4 describes the dredge and excavation design and material handling and disposal methods.
- Section 5 describes the sediment cap design.
- Section 6 identifies habitat considerations.
- Section 7 identifies the short-term impacts during construction.
- Section 8 outlines access, easement and permit requirements.
- Section 9 describes construction sequencing and schedule and presents the cost estimate.
- Section 10 contains the institutional control implementation plan.
- Section 11 contains the report reference list.
- Appendix A contains the pre-design investigation data summary report.
- Appendix B contains structural survey findings of the pier, outfalls, and bulkheads.
- Appendix C contains the results of erosion analyses.
- Appendix D provides results of the chemical isolation analysis.

- Appendix E provides the results of the slope stability analyses.
- Appendix F contains figures depicting the pre-and post-construction elevations and associated areas, for assessing habitat effects.
- Appendix G contains cost estimate backup information.
- Appendix H contains documentation of a soil removal in a former swale adjacent to the First South Properties bank.
- Appendix I contains summary information from the Slip 4 Upland Phase II Environmental Site Assessment.
- Appendix J provides background information on the use of institutional controls as a remedy component.

2 REMOVAL STRATEGY

This section presents the overall construction and contracting strategies for implementing the NTCRA in Slip 4, and summarizes the roles of the key design and post-construction documents associated with the cleanup.

2.1 CONTROL OF SOURCES

Foremost in the removal strategy is the need to ensure upland sources of contamination in storm drainage systems are adequately controlled to minimize the potential for recontamination. While control of stormwater sources is outside the scope of this design. Ecology, King County, Seattle Public Utilities (SPU), and The Boeing Company are continuing to investigate and implement controls to address these sources (Ecology 2006). It is important that these sources are adequately controlled prior to construction of the Slip 4 removal action to minimize the potential for recontamination of Slip 4 sediments. Ecology will make the final decision regarding source control effectiveness and completeness (Ecology 2004 and 2006). Following EPA and Ecology's assessment and before implementing the cleanup actions, the City of Seattle will consider whether or not source control is considered adequate to prevent recontamination to levels of concern.

EPA and Ecology are expected to notify the City in early 2011 as to whether sources are adequately controlled; this time frame will allow the construction to be competitively bid and the contractor to be procured for construction in the fall of 2011. Construction may be delayed until fall of 2012 if source control is not considered adequate by early 2011.

2.2 PROPERTY ACQUISITION

The City has completed the acquisition of approximately 3.9 acres of land from Crowley, including the majority of the removal action area (Figure 1-3). The sheetpile retaining wall adjacent to the existing pier will remain Crowley property. Crowley will be responsible for any necessary improvements on their property, such as security fencing, curbs, rails, etc. The City is negotiating the acquisition of approximately 0.23 acres of land from First South Properties, which is the portion of First South Properties' land on which the sediment cap will be constructed (Figure 1-3).

2.3 CONSTRUCTION STRATEGY

The overall construction strategy has been developed with the following goals:

- Implement the removal action in a manner that achieves the removal action objectives for the project

- Limit the short-term, construction-related impacts to aquatic resources and nearby communities
- Limit the short-term, construction-related impacts to adjacent landowners and commercial marine navigation
- Implement the design in a cost-effective manner.

The general approach to the major construction elements (in the general sequence of construction) is described below. Specific information on construction sequencing and scheduling is provided in Section 9.

2.3.1 Construction Window

The Slip 4 NTCRA is scheduled to occur during the fall 2011/winter 2012 construction season. The Washington State Hydraulic Code Rule—Saltwater Technical Provisions sets forth prohibited work times in saltwater areas (WAC 220-110-271) for protection of juvenile salmon migration. However, additional timing restrictions will apply for protection of other species. Requirements for any additional timing restrictions are being identified through consultation with the National Oceanic and Atmospheric Administration (NOAA) Fisheries and the U.S. Fish and Wildlife Service (USFWS), as part of the ESA consultation. These additional constraints are site- and activity-specific. For planning purposes during design, it is assumed that the natural resource agencies may identify the following restrictions on in-water activities:

- **Dredging**—prohibited from February 14–September 30
- **Capping**—prohibited from February 14–September 30.

The above restrictions have been used for developing the project schedule presented in Section 9. It is possible that the prohibited times could be modified through special measures, such as onsite monitoring for the presence of species of concern during in-water work during these prohibited periods.

It is currently anticipated that in-water dredging or capping of contaminated material will be permitted only between October 1, 2011 and February 13, 2012. It is possible that some construction elements could be completed "in-the-dry" earlier than October 1, 2011, or other timing modifications could occur, if approved by EPA in coordination with NOAA Fisheries and USFWS.

2.3.2 Construction Access

Construction access issues are discussed in detail in Section 8. All in-water work will require coordination of vessel traffic to minimize any impediments to navigation in the project vicinity. Particular care will be required in coordinating removal activities (dredging and capping) with Crowley Marine Services and their tenant's navigation needs. Accommodations for tribal fishing may also be required.

Construction will also require land access on land owned by Crowley Marine Services and First South Properties.

The specifications will require the contractor to plan the construction activities to minimize conflict with commercial operations. Where such conflicts cannot be avoided, the required coordination will be effected through the City and/or the EPA. The contractor will be required to describe construction access, staging, and vessel management procedures as part of their Removal Action Work Plan (RAWP).

2.3.3 Georgetown Steam Plant Outfall

The Georegetown Flume operated as a 2,450-foot long system of wood-fortified and concrete lined open ditches and buried piped segments that connected the Georgetown Steam Plant to the LDW at Slip 4. In 2007, the flume was modified, as presented in the Removal Action Completion Report (Herrera 2010), to remove contaminated sediments from within the flume and implement controls so that the flume no longer served as a potential conveyance for contamination to reach Slip 4. This was accomplished by completing the following actions under the Slip 4 ASAOC:

- The flume, as a conveyance structure, was replaced with a pipe that has no inputs other than surface runoff limited to the immediately adjacent land surface.
- Sediments from within the flume were removed and contaminated soil immediately surrounding the flume were removed above MTCA soil cleanup levels.
- A new pipe and bioswale system was installed to provide stormwater conveyance for the steam plant property and the South Myrtle Street right of way.
- Construction was completed such that minimal sediment was disturbed in Slip 4 and no material was discharged from the flume to Slip 4 during field activities.

2.3.4 Pier Demolition

Within the project boundaries, a portion of a concrete pier owned by the City extends over the northwest bank of Slip 4 (Figure 1-3). This segment of the pier is no longer used. Contaminated sediments beneath the pier will be capped as part of this removal action. The Slip 4 Action Memorandum states (USEPA 2006a):

> *To accommodate these actions, a portion of the existing Crowley pier may be removed from within the removal action area. During project design, the City of*

> *Seattle and King County will evaluate the most feasible approach to remediate the under-pier area and to implement long-term maintenance of that remedy. The evaluation will include consideration of effectiveness, implementability, cost, and habitat functions.*

Based on the evaluation presented in Section 3, the City has determined that removal of this portion of the pier during remediation is the most appropriate approach to implement the removal action and maintain the sediment cap over the long term.

Portions of the pier demolition that are not considered “in-water work” (e.g., decking and piling cap removal, or removal of piling in the dry) may be conducted outside the established in-water construction window, subject to EPA approval.

The basis for the pier demolition design is provided in Section 3.

2.3.5 Water-Based and Land-Based Construction Methods

The EE/CA identified two general methods for removal of sediment and bank material:

- Construction “in-the-dry,” typically using land-based construction equipment from the upland side of the site (referred to as “excavation” in the EE/CA), or
- In-water construction, typically using floating equipment (referred to as “dredging” in the EE/CA).

The EE/CA further states:

> *Generally, excavation will be used as practicable, given the availability of low tides during the construction time frame. Excavation will generally be used on embankments and potentially at the head of Slip 4 at elevations above approximately 0 ft MLLW. Dredging will be used throughout the remainder of the Slip 4 EAA.*

As part of the removal action design, the practicability of bank excavation “in-the-dry” and with land-based or floating equipment has been assessed, with consideration of the four design goals identified in Section 2.3. Specific considerations of this assessment are described below:

- **Construction issues for bank excavation using floating equipment.** Excavating banks using floating construction equipment (e.g., a derrick and wire-mounted bucket or a barge-mounted excavator) would employ the same equipment and materials handling operations already mobilized for the dredging and capping operations. The derrick (typically measuring 150′ by 55′ and drawing about 6 ft of water) would spud near the banks and excavate the bank material, either in-the-dry or below the water level, as allowed by the tides and the draft requirements of the derrick. Modern positioning controls allow precise attainment of grades, and the excavated slopes can visually be inspected at low tides (as with land-based excavation). The removed bank material would be loaded onto a haul barge (typically measuring 200′ by 50′ or smaller and drawing up to 12 ft of water) equipped with runoff controls, in the same way that dredged material from submerged areas would be managed. Under this approach all material removed from Slip 4 would be transloaded from the barge to land, and transported to the disposal site(s), under one waste materials management operation.

- **Construction issues for land-based excavation of banks.** Excavating banks using land-based construction equipment from the upland sides of the site would require two additional "setups" of working areas and equipment, on the Zone 2 (Crowley side) and Zone 3/4/5 (First South Properties side). Land requirements for these additional material handling operations would be greater compared to the use of floating equipment. Each of the setups includes establishing haul routes; clearing existing upland stored materials; establishing stockpile, loading, and decontamination areas; providing security fencing; and mobilizing the excavators, loaders, and trucks to the site. Additional temporary engineering controls, such as paving and runon/runoff control measures, may be needed at each site. Access agreements for these areas would be negotiated between the City and the landowners. Importantly, all of the floating equipment and transloading operations would still be required for the dredging at the head of the slip, and so three separate waste materials management operations would be required under this approach.

- **Ability to excavate "in-the-dry."** The more highly contaminated sediments at the head of the slip are being dredged to -6 ft MLLW and cannot be excavated in-the-dry. Excavation of bank material in-the-dry has certain advantages, including the ability of the operator and oversight staff to visually observe the progress and the minimization of generated turbidity. The availability of daytime low tide is the primary limiting factor on the practicability of excavation in-the-dry. Under either construction approach described above, bank material would be excavated in-the-dry to the extent practicable, and a similar amount of material could be removed in-the-dry under either approach.

- **Short-term impacts to aquatic resources and nearby communities.** The overall impacts to water quality during construction are expected to be minor and localized in nature under either construction approach. Importantly, most bank material has relatively low PCB concentrations, and so water quality impacts associated with bank excavation are primarily related to localized turbidity generation. A similar amount of bank material could be excavated in-the-dry under both approaches. A primary difference among the two construction approaches is the duration of the short-term impacts: using floating equipment, bank excavation (and bank capping) is expected to have higher production rates and hence the duration of impacts should be shorter. Bank excavation using floating equipment may also have fewer impacts to local communities, since only one waste materials management operation would be needed.

- **Short-term impacts to adjacent landowners and navigation**. Upland access and staging requirements for the use of land-based equipment may have significant impacts to the operations of the tenants at both Crowley and First South Properties. Excavating banks using floating construction equipment would have fewer impacts to the upland operations. However, several more days of navigable access to the slip would be required if floating construction equipment is used on the banks, potentially increasing the impacts to commercial moorage at the outer portions of Crowley's pier. Given the overall project needs for water-side access (e.g., during pier demolition, in-water dredging, and capping), the additional impact to commercial navigation is considered minor.
- **Cost.** Land-based excavation of banks may cost considerably more than bank excavation using floating equipment due to the additional equipment, labor, planning costs, and potential financial impacts to the upland tenants. Given the relatively small volumes of materials to be removed from the banks, the fixed cost of the two additional setups could significantly raise the unit cost of bank excavation if land-based excavation were specified.

In summary, either construction approach could achieve the removal action objectives. Bank excavation using floating construction equipment is favored over land-based equipment due to lower costs and fewer and lesser short-term impacts to aquatic resources, nearby communities, and adjacent landowners.

Similar to the excavation considerations described above, it is expected that capping of bank areas can most efficiently be accomplished using floating equipment. Cap placement techniques are discussed in Section 5.6.

Given the lower anticipated costs and more favorable logistics, it is expected that most bidders will propose the use of floating construction equipment for most or all of the bank work. However, the technical specifications for bank excavation and capping are performance-based, and do not proscribe the use of land-based equipment for some excavation or capping activities. The contractor will propose detailed work methods in its work plan, which would require approval by the City and EPA.

2.3.6 Transloading of Waste Materials from Barge to Land

Waste soils, sediments, and debris will be loaded onto barges in Slip 4, and will require transloading at a nearshore location for transfer to rail or truck, and subsequent transportation to a permitted landfill. This transloading may occur either onsite or at a location outside of Slip 4; and the optimum approach may vary depending on which contractor is selected. To maintain flexibility, both options are retained in this design.

Both approaches require the contractor to establish engineering controls at the transloading site to contain and control any sediment spillage, and manage stormwater run-on, run-off, and leachate associated with the transloading operations. Section 4.3 describes the materials handling and transloading approaches. The specifications establish performance-based requirements for transloading and require the contractor to provide detailed information on their proposed transloading facility. The contractor will propose the transloading location and detailed work methods in its work plan, which will require approval by the City and EPA.

2.4 CONTRACTING STRATEGY

The design for the Slip 4 removal action will be issued for prospective construction contractors to bid the work. The City will award the construction contract to a responsive and responsible bidder and administer the contract. Performance-based specifications will ensure that the removal action is constructed in accordance with the requirements of the design, but will typically not specify specific means and methods for the construction.

Following the construction contract award, the City and the contractor will develop a RAWP (described in Section 2.5) that describes specific means and methods for the construction. Construction quality control (e.g., daily progress surveys, sampling and analysis to verify import materials quality) will be the responsibility of the construction contractor, in accordance with the specifications and the RAWP. The RAWP will be subject to review and approval by the City and EPA.

The City of Seattle will provide a Resident Engineer to directly oversee the contractor's work and manage the construction contract. Construction management (CM) support and construction quality assurance (CQA) will be accomplished by Integral, in accordance with the Construction Quality Assurance Plan (CQAP). CM/CQA will include daily oversight of construction activities, review of submittals, water quality monitoring and reporting, confirmation sampling and analysis, and associated coordination and reporting.

Throughout the construction, EPA will oversee all construction and CQA activities. Project roles and responsibilities and CQA activities are described in detail in the CQAP.

2.5 DESIGN AND POST-CONSTRUCTION DELIVERABLES

This document is the 100% DAR for the project. This design builds on the information presented in the EE/CA and implements the selected removal alternative documented in

USEPA's Action Memorandum (2006a). Key design and construction documents for the project, as required by the ASAOC are discussed in the following subsections.

2.5.1 Final (100%) Design Package

The Final (100%) design package incorporates agency and stakeholder comments on the 60% Design, which was submitted in October 2006. The 100% design package includes this DAR, all construction drawings, and specifications. The DAR also includes an ICIP describing the institutional controls (ICs) needed to ensure the long-term effectiveness of the removal action, including the objectives and goals for each institutional control; descriptions of the portions of the site where each IC applies; descriptions of how such controls would be implemented, monitored, and enforced, and by whom and under what enforcement mechanism; a time frame for how long the ICs must remain in place; and under what circumstances such controls could be removed or terminated. The 100% design package also includes the CQAP and associated sampling and analysis plan (SAP), and the water quality monitoring plan (WQMP). The 100% design package is subject to agency review and final EPA approval.

The 100% design package received EPA approval in 2007. This package has been updated in 2010 in preparation for construction in 2011 /2012.

2.5.2 Biological Assessment

To meet substantive and procedural requirements of the ESA, the BA identifies sensitive (threatened, endangered, proposed, or candidate) species and their habitat within the project area and the types of impacts that could be associated with the removal action. Best management practices (BMPs) and conservation measures designed to avoid or minimize potential impacts are also presented in the BA. The BA will be used by the EPA in its consultation requirements under Section 7 of the ESA.

The Final BA is being submitted concurrently with this 100% Design package. The final BA will be submitted by EPA to NMFS and USFWS for review and concurrence.

2.5.3 Bid Package

Following EPA's approval of the final design, the City will develop a bid package for the competitively bid construction in Slip 4. The bid package will include any changes to the 100% Design resulting from Agency comments, the stamped and signed plans and specifications, supporting documentation, contractual requirements (e.g., "Division 0" specifications containing contract requirements), and instructions for contractors to bid the work. The bid package will be provided to EPA and will be made available for prospective construction contractors to bid the work.

EPA and Ecology are expected to notify the City in early 2011 as to whether sources of contamination to Slip 4 are adequately controlled. Based on this notification and following the City and King County's determination on source control, the bid package will be issued.

2.5.4 Removal Action Work Plan

Following award of the construction contract for Slip 4, the City will submit a RAWP to EPA. The City will prepare portions of the RAWP; however, the RAWP will consist primarily of contractor submittals that will be prepared by the construction contractor. The construction specifications require the contractor to submit a RAWP that describes the equipment, procedures, materials, methods, transloading and disposal locations, vessel management procedures, and personnel to be employed in the work. The contractor's RAWP will include such elements as a dredging and disposal plan, capping plan, schedule, environmental protection plan, and a Contractor Quality Control Plan (CQC). The CQAP as well as the specifications provide detailed information on the various elements of the RAWP.

Per the Settlement Agreement, the assembled RAWP will include the following elements:

- Description of the removal action and construction activities, including project organization; construction contractor selection; site mobilization and preparatory work; dredging activities; dredged or excavated material handling; bathymetric surveys; dredged or excavated material spill prevention; procedures and plans for the decontamination of equipment and the disposal of contaminated decontamination materials; stormwater pollution prevention plan; capping activities; performance verification; water quality monitoring; quality assurance; and implementation of the ICIP
- A construction schedule and a schedule of other activities, including inspections, meetings, and documents associated with the removal action
- Schedule for developing and submitting other required removal action plans
- Formulation of the removal action team
- Construction quality control plan and statement of qualifications
- Procedures for processing design changes and securing EPA review and approval of such changes to ensure changes conform to performance standards and requirements of this SOW, and are consistent with the objectives of this removal action
- Procedures for coordinating with EPA regarding compliance with EPA's Off-Site Rule
- A health and safety plan.

Draft and final versions of the RAWP will be submitted to EPA. EPA must approve the RAWP prior to initiation of construction.

2.5.5 Removal Action Completion Report

The Removal Action Completion Report will follow EPA guidance for closeout reports (*Close Out Procedures for National Priorities List Sites*, EPA 540-R-98-016). It will contain a description of the work that was actually performed during construction, and a certification that the removal action has been constructed in accordance with the drawings and specifications. The report will provide as-built drawings, an estimate of total costs, a listing of quantities and types of materials removed offsite or handled onsite, a listing of the ultimate destination(s) of those materials, a presentation of the analytical results of all sampling and analyses performed (including a map showing the locations of any confirmatory samples), and accompanying appendices containing all relevant documentation generated during the removal action (e.g., manifests, invoices, bills, contracts, and permits). All analytical data will be provided electronically to EPA. A final Water Quality Monitoring Report may be submitted as an appendix to the Removal Action Completion Report.

The Removal Action Completion Report will also contain a description of ICIP implementation to date, with copies of all implementing documentation, a schedule for completion of all outstanding ICIP tasks, and a proposed submittal date for a draft and final Institutional Control Implementation Report.

The Removal Action Completion Report will be submitted within 60 days after completion of the construction phase of the removal action.

2.5.6 Long-Term Monitoring and Reporting Plan

A Long-Term Monitoring and Reporting Plan for the removal action will be developed following completion of the Removal Action Completion Report. The goal of the plan is to monitor the long-term effectiveness of the remedy. The Long-Term Monitoring and Reporting Plan will describe the required monitoring activities, including inspections and analyses, and associated schedules; the responsible party for performing each activity; the specific reporting requirements, and the process to be followed for addressing any contingency or corrective actions.

The Long-Term Monitoring and Reporting Plan will include monitoring objectives, an overview of the monitoring approach, design of the monitoring program (e.g., sampling strategy, station locations and replication, field sampling methods, laboratory methods), data analysis and interpretation, reporting requirements, and a schedule. The plan will include, as appropriate, visual inspections, bathymetric surveys, sediment deposition monitoring, chemical monitoring, and sediment sampling to monitor for recontamination.

The Long-term Monitoring and Reporting Plan will also include a description of monitoring of ICs to ensure that all requirements remain in place and that the ICs continue to work effectively. The Plan will include notification requirements to EPA when an IC fails or a land use restriction is violated, and provisions shall be included that describe what actions should be taken in the event of a failure or violation, and what entity should be responsible for addressing the problem.

2.5.7 Institutional Control Implementation Report

The Institutional Control Implementation Report will document complete implementation of the ICIP, including copies of all relevant paperwork (e.g., easements, filings with Recorders Offices).

2.5.8 Long-Term Monitoring Reports

Data from long-term monitoring will be assembled into reports and submitted to EPA in accordance with the schedule set forth in the Long-Term Monitoring and Reporting Plan. Based on long-term monitoring results, EPA will evaluate the effectiveness of the cleanup and determine if future response actions are needed to achieve the cleanup objectives.

3 PIER REMOVAL DESIGN

Within the project boundaries, a portion of a concrete pier formerly owned by Crowley extends over the northwest bank of Slip 4 (Figure 1-3). This segment of the pier is currently owned by the City and will be demolished during the remediation work. Contaminated sediments beneath the pier will be capped as part of this removal action. This section describes the rationale for removal of the pier segment and the basis for the demolition design.

3.1 RATIONALE FOR PIER REMOVAL

The City has determined that removal of this portion of the pier prior to remediation is the most appropriate approach to implement the removal action and maintain the sediment cap over the long term. The following factors were considered in this determination, consistent with the requirements of the Slip 4 Action Memorandum (USEPA 2006a):

- **Effectiveness:** The under-pier area could effectively be capped without pier removal; however, the pier would eventually require maintenance or demolition. If the pier were not removed, these future maintenance actions may involve piling pulling, piling cutting, piling driving, spudding of work barges, and heavy tug operations—all of which could potentially damage the cap and affect long-term cap effectiveness. These factors could be managed (e.g., with special construction and monitoring requirements); however, eliminating these future construction needs is considered to improve the overall long-term effectiveness of the cap. Additionally, pier removal will include removal of approximately 50 creosote-treated fender piling along the pier face, further reducing potential contaminant sources to the slip.
- **Implementability:** Special cap construction methods would be required if the pier were left in place. Removal of the pier prior to capping allows for conventional cap placement methods in this area, improving the constructability of the cap. The ability to monitor and maintain the cap in this area is also improved by pier removal.
- **Cost:** The additional capital expenditure for pier removal is offset by the following cost savings and value added:
  - Reduced capital cost of capping the former under-pier area
  - Eliminated long-term pier maintenance/demolition costs. These future costs would be considerably higher than the industry standard due to increased transaction costs (design, permitting, contracting, agency and

City oversight, remobilization) and special construction requirements for working in the capped area.

- Potentially reduced long-term cap monitoring and maintenance costs. Any future pier maintenance or demolition would likely trigger special cap monitoring requirements and could result in cap damage and the need for cap repair.
- Reduced liability associated with the structure on City property.
- Added value in removal of creosote-treated fender piling.
- Added value in habitat quality and quantity.

- **Habitat Function:** Removal of the pier will eliminate the artificial shading over approximately 20,400 ft^2 (0.48 acres) of shallow subtidal, lower intertidal, and upper intertidal habitat. In addition, approximately 50 creosote-treated piling and 175 concrete piling will be removed, restoring several hundred square feet of mudline substrate in the piling footprints.

3.2 PIER REMOVAL DESIGN BASIS

The pier will be demolished from the water side, and demolition debris will be loaded onto barges for transport to approved offsite disposal and/or recycling facilities. Pier decking will be lifted off the pile caps. The pier will be saw-cut even with the coping beam along the existing sheetpile wall, to maintain the integrity of the bulkhead. At the southern limit of pier demolition, the pier decking will be cut at a piling bent located outside the cap area such that no portion of the remaining pier is on City-owned land or the constructed sediment cap.

Certain utilities, including electrical and water, are present on the portion of the pier to be demolished. In its purchase and sale agreement with the City, Crowley has agreed to disconnect and abandon all utilities affected by the pier removal. The contractor will remove any remaining abandoned utility components (e.g., piping, wiring) as part of the demolition.

Two options exist for piling removal: cutting the piles at the mudline, or extraction of entire piles. The pier's timber fender piles (and other derelict timber piles in the cleanup area) will be removed with vibratory extraction or dead line pull, consistent with EPA's preferred method for treated piling removal (USEPA 2005a). Cutting the pier's reinforced concrete piling at the mudline is specified for the following reasons:

- It preserves any marginal slope stability improvements that the piles may currently provide.
- It minimizes waste generation.

- It can be accomplished at similar cost to extraction.
- Contractors have the ability to efficiently cut reinforced concrete piling.
- Extraction can result in pile breakage.

The Contractor will record the coordinates of the cut piling and include these on the as-built drawings.

Section 9 discusses construction sequencing. In general, if transloading occurs outside of Slip 4, pier demolition will be accomplished before dredging, excavation, and capping actions. If transloading occurs within Slip 4, the pier demolition will occur following the dredging and excavation activities. Portions of the pier demolition that are not considered "in-water work" (e.g., decking and piling cap removal, or removal of piling in-the-dry) may be conducted outside the established in-water construction window, subject to EPA approval.

Roughly 2,000 cy of concrete waste will be generated by the pier removal. This will be sent offsite to an approved disposal or recycling facility in accordance with the specifications and the approved RAWP.

4 DREDGE/EXCAVATION DESIGN

This section describes the design for dredging at the head of Slip 4 and dredging/ excavation in designated bank areas. Piling and debris removal is also described. The Specifications define the term "dredging" to include excavation, where not otherwise specified.

4.1 DREDGE/EXCAVATION DESIGN CRITERIA

4.1.1 Objectives and Scope of Dredging and Excavation

The lateral extent of dredge/excavation areas was developed as part of Alternative 2 in the EE/CA (Integral 2006a) and is defined in USEPA's Action Memorandum (2006a). Figure 1-6 depicts the dredge/excavation areas as presented in those documents. The overall rationale for the extent of dredging/excavation is described in the EE/CA (Integral 2006a) and is based on achieving the following objectives:

- Accommodate outfall drainage
- Ensure no net loss of aquatic habitat
- Improve conditions of bank areas in preparation for capping (including improving slope stability, removing debris, and preparing a subgrade for cap placement)
- Remove near-surface material with the highest concentrations of contaminants
- Minimize changes to mudflat habitat at the head of the slip
- Consider improvements to intertidal habitat in locations where the City will own the bank and adjacent upland areas.

The extent of dredging and excavation is based on the following:

- Dredging a minimum of 3 ft of material throughout the head of Slip 4 from Station 0+00 to approximately Station 2+50, and extending along the Zone 3 shoreline to approximately Station 3+00. This dredging targets the near-surface material with the highest concentrations of contaminants and is designed to accommodate a sediment cap that approximately reestablishes the existing contours.
- In the area targeted for dredging, the dredge cut is designed to expose substantially cleaner material in order to improve the long-term effectiveness of capping. The depth of dredging in the mudflat area at the head of the slip is designed to generally extend below the observed depth of contamination in the existing cores, which is typically 2–4 ft below the mudline. The dredging and

bank excavation is not designed to remove all SQS or CSL exceedances because the area will be capped, but the dredged surface is expected to be substantially cleaner than the material that is removed.

- Approximately 300 linear ft of the Zone 3 bank, 100 linear ft of the Zone 4 bank, and 140 linear ft of the Zone 5 bank will be excavated shoreward an average of 3 ft to a 2 horizontal:1 vertical (2H:1V) slope or flatter, removing impacted soil and sediment, creosote-treated timbers and piles, debris, and other material.
- In portions of Zone 2 and Zone 3 near the head of the slip where the City will own the adjacent uplands, the bank excavation is extended landward to improve and expand intertidal habitat. The excavation in these areas (covering approximately 250 ft of shoreline) will be at a flatter slope (approximately 3 to 4H:1V) and will create new aquatic habitat from existing uplands. Also, additional excavation is included above +11 ft MLLW to create two gently sloping backshore areas at the head of the slip. These areas include additional habitat enhancement measures such as large woody debris, as described in Section 6.

4.1.2 Dredge/Excavation Cut Stability Analysis

Section 5.2 summarizes the results of the analysis of slope stability for the existing slopes as well as the final capped slopes. Appendix E presents the complete slope stability analysis. The configuration and stability of the existing bank slopes varies around the slip. In some locations the slopes are near-vertical and appear to be failing or eroding. The existing slopes that were modeled have estimated static factors of safety of 1.2 or greater. The temporary dredged slopes will be flatter than the existing slopes (2H:1V or flatter), and will therefore have acceptable short-term stability.

4.1.3 Dredge/Excavation Overdepth Allowance

The contractor will be required to ensure that the material is removed to the required depths and specified slope cutbacks are attained. It is expected that the contractor will remove up to an additional 12 in. beyond the required amount to address any sloughing that may occur and ensure the required depths are achieved. Therefore, in all dredge and bank excavation areas, a 1-ft dredge overdepth allowance has been specified.

4.2 DREDGE/EXCAVATION AND DEBRIS QUANTITIES

Based on the required depths and specified slope cutbacks, and with the 1-ft dredge overdepth allowance, the total estimated maximum dredge/excavation quantity is 10,256 cy. This includes 6,134 cy on bank areas and 4,121 cy in the mudflat area. All estimated quantities are expressed as in-place volumes, and payment will be made based on the in-place volume removed.

Assuming that approximately 30% of the bank material is considered soil, and the rest of the material to be removed is considered sediment, the total estimated volume of soil to be removed from bank areas is 1,840 cy. The total estimated amount of sediment to be removed is 8,415 cy.

The estimated dredge/excavation quantities have been calculated based on the completed 100% design drawings, using triangulated irregular network volume computations in AutoDesk Civil 3-D. These volumes differ from the preliminary estimates provided in the EE/CA, which were engineering estimates based on conceptual-level designs. The dredge boundaries on the banks have been slightly expanded from those depicted in the EE/CA, and additional habitat bank cutbacks have been added at the head of the slip. Dredge depths are the same as those presented in the EE/CA (Integral 2006a).

The quantities and types of debris that are expected to be encountered during the dredging and excavation were estimated as part of the pre-design investigation (Appendix A). It is estimated that approximately 800 tons of debris is located within the slip, including a contingency for debris that is not visible. The following is a summary of estimated debris types and quantities:

- Timber/Wood Debris: 530 tons
- Concrete Piling/Cinder Blocks: 160 tons
- Metal Debris: 12 tons
- Miscellaneous: 70 tons

4.3 DREDGE/EXCAVATION METHODS AND MATERIAL HANDLING

4.3.1 Removal of Derelict Piling and Debris

Appendix A details the estimated quantities and types of debris that are expected to be encountered during the dredging and excavation. Visible large debris and derelict piling will be removed in a debris sweep prior to the dredging and excavation so that the debris does not impede closure of the dredge bucket. The contractor will remove derelict timber piling by vibratory extraction or dead line pulling (removal of concrete structural piling is discussed in Section 3). In some cases, debris will be removed concurrently with the dredging and excavation, such as when buried debris is encountered and where debris is currently retaining embankment soils.

As shown on the drawings, two timber fender walls at the I-5 outfall are to remain, to protect the structural integrity of that outfall.

The Contractor will record the coordinates of any cut or broken piling stubs and include these on the as-built drawings.

Piling and debris will be loaded onto flat-deck barges for handling and transloading. Large debris will be broken down as required for landfill disposal—typically to lengths less than 10 ft. The contractor will conduct any sampling of debris that may be required by the landfill for disposal characterization, in accordance with the specifications.

4.3.2 Dredging and Excavation

4.3.2.1 Equipment Selection

Use of mechanical dredging equipment is specified as it is more cost-effective and has fewer associated dewatering logistical concerns compared to hydraulic dredges. Additionally, the debris in Slip 4 would impede the operation of any hydraulic dredge.

Barge-mounted, wire-supported dredges (with clamshell or environmental buckets) or articulated mechanical excavators will likely be the equipment selected by the contractor, as this equipment can be used both for dredging the mudflat area at the head of the slip and dredging/excavating the bank areas. The contractor may propose to use land-based equipment to excavate certain bank areas.

Given the project size and requirements for slope dredging, it is anticipated that a 5–10 cy bucket will be used for dredging. The contractor will be required to have an enclosed environmental bucket available, and to use the environmental bucket to the extent practical. However, debris limits the ability to use an environmental bucket, and a clamshell bucket will generally be required to successfully remove any harder sediments and material containing debris.

4.3.2.2 Performance Requirements and Sequencing

Dredging performance requirements are set forth in the specifications, and verification of the dredge cuts and compliance with water quality criteria are addressed in the CQAP. Contractor requirements in the specifications include:

- Attaining the required design elevations and slopes
- Maintaining allowable overdepth for dredging
- Specific BMPs to be used (further described in Section 7)
- Dredge positioning and bathymetric survey requirements
- An overall requirement for the contractor to conduct the dredging, excavation, dewatering, transloading, demolition, and other activities in a manner such that water quality criteria are not exceeded
- Adherence to certain sequencing requirements (described below)
- Submittal of daily dredge and excavation reports to facilitate construction quality assurance

An evaluation of the short-term water quality impacts associated with mechanical dredging, excavation, and capping is presented in Section 7. Section 7 also discusses specific design elements, BMPs, and potential operational responses that collectively will ensure compliance with water quality criteria and reduce generation of resuspended material and dredge residuals.

Sequencing of the dredging and excavation relative to the other work is also specified, as summarized below:

- The contractor will construct a boundary berm before dredging to reduce the potential for transport of near-bottom turbidity in the form of a "mud-wave."
- The contractor will conduct a debris sweep before dredging to remove all visible large debris, thereby reducing resuspension or sediment loss from partially closed buckets. However, it is inevitable that some debris will still be encountered during the dredging.
- All dredging must be complete before any capping work can start, so that any residuals do not affect the cap and will be contained by the cap.
- The contractor is required to construct the cap in RA3 within a specified period after completing excavation, to reduce the potential for bank erosion to affect the area south of the project limits.

Because dredging and excavation must occur in a very confined area, and because the dredging is not intended to remove all contaminated sediments or leave a surface that meets the SQS, no location-specific sequencing of the dredging and excavation is specified. It is anticipated that the contractor will dredge proceeding from south to north, into RA4, to create the draft needed for the equipment.

The contractor is required to submit a removal action work plan that describes the equipment, procedures, materials, methods, disposal location, and personnel to be employed in the work. The requirements for this contractor submittal are set forth in the specifications.

4.3.2.3 Material to be Removed

As described in the *Pre-Design Investigation Data Summary* (Appendix A), the material to be dredged was physically characterized from analysis of cores and test pits.

Bank soils generally consisted of well-graded and silty sands with gravel (fill material). Dredge prism sediments generally consist of sandy and clayey silts in the top approximate 4.0 ft below mudline (bml) and silty sands closer to the bank. Below 4.0 ft bml, dredge prism sediments generally consist of silty sands and sand with interbedded silt. Within this material, debris including timber, riprap, and other material is expected to be present.

The results of this characterization will be included in the bid package for the contractor to evaluate. This material should be readily dredged and should not pose special difficulties in handling.

Debris will be handled as described in Section 4.3.1.

4.3.2.4 Dredging and Excavation in-the-Dry

The more highly contaminated sediments at the head of the slip are being dredged to -3 ft MLLW to -6 ft MLLW and cannot be excavated in-the-dry.

Excavation of bank material in-the-dry has certain advantages, including the ability of the operator and oversight staff to visually observe the progress and the minimization of generated turbidity. The availability of daytime low-tide windows is the primary limiting factor on the practicability of excavation in-the-dry. Bank material will be excavated in-the-dry to the extent practicable, considering tidal stages, equipment draft requirements, and boom reach capabilities.

4.3.2.5 Controls and Verification

Dredge positioning will be accomplished using an approved electronic positioning system providing a horizontal positioning accuracy of +/- 1 m. Vertical control of the dredging depth will be accomplished by reading distance markings on the bucket closing line; the water depth to the dredge depth will be a function of the tidal stage. The contractor will monitor the water level with tide boards visible to the operator, which will be checked daily against a NOAA tide gauge. Where sediment or bank material is excavated above the water line, vertical control can be established using vertical staffs or other direct sight control.

The progress of the dredging and excavation will be monitored by the contractor in its daily progress surveys. The contractor will be required to correct any dredge cuts that have not met the required depth. Final acceptance surveys will be completed by an independent, third-party, licensed surveyor experienced in hydrographic surveying, under contract to the construction Contractor.

4.3.2.6 Documentation Sampling of Dredged and Excavated Bank Areas

The dredging and bank excavation is not designed to remove all SQS or CSL exceedances because the area will be capped, but the dredged surface is expected to be substantially cleaner than the material that is removed. Documentation samples of the exposed bank surfaces will be collected as described in the CQAP. The purpose of these samples is to document the chemical concentrations remaining beneath the capped bank areas. These results will be documented in the Removal Action Completion Report and evaluated in the Long-Term Monitoring and Reporting Plan to assess long-term monitoring requirements.

The sampling will not be used to modify the slope cap construction; the contractor will proceed with capping the slopes immediately after the documentation samples are collected.

4.3.2.7 Materials Handling

Dredged and excavated materials will be allowed to gravity drain on barges onsite (within the removal area boundaries) for several hours to minimize free draining liquids, prior to being loaded for transportation and disposal. BMPs will be used in the material handling: overfill of the materials barge will not be allowed, and the materials barge will be fitted with sideboards and filter fabric or other measures to control turbidity in the drained water. These BMPs are described further in Section 7. The dewatering operations will be subject to monitoring and compliance with water quality criteria, as addressed in the WQMP.

Soils excavated entirely in the dry, and that contain no free-draining liquids, may be loaded directly into lined containers without dewatering on a barge.

Creosote-treated piling and timbers will be cut into 10-ft or smaller lengths, and loaded into separate containers.

4.4 WASTE TRANSPORTATION AND DISPOSAL

4.4.1 Transloading

Transloading of materials from the barge to lined containers may occur either onsite or at an alternate location proposed by the contractor, as summarized below.

Transloading Onsite: Onsite transloading (using the portion of the pier on City-owned property) is a viable option. The contractor would berth a loaded barge alongside the pier, and a derrick would be stationed either on the pier or on a second barge moored at the pier. The waste materials would be rehandled directly into lined containers (on truck chassis) on the pier. The loaded containers would then either be trucked directly to a landfill or trucked offsite to a transfer facility for rail transport to a landfill. A rail spur exists on site; however, use of the rail spur for transloading is not considered practicable because there is no pull-through capability, and no siding for storage of empty and loaded cars. Transloading onsite requires the pier demolition to occur after the dredging/excavation is completed. The Contractor will have to adhere to load limits on the pier structure (500 psf live load) during transloading operations. Onsite transloading will require greater use of Crowley's upland property during construction; these considerations and specific work area requirements are described in Section 8.

Transloading Outside of Slip 4: The nearby commercial transloading facility that formerly operated at Terminal 25 on the East Waterway is no longer active, and the Regional Disposal Company has indicated it has no plans to establish another dedicated facility in the near future (Starin 2006, pers. comm.). Some contractors have the facilities to accomplish the transloading on their own sites, as was accomplished for the recent transloading of material from the PSR site in Elliott Bay. Through communications with regional landfills, several other prospective transloading facilities exist on the Duwamish within a few miles of the site, to accomplish the transfer of dredged material from barge to lined rail cars. These are not dedicated sites but can be mobilized when planned for in advance (Starin 2006, pers. comm.; Willman 2006, pers. comm.). If barges are to be used for transport of material dredged from Slip 4, they will be subject to requirements for leakage and overflow that are commonly used in sediment remediation.

Any given transloading facility (at Slip 4 or elsewhere) may be suitable or unsuitable for a given contractor, depending on the contractor's expected production rates and schedule, the contractor's proposed landfill, and the contractor's ability to transload at its own facilities. If transloading is proposed outside of Slip 4, the contractor will contract with the rehandling and disposal facilities and will identify these facilities, operational procedures, and haul routes in the RAWP.

Both transloading approaches require the contractor to establish engineering controls at the transloading site to contain and control any sediment spillage, decontaminate trucks leaving the area, and control stormwater run-on, run-off, and leachate associated with the transloading operations. The specifications establish performance-based requirements for transloading and require the contractor to provide detailed information on their proposed transloading facility. The contractor will propose the transloading location and detailed work methods in its work plan, which will require approval by the City/County and EPA.

Management of liquids from the transloading operations, and transportation impacts to the community, are discussed in Section 7. Any return flow of water from the transloading operations will be subject to monitoring and compliance with water quality criteria, as addressed in the WQMP.

4.4.2 Transportation and Disposal

At the transloading location, sediment, soils, and debris will be loaded into lined shipping containers for transportation and disposal at a permitted landfill. Typically, 20-ft containers would be used. Containers would be loaded to 32-ton maximum weight for highway travel. Creosote-treated piling and timbers would be transported in a separate container. Depending on the transloading location and landfill, the containers may be trucked to the landfill, or trucked to a transfer facility in Seattle for rail transport. The transfer facilities in Seattle are not permitted to rehandle wet sediments; therefore, the loaded lined containers would be moved from the truck chassis directly to the railcars at the transfer facility (Cassalini 2006, pers. comm.).

Disposal of dredged sediments will be at an established upland solid waste landfill, in accordance with the Action Memorandum (USEPA 2006a). Piling or other debris encountered during the remediation will be managed in accordance with the substantive provisions of state regulations (WAC 173-304-200), and will be either recycled or sent to a permitted solid waste facility. Also, all offsite treatment, storage, and disposal of CERCLA waste will occur at facilities that are acceptable under EPA's Off-Site Rule (40 CFR 200.440). This rule is intended to avoid having CERCLA wastes contribute to present or future environmental problems by directing these wastes to sites determined to be environmentally sound.

Two upland regional landfills have established services to receive dredged sediments and low-concentration contaminated soil (PCB concentration <50 mg/kg DW): Roosevelt Regional Landfill near Goldendale, Washington, and Columbia Ridge Landfill near Arlington, Oregon. These sites are licensed as RCRA Subtitle D commercial landfills in the states in which they operate, and both have the ability to receive wet dredged sediments delivered to the landfill by rail.

The design specifications set forth the performance requirements for accomplishing waste transportation and disposal such as handling and dewatering requirements. The specifications require the contractor to submit a removal action work plan that describes the equipment, procedures, materials, methods, haul routes, disposal location, and personnel to be employed in the work.

As described in the *Pre-Design Investigation Data Summary* (Appendix A), the results of the bulk chemical analysis of sediment in the dredging area indicate that the material will not designate as dangerous waste, and thus can be disposed of in a RCRA Subtitle D landfill. The specifications do not specify a landfill, but specify the disposal requirements. The contractor will be responsible for any additional sampling and analysis of dredged material (or other waste) that may be required by the landfill

5 CAP DESIGN

This section presents an overview of the cap design process, a summary of the slope stability and erosion analyses, and the basis of the cap design for each portion of Slip 4.

Based on the analyses in this section, the removal area has been subdivided into a series of seven "Removal Areas" (RAs) that reflect distinct cap design considerations. The drawings show the configuration of the RAs.

5.1 CAP DESIGN PROCESS

The composition and thickness of the components of a cap can be referred to as the cap design. The cap thickness is based on a series of additive components that perform the various functions of the cap (USEPA 1998). The cap thickness is determined as follows:

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

where:

T_t = total cap thickness (as constructed)
T_b = thickness for bioturbation
T_e = thickness for erosion
T_c = thickness for cap consolidation
T_i = thickness for chemical isolation
T_o = thickness for operational considerations

The functions of these cap components are discussed in the following subsections. The cap thickness components for each of the cap areas are also defined in the following subsections. Typical cap sections are presented in the drawings. Considerations in determining cap component thicknesses are described below; detailed cap designs for each area and values for each thickness component are presented in Subsections 5.4, 5.5, and 5.6.

In addition, the following definitions are used in this design:

- **Minimum cap thickness per EPA guidance**—The minimum cap thickness that must be initially constructed, as determined following EPA design guidance (USEPA 1998). This thickness is the sum $T_b+T_e+T_c+T_i$. The cap thickness for operational considerations (T_o) is dealt with as an overplacement allowance, described below.
- **Required cap thickness**—The minimum cap thickness the Contractor must construct in all locations, based on this design. The required thickness is at least

as thick as the sum $T_b+T_e+T_c+T_i$, and in some cases may be set at a greater thickness due to engineering and materials considerations. Construction monitoring will confirm that the required thickness is met at all locations.

- **Overplacement allowance**—The maximum additional cap thickness the contractor can place, above the required cap thickness. The overplacement allowance accounts for inaccuracies in placement, and accounts for T_o. The contractor will not be paid for cap thicknesses greater than this.
- **Actual constructed thickness**—The actual thickness placed by the contractor, as measured by surveys at the end of construction. The actual constructed thickness will vary between the required cap thickness and the required cap thickness plus the overplacement allowance. Corrective actions by the contractor will be required if the actual constructed thickness is outside the specified range.
- **Minimum long-term cap thickness**—The minimum cap thickness that must remain over time, in order to maintain all of the protective functions of the cap. For unarmored caps, the minimum long-term cap thickness is equal to T_b plus $T_{i,}$. For armored caps, the minimum long-term cap thickness is equal to T_e plus T_i. If long-term monitoring detects a cap less than the minimum long-term thickness, additional investigation and/or cap repair will be required. Monitoring procedures to ensure that the minimum long-term cap thickness is maintained will be determined in the Long-Term Monitoring and Reporting Plan.

5.1.1 Evaluation of Bioturbation Thickness

Evaluation of the required bioturbation cap thickness is based on a review of existing information. The biologically active zone is generally taken to be the top 10 cm of sediment, and compliance with the Washington State SMS (WAC 173-204) is based on samples from 0 to 10 cm. However, it is well known that some burrowing animals may exist at greater depths. Most benthic species live in the oxic (i.e., oxygenated) sediment zone, which in the Puget Sound region commonly extends only about 10 cm into the sediment. However, under favorable conditions, some benthic species are known to burrow as deep as 6 ft. Deep burrowing species either use siphons to draw oxygenated water from overlying water, or live in burrows connected to the overlying water, which can provide a microhabitat of oxygenated conditions. Deep-burrowing species include the geoduck (*Panope abrupta*) and ghost shrimp (*Neotrypaea* spp.), both of which can be found as deep as 30 in. (75 cm). Members of the polychaete worm family, Chaetopteridae, live in tubes that can extend to depths up to 6 ft (2 meters) in sandy sediment.

No benthic community data for Slip 4 were identified in the EE/CA (Integral 2006a). The following descriptions are based on communities in similar habitat types and the limited monitoring results from other locations in the Duwamish. Cordell et al. (1994, 1996) sampled benthic invertebrate communities at two intertidal reference sites in the Duwamish: Kellogg Island and the turning basin. The grain sizes at these two locations are similar to intertidal areas at Slip 4, containing approximately 35% fines. Mean porewater salinities at Kellogg Island and Turning Basin No. 3 (10.8 and 5.3 ppt, respectively) likely bracket those at Slip 4. Intertidal benthic invertebrate assemblages were similar to other locations in the Duwamish River estuary. Although there were differences between sites, the dominant benthic macrofauna included nematodes, oligochaetes, the gammarid amphipod *Corophium* spp., the cumacean *Leucon* sp., the polychaetes *Manayunkia aesturina* and *Hobsonia florida*, and several species in the family *Spionidae.* The bivalve *Macoma* spp. was present at most stations. The benthic meiofauna (smaller marine organisms) community was dominated by harpacticoid copepods and nematode worms (Cordell et al. 1994, 1996).

Shellfish in the LDW include crab, shrimp, clams, and mussels. Windward (2004c) identified the beach along the east side of Slip 4 as high-quality clam habitat; the area at the head of the slip was categorized as low-quality habitat. Quantitative clam surveys included sampling at the east beach. The survey in July 2003 reported two clams (tentatively identified as horse clams [*Tresus capax*]) in Slip 4. In the August 2003 survey, Windward (2003c) reported finding eight clams in Slip 4, including two Baltic tellins (*Macoma balthica*), three bent-nose clams (*Macoma nasuta*), and two sand gapers (*Mya arenaria*).

Geoducks were not found at Slip 4 but are known to be present near the mouth of Elliott Bay. Bent-nosed clams (*Macoma nasuta*) are present at Slip 4, and can be found as deep as 6 in. (15 cm) at other locations within Puget Sound.

The majority of species and abundance of individuals at Slip 4 are shallow-burrowing organisms that inhabit the oxic top 4 in. (10 cm) of the sediment. To allow an additional degree of protection, the thickness of the bioturbation layer (T_b) in subtidal areas is 6 in. (15 cm). This value is consistent with the design bioturbation thickness selected for the Eagle Harbor and PSR caps in Puget Sound. Although some burrowing species may extend deeper than this, 6 in. is considered to be conservative given the presence of other cap layers, the additivity of the equation for cap thickness determination, and the potential multiple functions provided by the other thickness components. Also, the species present at Slip 4 that are found deeper than 10 cm in sediment at other locations within Puget Sound are generally either species with siphons that can draw water from at or slightly above the sediment-water interface, or are species that live in burrows connected to the overlying water, which can provide a microhabitat of conditions different from the conditions found at depth within sediment.

Ghost shrimp prefer intertidal to shallow subtidal habitats, and sandy silt to silty sand substrates. It is under these conditions that high densities of ghost shrimp burrows tend to exist, which could potentially result in deeper horizons of significant bioturbation (Stivers 2002). At Slip 4, the cap in the intertidal and shallow subtidal elevations will be relatively thick and composed of gravels and sands, which will tend to both decrease burrow density and provide sufficient cap thickness in the unlikely event of deeper bioturbation. Also, EPA has indicated that ghost shrimp are not present in river systems such as the Duwamish (USEPA 2006c).

The presence of burrowing organisms at depths greater than 6 in. (15 cm) would have no effect on chemical transport, as long as the organisms do not penetrate into the bottommost, chemical isolation horizon of the cap. If the deeper-burrowing organisms such as ghost shrimp do penetrate into the chemical isolation layer (or into the underlying contaminated sediments), then little in the way of sediment mixing is expected to occur. Some facilitated diffusion of contaminants may occur, as contaminants diffuse from the porewater, into the macroscopic burrows, and then out through the sediment cap. However, during the predesign investigation, it was determined that the contaminant concentrations in the porewater of the contaminated sediments (as measured by seeps) are generally below water quality criteria, and as previously noted, circulation of water within the burrows creates a microhabitat that would further decrease contaminant concentrations in the burrows. Such facilitated diffusion is therefore not expected to significantly affect the cap life.

In addition to bioturbation by benthic organisms, human activities such as potential future shellfishing could cause localized disturbances in unarmored, intertidal areas of the cap. For this reason, T_b is set at 36 in. in unarmored, intertidal areas. This additional thickness is intended to provide an additional margin of safety for possible localized cap disturbance by potential shellfishing activities, and will ensure that Native American shellfishing treaty rights are not limited by the presence of the cap.

In summary, bioturbation thicknesses are specified as follows:

- In subtidal areas, a T_b equal to 6 in. is considered adequate to prevent burrowing aquatic organisms from penetrating into deeper cap horizons.
- In unarmored intertidal areas, a more conservative T_b equal to 36 in. is used to account for potential human disturbances of the cap in the intertidal area, through such activities as shellfish harvesting or other recreational digging. This value for T_b will also protect burrowing aquatic organisms.
- In armored cap areas, a T_b equal to 6 in. is conservatively assumed to account for organisms that may establish in the interstices of the armoring. However, in armored areas, the cap functions for erosion resistance and bioturbation are

considered as a combined component, because the physical armor layer serves to both stabilize the cap and is the same layer in which bioturbation occurs. Therefore, the combined T_b/T_e thickness component is taken as the greater of 6 in. (T_b) or the required armor layer thickness (T_e).

5.1.2 Evaluation of Erosion Thickness

Appendix C presents an evaluation of erosive forces acting on the cap. This analysis includes an evaluation of wind-driven waves, boat wakes, propeller wash, and outfall scour, and is summarized in Section 5.3.

5.1.2.1 Erosion Thickness for Armored Caps

For areas subjected to repeated attack from erosive forces, the approach taken in this design is to develop materials specifications for armor layers consisting of particle sizes that resist the calculated erosive forces, with an appropriate factor of safety. The value of T_e for these armored areas is the required thickness of the engineered armor layer. This required armor layer thickness is determined by engineering analysis and best professional judgment considering the gradation of the armor layer stone. In general, T_e for armored caps is at least as thick as the greater of following general guidelines (USACE 1995):

- Twice the nominal diameter of the median stone size
- 25% greater than the nominal diameter of the largest stone
- Greater than 1 ft.

Based on the engineering analyses in Appendix C, armored caps include a T_e of 18 in.

5.1.2.2 Erosion Thickness for Unarmored Caps

Designing for no allowable movement of cap particles would result in an armored design for the entire Slip 4 EAA cap, which is inconsistent with the habitat goals for the project and is not necessary for ensuring the long-term protectiveness of the cap. For the remaining unarmored areas of the cap, the approach taken in this design is to develop materials specifications for cap material particle sizes that resist regularly occurring erosive forces, but that may experience some limited movement under infrequent, random events or natural nearshore processes.

The erosion analysis (Section 5.3) identifies cases where a recreational vessel could generate propwash velocities that could move unarmored cap particles; however, this occurrence would be infrequent and random, and the depth of any scour would be small given the typically short duration of such events. Similarly, waves from vessel wakes that shoal and break in gently sloping intertidal areas may cause cross shore (back-and-forth) motion of gravel particles, and over time these beach areas may naturally reshape. These processes indicate the potential for minor mixing or redistribution of surficial cap material over time. Given the configuration of the slip, there is little potential for movement of cap material offsite.

Rather than design an armored cap, an additional thickness to accommodate this potential redistribution of cap material is included in the cap thickness design. To account for minor reshaping of the intertidal areas by wave action, or minor movement of cap material due to recreational vessels or unanticipated vessel activities in the Crowley Marine Services area, a T_e of 12 in. is specified as a "sacrificial" layer in unarmored RAs. This approach is consistent with EPA guidance for stabilization/erosion protection (USEPA 1998). With this approach, possible future minor movement of surficial cap materials or reshaping of intertidal areas will not necessitate cap maintenance, unless the cap decreases over time to the specified minimum long-term cap thickness.

5.1.3 Evaluation of Cap Consolidation Thickness

Evaluation of cap consolidation thickness (T_c) is based on the properties of cap materials, which will generally consist of granular materials. The specified granular upland materials are essentially self-consolidating in a short timeline, and no additional cap thickness is needed to allow for long-term consolidation of the capping material itself. Thus, T_c is equal to 0 in. for all caps.

It is noted that underlying sediments will consolidate under the cap load, and this consolidation is evaluated in Appendix E.

5.1.4 Evaluation of Chemical Isolation Thickness

The chemical isolation thickness (T_i) considers the movement of contaminants upward into the cap over time through long-term diffusion, advection, and dispersion, as well as short-term expression of contaminated porewater into the cap after placement. Appendix D presents the chemical isolation analysis used to specify the value of T_i. T_i is set at 12 in. for all cap areas. Specifications for required organic carbon content of the cap materials are based on this analysis.

5.1.5 Evaluation of Operational Thickness

The operational thickness (T_o) component of the cap is primarily related to the ability to place a relatively uniform cap layer, although other factors are also considered.

5.1.5.1 Placement Accuracy and Overplacement Allowance

Any placement technique will result in some unevenness of the cap, and subaqueous caps cannot be constructed to the tolerances typical of those in terrestrial earthwork projects. The value allowed for T_o in the design is based on:

- The anticipated placement technique (e.g., placement with a bucket)
- Water depths
- Cap material properties
- Bottom roughness and slopes
- The number of cap material layers.

For Slip 4, the following approach is used for including T_o into the cap thickness design. For the purposes of developing plans and specifications, T_o is not added to the required cap thickness, but rather is included as an "overplacement allowance." Thus, the contractor will be required to achieve the minimum cap thickness in all locations, and will be paid for overplacement of material only up to the additional overplacement allowance. T_o is specified based on engineering judgment for conditions at the site and experience at other sites. Overplacement allowances account for potential inaccuracies and unevenness of cap construction, and provide a degree of assurance that the entire capping area will be covered with at least the minimum required thickness necessary for cap function.

The total overplacement allowance for all caps is 12 in., and caps with multiple layers have overplacement allowances for each layer. As described at the beginning of Section 5, construction monitoring will confirm that the required thickness is met at all locations. The actual constructed thickness will vary between the required cap thickness and the required cap thickness plus the overplacement allowance. Corrective actions by the contractor will be required if the actual constructed thickness is outside the specified range.

5.1.5.2 Additional Operational Considerations

The following additional operational issues were considered in the cap design:

- **Vessel anchoring.** To prevent damage to the cap, the selected remedy includes ICs to prohibit large commercial vessels from operating or anchoring in the cap area. While recreational vessels may anchor in the cap area, the area impacted by these anchors is very small, and penetration depth is typically limited to 1 to 2 ft (Palermo et al. 1998). When the anchors are removed, the disturbed area is quickly filled. Thus, no additional operational thickness for recreational vessel anchoring is required.
- **Consolidation of underlying sediments.** The verification method for cap thickness during construction is comparison of pre- and post-cap surveys. As described in Section 5.2.8, several inches of consolidation may occur before these surveys are complete. The contractor will be required to attain the required cap thicknesses as measured by pre- and post cap surveys, regardless of the effects of

consolidation. Because some of the consolidation of underlying sediments will occur during the construction period, slightly more than the required cap thickness will need to be placed by the contractor so that the surveys indicate the required thickness is met. It is anticipated that, in general, additional cap material that is placed as part of the overplacement allowance will compensate for the effect of consolidation. In any case, sufficient thickness will be placed such that the final acceptance survey indicates the required thickness is met in all locations. Overall, this effect will result in a cap that is on average several inches thicker than the required thickness.

- **Mixing with underlying sediments.** As cap material is placed, a limited amount of mixing will occur between the lowest horizon of cap material and the underlying sediments. Experience has shown that this mixing is minimal for a carefully placed cap, and the specifications include elements to minimize the potential for such mixing. Further, some intermingling of particles does not decrease the capacity of the isolation layer to adsorb dissolved-phase contaminants, and thus the function of the chemical isolation layer is not expected to be decreased by this effect.

In summary, no additional operational thickness components are considered necessary for these operational factors.

5.2 SLOPE STABILITY AND BEARING CAPACITY ANALYSES

5.2.1 Purpose

This section presents a summary of analyses conducted to assess the stability of the engineered sediment caps along the banks and within the slip. The analyses focus on the following design considerations:

- Existing stability of the bank slopes under static conditions
- Predicted long-term slope stability under both static and earthquake loading conditions
- Predicted bearing capacity and consolidation of underlying sediments to determine cap placement requirements
- Predicted effects of pier removal on Crowley's existing bulkhead.

5.2.2 Critical Design Slopes

The primary areas of concern for static and seismic stability evaluations of the Slip 4 cap are the relatively steep bank areas. The site includes five bank zones as shown in Figure 1-6**.** Engineered sediment caps will be constructed on Zones 2, 3, 4, and 5. An existing bulkhead and pier is present in zone 1, and the pier is to be removed. For the purpose of slope stability analysis, two slope areas were identified that are representative of the most critical slope conditions at the site. The steep banks on the west side of the slip present the greatest potential for localized slope failures, and caps on this bank will be constructed at slopes ranging from 2H:1V to a comparatively flat 3.5H:1V. Caps at Stations 2+80 and 6+00 (constructed to slopes of 2H:1V) were chosen as representative bank areas for stability analyses. The remainder of this section focuses on these two areas. Three scenarios were evaluated for each section: 1) existing conditions, 2) post-construction (after capping) under static loading conditions, and 3) post-construction under pseudo-static loading conditions.

The slope cap is a nominal 3-ft-thick layered granular cap that will be placed on the bank slopes up to elevations ranging from +15 MLLW in Zone 5 to +17 MLLW in Zones 3 and 4. The slope cap will consist of layers of sandy gravel filter material, rock armor for erosion protection and slope stability, and a surface layer of sandy fine gravel for improved habitat.

5.2.3 Method of Analysis

5.2.3.1 Loading Scenarios

During the life of the project, the slopes will experience shearing stresses resulting from different loading conditions. These loading conditions are defined as undrained loading, drained loading, and seismic loading, and are described below.

- Undrained loading, often referred to as the short-term condition, occurs during and immediately after cap placement. As the cap is constructed, porewater pressures increase in the soil under the cap due to the weight of the cap material. In underlying fine-grained layers, it takes more time to dissipate these excess porewater pressures. The soil strength is not changed by the porewater pressures in the short term and increases in the long term. This condition was not evaluated in the slope stability analysis because the existing slopes are stable, and regrading and capping is expected to improve the stability of the slopes.
- Drained strength, also referred to as the long-term condition, is achieved when excess porewater pressures in both the fine-grained and granular layers have dissipated after the cap has been fully constructed. The property used in slope stability analysis that describes this drained condition is internal angle of friction. Drained strength parameters were assigned to the site soil and proposed capping materials to analyze the long-term condition for both the existing slopes and the proposed capped slope configuration.
- Seismic loading is experienced during an earthquake event. Slope stability during earthquakes is evaluated using various approximations. Since the actual forces

generated during an earthquake cannot be estimated with certainty, a simplified, pseudo-static approach was used for the Slip 4 analysis. In this analysis, the existing drained soil strength parameters are used because the peak accelerations occur before soil has time to lose strength due to liquefaction. A pseudo-static analysis assumes that inertial horizontal forces resulting from an earthquake are applied to soil layers in addition to the vertical gravitational and hydrostatic forces acting on soil masses during static conditions.

The following loading scenarios were considered for each slope condition. The existing slopes were analyzed under static loading conditions to evaluate the assumed soil parameters and to calibrate the slope stability model. The post-construction scenario (following cap placement) was analyzed to verify that the planned regrading and capping work would have acceptable slope stability, under both static and seismic loading conditions.

5.2.3.2 Stability Model

The stability of the slopes was modeled using the computer program, WINSTABL©, developed at Purdue University. WINSTABL is a 2-dimensional, limit equilibrium slope stability program. The program uses an adaptation of the Modified Bishop Method of Slices to calculate factors of safety for potential surfaces of sliding. The factor of safety is defined as a ratio of shear strength of soil divided by the shear stress induced by gravity acting on the soil mass.

5.2.3.3 Acceptable Factors of Safety

A static factor of 1.5 or greater is recommended for long-term stability of slopes. A factor of safety between 1.3 to 1.4 is generally accepted for short-term stability of slopes (during construction) and may be acceptable for long-term static stability in those situations where the theoretical failure surface is shallow and/or where the potential consequences of failure are considered to be manageable within the long-term operation and maintenance of the site. For pseudo-static analyses, a factor of safety of 1.0 is considered acceptable and indicates that the slope is expected to be stable under earthquake loading conditions.

5.2.3.4 Description of Existing Slopes and Bed Material

Geologic cross-sections were developed using recent bathymetric and site investigation data. In addition, data from available historical investigations of the area were incorporated in the sections. Soil properties were defined for each geologic unit on the basis of geotechnical laboratory test results collected during the pre-design investigation (Appendix A), and using published correlations presented in the literature.

The upland areas adjacent to Slip 4 are mostly flat and generally consist of approximately 15 ft below ground surface (bgs) of fill material (sands and gravels). The bank slopes around the head of the waterway typically range between 1.5H:1V to 2.5H:1V. The subsurface soil and sediment within the Slip 4 banks consists of sands and silts with some gravels. The bed surface, at the toe of the slope (top 2 to 5 ft bml), is generally a sandy silt to clayey silt that stiffens with depth. Native sand material is present in the channel at depths ranging from 5 to 30 ft below MLLW.

Stations 2+80 and 6+00 were evaluated, as discussed previously. In Zone 3 (Station 2+80), the top of the bank elevation is at approximate elevation +17 ft MLLW. The existing bank slope in Zone 3 in the vicinity of Station 2+80 varies from 4:1 at the toe to the middle of the slope then 1:1 from the mid point of the slope to the top of slope. In Zone 5 (Station 6+00), the top of the bank elevation is at approximately +15 ft MLLW. The bank slope in Zone 5 in the vicinity of Station 6+00 is approximately 1H:1V. In all areas, much of the bank is within the tidal range (the extreme low tide is approximately -4 ft MLLW; extreme high tide is approximately +13 ft MLLW).

The bank on the west side of the slip (Zone 1) under the Crowley pier is covered with riprap next to a vertical bulkhead, with sediment deposits under the outer edge of the pier. The riprap slope beneath the pier is typically 1.5H:1V and is considered to be relatively stable.

5.2.3.5 Model Input Parameters

The geologic cross-sections and assumed soil properties used for slope stability analyses are presented in Appendix E, and summarized in Table 5-1. These parameters represent a reasonably conservative interpretation of the existing sediment and soil conditions within the slip, and proposed capping materials.

5.2.3.6 Piezometric Surface

The piezometric surface was defined for each cross-section. The elevation of the ground water in the upland area and the water surface in the waterway affect the slope stability factor of safety. The lowest factor of safety occurs during periods of low tide, when the water elevation in the waterway is lower than the inland water table. The factors of safety are greater when the tide is at mean sea level and greatest at high tide.

The piezometric surface was conservatively based on an assumed upland groundwater table at +6 to +7 ft MLLW, sloping down near the shoreline, to meet the surface water at low tide condition within the waterway of +0 ft MLLW. The extreme low tide condition was not analyzed, given the relatively conservative assumption used for the upland groundwater elevation at the shoreline.

5.2.3.7 Seismic Ground Acceleration

For the pseudo-static analysis, an appropriate value for ground acceleration in the soil mass is a required input parameter in the slope stability program. Seismic analyses for similar slopes and slope caps in the Pacific Northwest have utilized a maximum peak horizontal ground acceleration value of 0.15 g to representative a 100-year seismic event (e.g., Tetra Tech 2003). This value is consistent with the values for Seattle given in Kramer (1996) for an earthquake with approximately a 100-year return interval. Based on standard engineering practice, the horizontal inertial forces for the pseudo-static analysis were calculated using a horizontal ground acceleration factor equal to one-half of the maximum peak ground acceleration (i.e., 0.075 g).

Regional designs for facilities such as containment dikes for confined disposal facilities and slopes under bulkheads have been designed using higher ground accelerations based on a 475 year seismic event. This design criterion is not considered appropriate for Slip 4 slope caps given the relatively low consequences of failure associated with minor slope sloughing (e.g., absence of adjacent upland structures, absence of potential risks to public safety, and relatively low concentrations of bank soils that might be temporarily exposed). In the event of a major earthquake, any sloughing of cap material on slope areas could be easily detected and repaired.

5.2.4 Summary of Results

5.2.4.1 Existing Slope Stability

Results from the analysis of the existing slope stability are presented in Table 5-2. Model outputs are presented in Appendix E. The estimated factor of safety for the existing condition at Station 2+80 is 1.5. At Station 6+00, the estimated factor of safety for the existing condition is 1.2.

These results indicate that the existing slopes are relatively stable, although less than optimal at Station 6+00. It should be noted that the results do not reflect localized erosion and sloughing failures that appear to be occurring in certain slope areas around the slip. Rather, the analyses focused on identifying critical failure surfaces of greater consequence deeper within the slope.

5.2.4.2 Capped Slope Stability

As described above, the proposed cap is a nominal 3-ft-thick granular cap that will be placed on the bank slopes. Results for both the static and pseudo-static stability analyses for the post-construction capped slopes are summarized in Table 5-2. Model output for these runs is presented in Appendix E.

For Station 2+80, the estimated factor of safety for the proposed slope under static loading conditions is 1.4, consistent with the target value for long-term slope stability. The slight reduction in the factor of safety, relative to the existing slope, is a reflection of the conservative strength parameters assumed for the cap material and minor changes in the overall slope. For Station 6+00, the factor of safety for the proposed slope is greater than the existing condition (1.6 vs. 1.2) due to proposed flattening of the overall slope, coupled with the buttressing effect of the thickened cap to be placed at the toe of the slope.

The estimated factors of safety under seismic loading conditions at Stations 2+80 and 6+00 are both 1.2, which is considered acceptable for seismic design and indicates that the slopes are expected to remain stable. As discussed in the following section, there is a slight potential for localized slope failures due to liquefaction effects during an earthquake.

5.2.5 Liquefaction Analysis

5.2.5.1 Method of Analysis

Liquefaction is the process where saturated soil or sediment loses shear strength during an earthquake due to build-up of porewater pressures. Due to the complexity and variability of ground motions during earthquakes, it is not possible to develop precise mathematical models to liquefaction behavior during an earthquake or to quantify the changes in shear strength and compressibility. For this project, a common empirical approach was used to identify which sediment is susceptible to liquefaction during the design earthquake.

Liquefaction susceptibility was assessed using an empirical method based on standard penetration test (SPT) blow-count data, or "N-values" (Kramer 1996; NAVFAC 1983). In this approach, a factor of safety is calculated that is defined as the ratio of the cyclic stress ratio (CSRf) where liquefaction is likely to occur divided by the CSRi predicted to occur at the site during an earthquake. The value of CSRf is based on published correlations between SPT values and the CSR where liquefaction has been observed in past earthquakes. The value of CSRi is calculated based on sediment properties and the ground acceleration expected for the design earthquake.

5.2.5.2 Summary of Results

The liquefaction analysis is presented in Appendix E. The factor of safety against potential liquefaction for the design earthquake (100-year seismic event), with peak ground acceleration of 0.15g, was calculated for each SPT value in the deep borings performed for this study (SC19 to SC22). The assessment showed that those areas where the sediment consists of fine to medium sand with SPT less than about 15 is susceptible to liquefaction.

The results of the liquefaction analysis for the major sediment units at the site are discussed below:

- The SPT for the near-surface sand and gravel fill (Soil 3) ranged from 3 to 9 for the three samples. The gravel layers are not susceptible to liquefaction since the porewater pressures dissipate rapidly during an earthquake. The area where the SPT is 9 is not susceptible to liquefaction. The areas where the SPT values are 3 to 5 are susceptible to liquefaction.

- No SPT measurements were taken in the silt since the samples were collected by pushing Shelby tubes. Silt and clay are not susceptible to liquefaction at the design level earthquake, so no further analysis is necessary.
- The upper silty sand unit (Soil 5) had two SPT measurements that were 3 and 14. The area where the SPT is 14 is not susceptible to liquefaction. The area where the SPT is 3 is susceptible to liquefaction.
- The deeper sand unit (Soil 7) had SPT values that ranged from 4 to greater than 50. The sand in boring SC20 has SPT values from 4 to 7, and this area is susceptible to liquefaction. In borings SC19, SC21, and SC22, all the SPT measurements were greater than about 20, and the sand in these borings is not susceptible to liquefaction.

In summary, the above assessment indicates that there is a potential for localized areas where the sediment would lose some shear strength and become vulnerable to liquefaction during a 100-year design earthquake. However, widespread liquefaction is not predicted. While small localized slope failures could occur from liquefaction in isolated locations on the banks of Slip 4, design measures to prevent such occurrences are not warranted given the uncertainty and cost associated with such designs, and the relatively low consequences associated with a localized slope failure. Should they occur, such localized failures on slopes would be identified through visual inspections as part of the long-term monitoring program, and repairs (if needed) could easily be accomplished by re-dressing and armoring the impacted slopes. The remainder of the sediment cap on the bed of the slip would not be significantly affected by the design earthquake.

As described above, it is not possible to develop precise mathematical models to quantify changes in soil and sediment strengths during and after an earthquake. The above liquefaction susceptibility analysis shows that conditions vary along the length of the waterway; there are some zones where liquefaction may occur and zones where it is not expected during the design earthquake. Because additional analyses would not change these conclusions, further liquefaction analyses are not recommended.

Finally, it is also important to note that only a portion of the slope caps are designed as steep (2H:1V) as the modeled slopes. Most areas are considerably flatter (between 2.5H:1V and 3.5H:1V) and will have greater factors of safety than the modeled slopes.

5.2.6 Crowley Pier Slope Evaluation

As described in Section 3, the design includes removal of the portion of the Crowley pier in the cap area, which could involve either extraction of the support piling or cutting the piling at the mudline. The option of piling extraction is evaluated in this section.

One potential impact of piling extraction is that the slope stability could be reduced. This is not a concern for the stability of the adjacent sediment cap, but is a concern for Crowley's bulkhead and upland property. This section gives a qualitative evaluation of the potential impact of removing the existing Crowley piling support on the stability of the adjacent slope.

Theoretically, vertical piles driven below the depth of potential earth sliding increases the slope stability factor of safety. Tschebotarioff (1973) gives an example of a pile-supported trestle built over a slope on soft clay where the piles were moving laterally several inches. At that site, the post-construction slope stability analysis showed that the factor of safety was 0.92 without piles. Based on laboratory model tests and an approximate evaluation of the benefits of the piling, the factor of safety with pile reinforcement was estimated to be about 1.08.

It is standard practice to design slopes without considering the benefit of piles, which is consistent with the recommendation of Tschebotarioff (1973). There are practical reasons for not using piles to reinforce slope stability. One reason is that lateral displacement of the soil mass and piles is required in order to develop the pile resistance force. In a stable slope with no movement, the piles do not exert any lateral support for the soil mass. Lateral displacement of the soil would lead to lateral displacement of the piles and dock structure, which would have a detrimental effect on the dock structure. Another reason is that the piles would have to be designed to resist stresses imposed by the soil mass in addition to the stresses imposed by the dock loads. This would result in the need for larger, more expensive piling and is not done in standard engineering design.

As indicated in the example described above, a slope stability factor of safety of 1.0, or slightly less than 1.0, does not necessarily mean that the slope will fail. It usually indicates that there will be significant lateral displacement, which may or may not be followed by soil failure. If the existing piling has not shown signs of lateral displacement since installation, this is an indication that the slope is stable without the added resistance of the piling. On the other hand, if the piles or pier show signs of lateral displacement towards the waterway, this is an indication that the slope is marginally stable, and removal of the piling may reduce the stability below an acceptable level. Structural inspections conducted in preparation of the planned Crowley pier demolition did not reveal any signs of lateral movement or distress of the bulkhead, piling, or pier structure, although the sheetpile bulkhead itself exhibits significant lateral offsets likely associated with its original construction. The deck of the pier does not exhibit signs of lateral movement.

In summary, it is standard practice to design slopes to have a factor of safety of 1.5 without considering the lateral support of piling. Assuming that this procedure was used for the slope under the Crowley pier, then removing the piles would not reduce the slope stability factor of safety below an acceptable level. The performance of the pier is another line of evidence on slope stability. Given that the piles and pier structure do not show signs of lateral movement, then the piles are probably not providing lateral support for the slope and could be removed. However, as explained in Section 3, the design specifies cutting the concrete piling, which will provide a somewhat more conservative approach to maintaining the stability of this existing slope and bulkhead. The timber fender piles are not considered structural parts of the pier, and will be extracted as described in Section 3.

5.2.7 Bearing Capacity Analysis

One important factor in design of caps over extremely soft sediment is the ability of the sediment to support the weight of sand cap. This section evaluates this factor, and the evaluation is used to define allowable thicknesses of cap lifts in the specifications.

5.2.7.1 Cap Bearing Capacity Method of Analysis

During construction, the cap material is placed in parallel rows. Each row applies stresses to the underlying sediment similar to that of a long wall footing. The cap bearing capacity was evaluated using this foundation analogy, and the ability of soft, fine-grained surface sediment to support the cap was evaluated using foundation-bearing capacity equations, which are given in geotechnical engineering textbooks and design manuals such as NAFVAC (1982).

In order to apply bearing capacity equations to fine-grained sediment, the undrained shear strength must be known. The undrained shear strength was measured in unconsolidated, undrained triaxial shear tests on samples from borings SC20 and SC 21 (Appendix A). The results showed undrained shear strengths of 50 to 260 psf, which is consistent with conditions observed at similar sites in the Puget Sound (Otten and Hartman 2002).

5.2.7.2 Bearing Capacity Results

For a footing on the surface, the ultimate bearing capacity is equal to the bearing capacity factor, Nc, times the undrained shear strength, where Nc is 5.5 for continuous footings. The lowest shear strength measured in the laboratory test was for the sample at a depth of 1.0 ft bml, which is consistent with soil mechanics theory and experience. For the case where cap material is placed on existing soft sediment without dredging, this is the appropriate value to use in bearing capacity calculations.

Adopting the lower shear strength value for the surface sediment (50 psf) and Nc value (5.5), the ultimate bearing capacity of the surface sediment is estimated to be approximately 275 psf. For foundation design, a factor of safety of 3 is typically used. For sediment capping design, a lower factor of safety is reasonable because the only impact if the underlying sediment "fails" would be lateral displacement of the near-surface sediment. With a factor of safety of 2, the bearing capacity would be 138 psf. This is equivalent to the load applied by approximately 2 ft of cap material (sand with a total buoyant unit weight of 60 psf).

In summary, based on this conservative interpretation of the data and simplified analytical approach, the maximum recommended lift thickness during cap placement is 2 ft in areas where the cap is placed over very soft sediment without dredging. Placement of thicker lifts could be performed in areas where softer surface material has been removed by dredging.

5.2.8 Consolidation Evaluation

Consolidation of underlying sediments after cap placement was evaluated for two purposes:

- To consider short-term effects of consolidation and porewater expression on the chemical isolation function of the cap; and
- To consider interpretation of bathymetric surveys (construction monitoring and long-term monitoring) so that settlement is not misinterpreted as cap loss.

The weight of materials placed for capping results in settlement of native sediment under the cap. Coarse-grained material, such as sand and gravel, compresses quickly during the period of construction. Saturated fine-grained sediments, such as silt and clay, compress slowly because the soil particles can not compress until the porewater is forced out of the sediment. The process of slow settlement as the porewater pressures dissipate is called consolidation settlement.

5.2.8.1 Estimated Magnitude and Timeframe of Consolidation

The magnitude and rate of consolidation settlement depend on the sediment properties, sediment thickness and the increase in stress due to the new load. The thickness and properties of the soft silt vary within the waterway. A cap thickness of 3 ft of sand and gravel was used for all the cases. The consolidation settlement was calculated for four cases:

1. Areas where the soft silt is 8 ft thick with the most compressible silt and the cap is placed directly over the native sediment without dredging (represented by boring SC21).
2. Areas where the soft silt is 8 ft thick and the cap is placed after dredging 3 ft or more.
3. Areas where the soft silt is 6 ft thick with low compressibility and the cap is placed directly over the native sediment without dredging (represented by boring SC20)
4. Areas where the soft silt is 6 ft thick and the cap is placed after dredging 3 ft or more.

The consolidation calculations are presented in Appendix E. The results of the calculations are summarized below in Table 5-3.

In summary, most cap areas are expected to experience only about 2–3 in. of settlement, and in most areas this settlement will be 90% complete in about 2–3 weeks. Core SC-21 was purposely located in the area of the slip with the thickest deposits of soft silt. In this localized area (representing the northern portion of the former inner berth where up to 10 ft of shoaling has occurred since 1981), up to 9 in. of settlement may occur and would be 90% complete in about 5 weeks. This will be important to consider in evaluating post-cap survey information during construction and long-term monitoring.

5.2.8.2 Construction Implications

The contractor will be required to attain the required cap thicknesses as measured by pre- and post-cap surveys, regardless of the effects of consolidation. Because some of the consolidation of underlying sediments will occur during the construction period, slightly more than the required cap thickness will need to be placed by the contractor so that the surveys indicate the required thickness is met. It is anticipated that, in general, additional cap material that is placed as part of the overplacement allowance will compensate for the effect of consolidation. In any case, sufficient thickness will be placed such that the final acceptance survey indicates the required thickness is met.

5.2.8.3 Long-Term Monitoring Implications

Long-term cap monitoring will include comparison of periodic surveys against the as-built survey information (i.e., comparative bathymetry). Depending on the timing of cap placement and final acceptance surveys, several inches of consolidation could occur after construction is complete and before the first long-term monitoring event (i.e., within the first year). It is estimated that this post-construction settlement would be no more than 6 in. (and in most locations less than 2 in.), which would be the general range of achievable inter-survey precision, and would not be identified as a concern. However, in the event that significant apparent cap thickness losses are detected in the first year of comparative bathymetry, the potential for consolidation should be considered when interpreting the results. Responses could include additional engineering analysis, more frequent monitoring, through-cap coring, or other methods such as sub-bottom profiling to assess actual cap thickness. Specifics will be defined in the Long-Term Monitoring and Reporting Plan.

5.2.8.4 Chemical Isolation Implications

The worst-case settlement of 9 in. was used in the chemical isolation analysis (Appendix D) to assess short-term effects of consolidation and porewater expression on the chemical isolation function of the cap. The analysis in Appendix D found this effect to be negligible.

5.3 EROSION ANALYSIS

Erosive forces that affect the cap design in Slip 4 include wind-generated waves, vessel waves, propeller wash, and outfall scour. These are evaluated in Appendix C and summarized below.

5.3.1 Wind-Generated Waves

Slip 4 is an extremely sheltered feature, and the maximum fetch for wave generation due to winds is less than 2,000 ft. Quantitative modeling at the more exposed Duwamish/Diagonal site estimated that wind-generated waves would be a maximum of 1 ft (Anchor 2003). At Slip 4, maximum wind-generated wave heights are expected to be less than 1 ft. At Slip 4, vessel-generated waves are more important for erosion protection design than wind-generated waves.

5.3.2 Vessel Waves

A conservative estimate of the maximum vessel-generated wave heights (Hm) for a tugboat operating in Slip 4 is taken from empirical data (USACE 2002). At a distance of 100 ft from the tug, a value of Hm = 0.5 m (1.6 ft) would be associated with a tug operating at a speed of 5.1 m/s (10 knots). This vessel speed is considered unlikely but is used as a conservative upper bound. Therefore, a 1.6-ft wave is selected as the design wave height for the site and is used in determining the cap material specifications for erosion resistance on capped slopes. Appendix C summarizes the slope cap analysis for armor sizing. The slope caps include an armor layer with a minimum average weight (W_{50}min) of 50 pounds per armor unit.

5.3.3 Propwash Analysis

5.3.3.1 Propwash Analysis and Results

Tug activities in the middle berth area of Crowley's portion of the slip were modeled to assess propwash forces on the sediment cap. The propwash analyses followed USEPA guidance (USEPA 1998). Western Towboat (the current contractor for vessel movements in Slip 4) was contacted for descriptions of their tug and barge operations. The heaviest tug (the *Westrac II*) was modeled with two water depths (10 ft representing the top of a 3-ft cap at the riverward end of the cap and 13 ft representing the existing depth at the riverward end of the sand/gravel cap). The *Westrac II* has a rated power of 2,400 hp with two propellers. Western Towboat indicated they may use up to 50% power on one propeller oriented parallel to the dock when departing. This was used for propwash calculations with various lengths between the barge and the edge of the cap.

To specify the required armor size, movement of both a 100-ft and a 200-ft-long barge located at the northern end of the Crowley dock was modeled. The resulting maximum velocity at the surface of the sediment cap is 1.64 ft/sec, and the required D_{50} rock size is 0.174 ft or 2 in. Therefore, 3 in. armor minus cobble would suffice.

Modeling a 10-ft vs. 13-ft water depth does not have a large effect on the results. For a shorter (100-ft-long) barge, the rock size increases beyond 0.174 ft (for this evaluation, the coefficient C3 was set to 0.7 for some rock movement associated with infrequent events).

A 25-ft jet-powered recreational boat operating in the cap area was also evaluated. With a draft of 2 ft and, assuming the boat applies one-half of its power to the jet, there is about a 60-ft-long distance where the rock size of 1 in. is exceeded. The infrequent and random nature of this type of loading, in addition to its relatively short duration, does not warrant use as a design condition, but highlights the fact that minimal mixing of the cap surface layer can be expected from recreational vessel operations.

Therefore, a minimum 3 in. armor minus cobble is required in the southern portion of the cap (i.e., between Stations 6+50 to Station 5+50). For the remainder of the slip, smaller rock and or gravel can be used, with the expectation of some random surficial movement due to sporadic recreational, fishing, or work boat (e.g., survey boat) activity. For stations less than 5+50, a D_{50} of 1 in. (max. rock size 1.5 in.) is calculated to be protective against operations associated with both a 100-ft and a 200-ft-long barge and the *Westrac II* tug.

5.3.3.2 Propwash Analysis Uncertainties and Design Considerations

One limitation of the model is that propeller angles directed downward could induce greater local velocities and shear stresses. However, this same effect would tend to decrease farfield velocities, which are of most interest in the analysis of Crowley's operations. This is because the tugs would not be operating on top of the cap, but at least

100-ft away from the cap. Therefore the modeled horizontal propeller angle is considered the most conservative condition.

In the future, if substantially different operations are undertaken at the site there is a risk the selected design conditions discussed above could be exceeded. This is accounted for in the cap design through specification of somewhat larger armor materials than calculated above. The specified cap armor material between Stations 6+50 to Station 5+50 is significantly larger that the calculated minimum 3-in. armor indicated by the propwash analysis. This provides a considerable added factor of safety in the erosion resistance in this area while also improving constructability by limiting the number of products used on the project.

Additionally, the cap design in unarmored areas (RA5, RA6, and portions of RA4) includes specification of a thicker cap with an allowable erosion thickness, such that minor movement of cap material from recreational vessel operations or wave-induced reshaping of gently sloping intertidal areas will not trigger the need for maintenance.

5.3.4 Outfall Scour Analysis

Flows from the four major public storm drain outfalls at the head of Slip 4 were modeled to determine erosion protection requirements at the outfalls. The contributory flow areas for each outfall were modeled using the Western Washington Hydraulic Model, Version 2. All upland areas were assumed to be impervious surfaces, and flows generated for a 100-year storm event were used.

Using the Manning equation, flow velocities were calculated using the 100-year flow in the various pipes. This analysis yielded a maximum flow velocity of approximately 10 ft/second exiting the pipes. The channel at the head of the slip was sized to contain this flow, with a flow velocity in the channel of about 6 ft/second. Using methods described in WSDOT's Hydraulic Manual (Section 4-6.3.1 Riprap Sizing for Bank Protection) the armor rock size was determined.

Based on this analysis, it was determined that armor for the outfall area should be at least as large as 4 by 8 in. quarry spalls, to provide adequate channel protection for the maximum anticipated flows.

Splash pads are required at the outfalls themselves to dissipate energy from the grade transition of the outfall invert (typically about +5 ft MLLW) to the cap surface. Heavy, loose riprap is required for erosion resistance at the splash pads.

5.4 SLOPE CAP DESIGN (RA1, RA2, RA3)

This subsection describes the cap design for RA1, RA2, and RA3 as shown on the drawings. Embankment areas of Slip 4 will be capped with an engineered slope cap constructed on excavated embankment subgrades. Habitat areas in riparian portions of the RA1 and RA2 embankments will be covered with engineered soil covers.

Subsection 5.4.1 presents the "minimum cap thickness per EPA guidance" which considers the USEPA/USACE cap design guidance (USEPA 1998). Subsection 5.4.2 presents the cap materials, configuration, and required cap thickness, which also considers other engineering aspects of the cap design and materials selection. Subsection 5.4.2 also presents the design for habitat area soil covers in RA1 and RA2. Subsection 5.4.3 describes the minimum long-term cap thickness requirements for the slope caps.

5.4.1 Minimum Cap Thickness per EPA Guidance

The thickness of each component of the slope cap is described below:

- The bioturbation thickness, T_b, is considered a part of the erosion layer thickness. This is because the physical armor layer serves to both stabilize the cap and is the same layer in which bioturbation occurs. No separate thickness for T_b is included (Section 5.1.1).
- The erosion layer thickness, T_e, is specified at 18 in. The slope cap is subject to erosive forces from wind and wake waves, as well as propeller wash. The specified value of T_e is based on the designed thickness of the armor layer.
- The consolidation thickness, T_c, is specified at 0 in. The capping material will be granular and is expected to undergo negligible consolidation.
- The chemical isolation thickness, T_i, is specified at 12 in. This thickness was determined based on the results of the chemical isolation analysis (Appendix D). The associated design life for chemical isolation is conservatively modeled at over 100 years; the expected actual service life of the cap is infinite.
- The operational thickness, T_o, is specified at 12 in. This additional allowance accounts for the potential inaccuracies and unevenness of cap construction, and ensures that the entire capping area will be covered with at least the minimum required thickness needed for the above-described cap functions.

Based on the cap components described above, the minimum cap thickness per EPA guidance of the slope cap is:

T_t = 0 + 18 + 0 + 12 = 30 in. minimum, plus 12 in. (T_o) overplacement allowance for the final cap surface.

Table 5-4 summarizes the components of the minimum cap thickness per EPA guidance.

5.4.2 Cap Materials, Configuration, and Required Cap Thickness

5.4.2.1 Slope Cap

The slope cap in Slip 4 is a typical armored revetment/containment cap configuration that is widely used for shoreline embankments in the region. In addition to sediment cap design guidance (USEPA 1998), USACE guidance on coastal protection for the design of revetments is pertinent to ensuring armor stability, filtering function, and erosion resistance on steep slopes (USACE 1986, 1995). Protective material (revetment or riprap) on shoreline slopes should consist of an armor layer, a filter layer, and toe protection. From the geotechnical perspective, the revetment must be designed to resist slope failure and slumping, and must not induce failure of the slope on which it may be placed. Excessive differential settlement can lead to local failure zones within the revetment. Without adequate filter layer design, settlement and slumping could be induced by washing out of filter material and or existing bank sediment due to wave action.

To address these issues, revetment slopes, materials sizing, and toe berm design were conducted in accordance with USACE (1995) guidance. Significant wave heights for the design wave were conservatively estimated and used to size the riprap, and geotechnical filtering criteria were used to size an appropriate filter material. The revetment design analysis is included in Appendix C. Based on these analyses, the slope cap consists of:

- A filter layer of 3-inch-minus, well-graded, sandy gravel containing 10 to 30% sands ("filter material"). The filter material will be a minimum of 12 in. thick. To provide the required sorptive capacity, the filter material will be amended with granulated activated carbon (GAC) at a minimum 0.5% by weight. The filter layer will have a 6-in. overplacement allowance.
- An armor layer of 15-inch-minus, graded, angular broken stone ("cap armor"). The armor layer will be a minimum 18 in. thick based on USACE design guidance (Appendix C). The armor layer will have a 6-in. overplacement allowance, for a total 12-in. overplacement allowance for the final surface.
- A rock toe berm constructed at the base of the slope to provide support to the overlying cap armor.
- Habitat mix (2-inch-minus, rounded, well-graded sandy gravel) placed over the armor layer to fill the voids in the armor. The habitat mix will be applied at 3 tons per 100 square ft, which is designed to fill the voids and leave an average 3-in.-thick layer of habitat mix on top of the armor. (Note: Throughout the Slip 4 removal area, habitat mix will be applied to the final surfaces of all new and existing cap armor or riprap in the littoral zone, between the elevations of -10 ft and +13 ft MLLW. This is a conservation measure to improve littoral habitat

substrate quality.) The habitat mix is a one-time placement, and some movement of the habitat mix is expected over time.

Table 5-5 summarizes the cap design thicknesses and materials. With this design configuration, the slope caps have a required thickness of 30 in., consistent with the 30-in. minimum cap thickness per EPA guidance calculated above.

5.4.2.2 Habitat Area Soil Cover

The design includes construction of backshore/riparian habitat areas in RA1 and RA2 with final grades above +13 feet MLLW. Section 6 discusses the habitat goals and functions of these areas, and describes the placement of anchored large woody debris (LWD).

The habitat area soil covers are not sediment caps and EPA sediment cap guidance does not directly apply. As discussed in Section 1.2.4.1, pre-design investigations in these areas indicate the potential for soils to be present that exceed the SQS and/or MTCA soil cleanup levels in these areas. However, no samples have been collected directly in the soil horizons affected by the cutbacks. The design includes an engineered soil cover in this area, along with sampling of the exposed soils before placing the soil cover (sampling is described in the CQAP). Based on the results of those samples, the Long-Term Monitoring and Reporting Plan will define the monitoring requirements and the minimum long-term soil cover thickness requirements for the habitat area soil covers in RA1 and RA2.

As designed, the habitat area soil covers consist of the following:

- A base layer of 3-inch-minus, well-graded, sandy gravel containing 10 to 30% sands (“waterway cap material”). The waterway cap material will be a minimum of 12 in. thick and will have a 3-in. overplacement allowance. This layer is intended to provide a barrier between any impacted soils and the environment, to resist erosion during extreme high tides (when waves could move the sand material), and also to discourage digging.
- A surface layer of well-graded sand (“beach sand”). The beach sand material will be a minimum of 12 in. thick and will have a 3-in. overplacement allowance. This layer is intended to provide a finer-grained substrate to potentially allow backshore vegetation to establish.

Table 5-5 summarizes the soil cover design thicknesses and materials. With this design configuration, the habitat area soil covers have a required thickness of 24 in. with a total 6-in. overplacement allowance.

5.4.3 Minimum Long-Term Cap Thickness

Actual pre-cap and final cap elevations, and cap thicknesses as-constructed, will be documented in the as-built drawings for the cap. Long-term monitoring will include periodic surveys of the cap surface, for comparison to the as-built conditions. The Long-Term Monitoring and Reporting Plan will define the monitoring requirements.

Because the design for RA1, RA2, and RA3 includes an engineered erosion layer, the minimum long-term cap thickness is the sum ($T_i + T_e = 30$ in.). This will ensure that the chemical isolation, bioturbation, and physical stability functions of the cap are maintained. Therefore, the minimum long-term cap thickness for slope caps in RA1, RA2, and RA3 is 30 in. Apparent cap thickness less than 30 in. (based on the surveys) would trigger the need for additional investigation or contingency actions.

The Long-Term Monitoring and Reporting Plan will define the minimum long-term soil cover thickness requirements for the habitat area soil covers in RA1 and RA2. It is noted that the beach sand material as designed can experience movement, and is not intended as a permanent thickness to be uniformly maintained.

5.5 OUTFALL AREA CAP DESIGN (RA4)

This subsection describes the cap design for RA4 as shown on the drawings. The mudflat area at the head of Slip 4 will be dredged to elevations of -3 to -6 ft MLLW as described in Section 4. This area (from STA 0+00 to STA 3+00, as shown on the drawings) will be capped with an engineered cap and will include an engineered channel (with appropriate armoring) to collect outfall flows during periods of low tides.

5.5.1 Minimum Cap Thickness per EPA Guidance

The thickness of each component of the outfall area cap is described in the following subsections. Table 5-4 summarizes the components of the minimum cap thickness per EPA guidance.

5.5.1.1 Armored Channel Portion of RA4

The armored channel portion of RA4 consists of the same materials and layering as the slope caps described in Section 5.4.1. This same configuration is also engineered to withstand outfall flows that discharge directly onto the cap at low tides. Based on the cap components described in Section 5.4.1, the minimum cap thickness per EPA guidance of the armored channel cap is:

T_t = 0 + 18 + 0 + 12 = 30 in. minimum, plus 12 in. (T_o) overplacement allowance for the final cap surface.

5.5.1.2 Unarmored Intertidal Portion of RA4

- The bioturbation thickness, T_b, is specified at 36 in. to account for potential human disturbances of the cap in the intertidal area (e.g., shellfishing in unarmored areas) (Section 5.1.1).
- The erosion thickness, T_e, is specified as a 12-in. sacrificial layer The unarmored areas of the RA4 cap are subject to erosive forces from propwash, wind, and wake waves. The specified value of T_e will allow limited movement of cap material without triggering the need for maintenance.
- The consolidation thickness, T_c, is specified at 0 in. The capping material will be granular and is expected to undergo negligible consolidation.
- The chemical isolation thickness, T_i, is specified at 12 in. This thickness was determined based on the results of the chemical isolation analysis (Appendix D). The associated design life for chemical isolation is conservatively modeled at over 100 years; the expected actual service life of the cap is infinite.
- The operational thickness, T_o, is specified at 12 in. This additional allowance accounts for the potential inaccuracies and unevenness of cap construction, and ensures that the entire capping area will be covered with at least the minimum required thickness needed for the above-described cap functions.

Based on the cap components described above, the minimum cap thickness per EPA guidance of the unarmored intertidal portion of the RA4 cap is:

T_t = 36 + 12 + 0 + 12 = 60 in. minimum, plus 12 in. (T_o) overplacement allowance for the final cap surface.

5.5.2 Cap Materials, Configuration, and Required Cap Thickness

The design analysis for estimating outfall flow velocities, defining the channel configuration, and determining channel armor materials is included in Appendix C. Based on these analyses, the outfall area cap consists of:

- A base layer of 3-inch-minus, well-graded, sandy gravel containing 15% to 25% sands (“filter material”). The filter material will be a minimum of 12 in. thick. To provide the required sorptive capacity, the filter material will be amended with granulated activated carbon (GAC) at a minimum 0.5% by weight. The filter layer will have a 6-in. overplacement allowance.

- Outside the channel, a grading layer of well-graded, sandy gravel ("waterway cap material"). This material has the same gradation as the filter material but does not have the GAC amendment. The waterway cap material will be at least 48 in. thick and will be graded to the design lines and grades, which are designed to attain the total 60-in. minimum cap thickness per EPA guidance. The grading layer will have a 12-in. overplacement allowance for the final surface.
- Within the channel, an armor layer of 15-inch-minus graded, angular broken stone ("cap armor") will be placed. The armor layer will be a minimum 18 in. thick based on USACE design guidance (Appendix C), and in most locations is substantially thicker. The armor layer will be constructed to the final grades shown on the drawings, with a 12-in. overplacement allowance for the final surface.
- At the outfalls, splash pads of 1-ton and smaller rock ("heavy, loose riprap") will be placed to dissipate the flow energy associated with the elevation change from the outfalls to the channel. Cap armor will be used to choke the interstices and feather transitions to the adjacent cap.
- Habitat mix (2-inch-minus, rounded, well-graded sandy gravel) placed over the armor layer (in the channel) to fill the voids in the armor. The habitat mix will be applied at 3 tons per 100 square ft, which is designed to fill the voids and leave an average 3-in.-thick layer of habitat mix on top of the armor. The habitat mix is a one-time placement, and some movement of the habitat mix is expected over time.

Table 5-5 summarizes the cap design thicknesses and materials. Because grading is critical in this location to maintain drainage, the drawings specify the final lines and grades that must be attained, rather than a required thickness. With this design configuration, the outfall area cap will be constructed with a required thickness of at least 30 in. in armored areas, and at least 60 in. (5 ft) in unarmored areas, exceeding the minimum cap thickness per EPA guidance. Figure 5-1 illustrates the minimum cap thicknesses achieved by the grading in RA4.

The 5-ft thickness in unarmored intertidal areas is intended to provide an additional margin of safety for possible localized cap disturbance by potential shellfishing activities, and will ensure that Native American shellfishing treaty rights are not limited by the presence of the cap.

5.5.3 Minimum Long-Term Cap Thickness

Actual pre-cap and final cap elevations, and cap thicknesses as-constructed, will be documented in the as-built drawings for the cap. Long-term monitoring will include periodic surveys of the cap surface, for comparison to the as-built conditions. The Long-Term Monitoring and Reporting Plan will define the monitoring requirements.

5.5.3.1 Armored Channel Portion of RA4

Because the armored channel design for RA4 includes an engineered erosion layer, the minimum long-term cap thickness is the sum ($T_i + T_e = 30$ in). This will ensure that the chemical isolation, bioturbation, and physical stability functions of the cap are maintained. Therefore, the minimum long-term cap thickness for channel area in RA4 is 30 in.. Apparent cap thickness less than 30 in. (based on the surveys) would trigger the need for additional investigation or contingency actions.

5.5.3.2 Unarmored Intertidal Portion of RA4

Because the design for the unarmored portion of RA4 includes a 12-inch "sacrificial" layer as an erosion thickness (T_e), an apparent loss (based on the surveys) of 12 in. (or greater depending on the actual overplacement) would be allowable without triggering the need for additional investigation or contingency actions. Therefore, the minimum long-term cap thickness in unarmored portions of RA4 is ($T_i + T_b =$ 48 in.). This will ensure that the chemical isolation, bioturbation, and physical stability functions of the cap are maintained. Apparent cap thickness less than 48 in. (based on the surveys) would trigger the need for additional investigation or contingency actions.

5.6 MID-SLIP CAP DESIGN (RA5, RA6, RA7)

This subsection describes the cap design for RA5, RA6, and RA7 as shown on the drawings. The subtidal and intertidal cap in these areas will be placed over existing native sediments. This area (from STA 2+40 to STA 6+70, as shown on the drawings) will be capped with an engineered cap and will include an erosion protection layer near the southern cap boundary (i.e., in RA7) to resist propwash from adjacent tug operations outside the cap area.

5.6.1 Minimum Cap Thickness per EPA Guidance

The thicknesses of each component of the caps in RA5, RA6, and RA7 are described in the following subsections. Table 5-4 summarizes the components of the minimum cap thickness per EPA guidance.

5.6.1.1 RA5 and RA6

- The bioturbation thickness, T_b, is specified at 6 in. in RA5 (subtidal) and 36 in. in RA6 (intertidal). The additional thickness in RA6 is included to account for potential human disturbances of the cap in the intertidal area (e.g., shellfishing in unarmored areas).

- The erosion thickness, T_e, is specified as a 12 in. sacrificial layer. RA5 is subject to erosive forces from propwash, and RA6 is subject to erosive forces from propwash, wind, and wake waves. The specified value of T_e will allow limited movement of cap material without triggering the need for maintenance.
- The consolidation thickness, T_c, is specified at 0 in. The capping material will be granular and is expected to undergo negligible consolidation.
- The chemical isolation thickness, T_i, is specified at 12 in. This thickness was determined based on the results of the chemical isolation analysis (Appendix D). The associated design life for chemical isolation is conservatively modeled at over 300 years; the expected actual service life of the cap is infinite.
- The operational thickness, T_o, is specified at 12 in. This additional allowance accounts for the potential inaccuracies and unevenness of cap construction, and ensures that the entire capping area will be covered with at least the minimum required thickness needed for the above-described cap functions.

Based on the cap components described above, the minimum cap thickness per EPA guidance of the caps in RA5 and RA6 are:

RA5: **T_t = 6 + 12 + 0 + 12 = 30 in. minimum**, plus 12 in. (T_o) overplacement allowance

RA6: **T_t = 36 + 12 + 0 + 12 = 60 in. minimum**, plus 12 in. (T_o) overplacement allowance.

5.6.1.2 RA7

The armored cap in RA7 consists of the same or similar materials and layering as the slope caps described in Section 5.4.1.[2] This same configuration is also engineered to withstand the higher propwash velocities that are expected in RA7. Based on the cap components described in Section 5.4.1, the minimum cap thickness per EPA guidance of the RA7 cap is:

T_t = 0 + 18 + 0 + 12 = 30 in. minimum, plus 12 in. (T_o) overplacement allowance for the final cap surface.

5.6.2 Cap Materials, Configuration, and Required Cap Thickness

The design analysis for estimating propwash velocities and erosion protection requirements is included in Appendix C. Based on these analyses, the mid-slip cap consists of three designs:

[2] The RA7 cap includes waterway cap material as the lower layer, rather than filter material as used in RA1, RA2, and RA3. However these materials have the same gradation and the thickness considerations are the same.

- **RA5—30-Inch Waterway Cap**: The cap in this area is a single thickness of waterway cap material (3-inch-minus, well-graded, sandy gravel containing 10 to 30% sands). In this subtidal area between STA 2+40 to 5+50, the waterway cap has a required thickness of 30 in. and has a 12-in. overplacement allowance for the final surface.
- **RA6—60-Inch Waterway Cap**: The cap in this area is a single thickness of waterway cap material. In this intertidal area between STA 2+40 to 5+50, the waterway cap material has a required thickness of 60 in. and has a 12-in. overplacement allowance for the final surface. This additional thickness in RA6 is intended to provide an additional margin of safety for possible localized cap disturbance by potential shellfishing activities, and will ensure that Native American shellfishing treaty rights are not limited by the presence of the cap.
- **RA7—Armored Cap**: To resist propwash, an armored cap is required between STA 5+50 to 6+70 consisting of:
  - A base layer of waterway cap material. The waterway cap material will be a minimum of 12 in. thick and will have a 6-in. overplacement allowance.
  - An armor layer of 15-inch-minus, graded, angular broken stone ("cap armor"). The armor layer will be a minimum 18 in. thick based on USACE design guidance (Appendix C). The armor layer will have a 6-in. overplacement allowance, for a total 12-in. overplacement allowance for the final surface. Notably, the specified cap armor material is significantly larger that the calculated minimum 3-in. armor indicated by the propwash analysis. This provides a considerable added factor of safety in the erosion resistance in this area while also improving constructability by limiting the number of products used on the project.
  - Habitat mix (2-inch-minus, rounded, well-graded sandy gravel) placed over the armor layer to fill the voids in the armor. The habitat mix will be applied at 3 tons per 100 square ft, which is designed to fill the voids and leave an average 3-in.-thick layer of habitat mix on top of the armor. The habitat mix is a one-time placement, and some movement of the habitat mix is expected over time.

Table 5-5 summarizes the cap design thicknesses and materials. With this design configuration, the mid-slip caps in RA5 and RA7 have a required thickness of 30 in. consistent with the 30-in. minimum cap thickness per EPA guidance. The cap in RA6 has a required thickness of 60 in., consistent with the 60-in. minimum cap thickness per EPA guidance.

5.6.3 Minimum Long-Term Cap Thickness

Actual pre-cap and final cap elevations, and cap thicknesses as-constructed, will be documented in the as-built drawings for the cap. Long-term monitoring will include periodic surveys of the cap surface, for comparison to the as-built conditions. The Long-Term Monitoring and Reporting Plan will define the monitoring requirements.

5.6.3.1 RA5 and RA6

Because the design for RA5 and RA6 includes a 12-in. "sacrificial" layer as an erosion thickness (T_e), an apparent loss (based on the surveys) of 12 in. (or greater depending on the actual overplacement) would be allowable without triggering the need for additional investigation or contingency actions. Therefore, the minimum long-term cap thicknesses in these unarmored areas are:

RA5: $T_i + T_b$ = 18 in. minimum required long-term thickness
RA6: $T_i + T_b$ = 48 in. minimum required long-term thickness

This will ensure that the chemical isolation, bioturbation, and physical stability functions of the cap are maintained. Apparent cap thickness less than these minimum long-term cap thicknesses (based on the surveys) would trigger the need for additional investigation or contingency actions.

5.6.3.2 RA7

Because the armored design for RA7 includes an engineered erosion layer, the minimum long-term cap thickness is the sum ($T_i + T_e$ = 30 in.). This will ensure that the chemical isolation, bioturbation, and physical stability functions of the cap are maintained. Therefore, the minimum long-term cap thickness for RA7 is 30 in. Apparent cap thickness less than 30 in. (based on the surveys) would trigger the need for additional investigation or contingency actions.

5.7 MATERIALS SPECIFICATIONS AND QUANTITIES

5.7.1 Quantities and Quality Control

Table 5-6 summarizes the estimated quantities of the cap materials. The specifications provide the required gradations and other properties of the various cap materials.

Cap materials for Slip 4 will be obtained from established upland borrow sources. Consistent with Clean Water Act (CWA) 404 requirements, the capping material will be evaluated to verify that it is "clean"—that is, suitable for in-water use. The evaluation would include consideration of physical and chemical properties of the material, as appropriate. The specifications require testing of all non-rock cap materials to verify their chemical concentrations are below one-half of the SQS (or the dry-weight analogue of the

SQS for materials with TOC < 0.5%). The contractor submittals will include documentation that the materials meet all specification requirements. No cap material will be placed until the submittals have been approved by the City and EPA.

The final acceptance criteria for the placed cap materials is to meet the SQS (or the dry-weight analogue of the SQS for materials with TOC < 0.5%). This will be verified by sampling of the final cap surface as defined in the CQAP.

5.7.2 Carbon Amendments

Based on the analyses described above, the filter material product (an engineered sandy gravel) will contain a minimum TOC content of 0.5%, which will require amendment of available upland-sourced materials. Several amendment options exist for providing this TOC content:

- **Granulated anthracite, coal, or coke breeze.** These products, respectively, have been used (or will be used) as amendments at the PSR site in Elliott Bay (completed) (USEPA 2005b); the Upriver Dam site in the Spokane River (planned) (Anchor 2006), and the Anacostia River (HSRC 2004). Although coal products can contain detectable concentrations of impurities such as PAHs and metals, testing has shown that these impurities are not leachable (Anchor 2006). Granulated anthracite has been used in drinking water treatment applications.
- **Peat or other natural soil products.** Peat was successfully used in the Head of Thea Foss Waterway cap to provide TOC content. Other soil products (e.g., compost, topsoil) are generally not suitable for capping applications due to potential presence of pesticides, turbidity generation, floatability, and handling properties. In general, aggregate suppliers do not want to handle or blend these materials at their facilities, as organic soils, silts, and clays are considered "contaminants" for their other products.
- **Granulated activated carbon (GAC).** GAC has been used at the Olympic View Resource Area (OVRA) in Commencement Bay. In the Grasse River pilot project, GAC has been successfully placed using several application methods. GAC is considered contaminant-free and is widely used in drinking water treatment applications. Although somewhat more expensive than the other options, GAC also has far greater adsorptive capacity (as measured by its "iodine number") than the other products.

Importantly, chemical adsorptive capacity is what determines the cap performance, but the standard TOC analytical method used for sediments (EPA Method 9060) does not distinguish the actual adsorptive capacity of the various types of carbon.

Based on its materials handling properties, known quality control by suppliers, widespread use in drinking water treatment, and high sorptive capacity, GAC is specified as the amendment for the filter material. Either virgin or regenerated GAC may be used. The specifications identify amendment product options for the contractor; the contractor may propose alternate amendments provided they meet the requirements of the specifications.

The specific GAC particle size range was specified considering materials handling factors, based on conversations with carbon and aggregate suppliers. Compared to finer grain sizes, GAC meeting a U.S. Sieve 8x30 mesh size (medium to coarse sand size) is considered to be the most amenable to materials handling at the aggregate supplier, should experience less segregation within a pile of the amended filter material, and may be less susceptible to flotation during placement. However, some flotation of GAC will occur. The specifications identify the need to pre-wet the filter material to reduce flotation of the GAC, and to contain all floatable material within the capping area.

5.8 CAP PLACEMENT TECHNIQUES

Caps can be placed using land-based or waterway-based equipment. In areas below 0 ft MLLW, capping will be accomplished with floating equipment similar to that used for mechanical dredging. The dredge will use a bucket or skip box to collect capping material from a haul barge and spread the material for uniform placement on the bed of the waterway. The material is typically released from the bucket or skip box just above the water surface, as the boom is swung. This allows the operator to view the material as it is released. In some areas, the placement may have to be timed to take advantage of periods of moderate to high tides in order to provide required water depth for the equipment (5- to 15-ft draft depending on specific equipment).

Capping of banks and portions of the head of Slip 4 (above approximately 0 to +4 ft MLLW) may be completed with land-based earthmoving equipment (excavators, front-end loaders, and dump trucks) or floating equipment. Clean capping material will be imported to the site in dump trucks or on barges, and then placed as engineered fill over the impacted soil and sediment. Use of barge-mounted equipment is often more practicable than land-based equipment, and numerous contractors in the region are experienced in the successful placement of caps on banks and in waterways using floating equipment. In some upper intertidal areas, fine grading of cap material may be accomplished with earthmoving equipment operating above the water line.

Cap materials will be placed in two or more lifts, and where multiple cap materials are used, thicknesses of individual layers will be verified. The bearing capacity analysis (Section 5.2) concluded that the first lift of cap material should not exceed 2 ft. This requirement is stipulated in the plans and specifications.

Construction monitoring, described in the CQAP and WQMP, will verify that the cap is being placed according to the specifications and in accordance with EPA's CWA 401 Certification. The contractor will be required to modify its placement methods if the monitoring results are not acceptable.

Section 7 discusses potential short-term water quality issues during capping and BMPs, operational controls, and equipment options available for minimizing water quality concerns.

6 HABITAT CONSIDERATIONS

The effects of the Slip 4 removal action on habitat quality and quantity have been extensively documented in the EE/CA (Integral 2006a) and CWA 404(b)(1) analysis (USEPA 2006b), and were factored into the remedy selection in the Action Memorandum (USEPA 2006a). This section provides a brief overview of the habitat effects of the remedy as designed, which includes minor changes to the acreage estimates presented in these previous documents. Additional discussion of the effects of the project on endangered species is presented in the Biological Assessment (Integral 2006b).

The removal action is expected to be beneficial to threatened Puget Sound chinook and Coastal/Puget Sound bull trout by greatly reducing their potential exposure to PCBs. Conservation measures in the design include design for optimum habitat elevations and areas, and use of specific substrates for the cap surface.

6.1 HABITAT AREAS

The design affects approximately 3.36 acres of existing aquatic habitat and includes a total of 3.83 acres. The removal action will result in no net loss (and some gain) of aquatic habitat acreage, and results in some conversions between elevation ranges, including sublittoral (deeper than -10 ft MLLW), shallow subtidal (-10 to -4 ft MLLW), lower intertidal (-4 to +4 ft MLLW), and upper intertidal (+4 to +12 ft MLLW). Table 6-1 summarizes the surface area within different elevation ranges for the existing conditions, the designed project, and the net differences.

Appendix F presents the approximate elevation contours of the existing conditions and the planned final constructed surface. Over time, accumulations of fine-grained sediments are expected to deposit on top of the constructed cap surface. This sediment deposition is expected to result in a gradual net shallowing of the slip over time, and is a continuation of existing sediment transport processes in the LDW.

Relative to existing conditions, the design expands shallow subtidal habitat by approximately 0.29 acres and expands intertidal habitat by approximately 0.50 acres. Lower intertidal (-4 to +4 ft MLLW) habitat area will slightly increase by approximately 0.01 acres. Approximately 0.08 acres of new aquatic habitat will be created by bank excavation. Also, approximately 0.28 acres of new riparian areas (between +12 ft MLLW and the top of bank) will be created, including 0.15 acres of backshore/riparian habitat enhancement (above +13 ft MLLW) that are being created near the head of the Slip, in RA1 and RA2.

In summary, the design results in net gains in intertidal, shallow subtidal, and total aquatic habitat relative to existing conditions, thereby providing additional habitat for threatened Puget Sound chinook and Coastal/Puget Sound bull trout. These habitat changes are also consistent with salmon recovery goals for the LDW (King County 2005). These intertidal and shallow subtidal area increases result primarily from conversion of equivalent sublittoral acreages (i.e., shallowing of the slip through capping) and, to a lesser extent, from excavation of bank and upland areas.

6.2 SUBSTRATES

The primary substrate modification will be conversion of contaminated substrate (organic silts and sands with PCB concentrations exceeding the SQS) to clean substrate in the cap design area.

The waterway cap material covering the majority of the area will consist of coarse sand and gravels (3-in. minus) that are considerably coarser than the existing substrate—this material is required for erosion resistance.

In areas where cap armor material is needed for slope stability or erosion resistance, habitat mix will be placed over the riprap at elevations between -10 and the top of the bank to enhance habitat value.

Additional substrate enhancement will be provided on the existing riprap bank at elevations above the cap design limits. Habitat mix will be placed over existing riprap at elevations above the point where the cap tapers into the riprap. The habitat mix is intended to fill the interstitial spaces between the riprap materials, enhancing the habitat for the benthos.

As mentioned above, accumulations of fine-grained sediments are expected to deposit on top of the constructed cap surface over time, resulting in a finer substrate.

6.3 ADDITIONAL HABITAT ENHANCEMENT

Section 6.1 presents the net changes in habitat areas resulting from the cap. In response to stakeholder input, additional habitat enhancements have been included in the design within RA1 and RA2 where the finished cap surface is above +13 ft MLLW. The goals of the enhancements are to create a stable and more natural riparian/backshore area, to enhance the recruitment and retention of fines, and to provide conditions conducive to establishment of backshore riparian vegetation. The habitat enhancements consist of the following elements, which are shown on the drawings and cover 0.15 acres:

- Overexcavating bank areas on City-owned property, to create a gently sloping subgrade at the desired elevations in the habitat areas.
- Placing a soil cover in the habitat areas, to contain any remaining contaminants in bank soils. The soil cover includes a base course of waterway cap material, to

resist erosion during extreme high tides (when waves could move the sand material) and also to discourage digging. A top course of beach sand will overlie the waterway cap material. The beach sand consists of a well-graded sand with significant fines content and is intended to provide a suitable substrate for vegetative growth.

- Placing anchored LWD in the habitat areas. Over time, additional LWD may naturally accumulate in these locations. The goal of placing the LWD is to enhance the recruitment and retention of fines and to allow for more rapid establishment and increased survival of vegetation. The LWD is designed to last for several years (potentially decades) and to leave minimal anthropogenic debris when the LWD eventually deteriorates. The LWD consists of partially buried durable native log species (cedar or fir) with rootwads, cabled to buried concrete anchors. The LWD is installed at elevations between +13 ft MLLW and higher, which is the elevation range expected to naturally recruit additional LWD over time. At these relatively high intertidal elevations (above mean higher high water [MHHW]), there is less potential for wave action to dislodge the LWD. When the LWD eventually deteriorates, minimal cleanup (e.g., cutting exposed cable sections) may be desired to remove anthropogenic material.

There is no planned long-term monitoring, maintenance, or adaptive management specific to the LWD or to the potential future natural evolution (or planting) of riparian vegetation. It is anticipated that the areas of habitat enhancement will undergo changes over time due to natural processes. Planting and/or management of vegetation in these areas may be addressed separately from this removal action.

7 SHORT-TERM IMPACTS DURING CONSTRUCTION

This section discusses potential short-term impacts to water quality and the surrounding community during construction activities.

7.1 SHORT-TERM WATER QUALITY IMPACTS

Short-term water quality impacts will be monitored and managed during cleanup to ensure protection of the environment. The contractor will be required to conduct all operations in such a way that they meet all applicable water quality standards at designated points of compliance that are defined as part of EPA's CWA 401 Water Quality Certification. This section summarizes the water quality criteria that will apply, describes the expected types of short-term water quality impacts, summarizes the controls and procedures used to reduce water quality impacts during construction, and presents the water quality monitoring requirements contained in the WQMP (an ancillary document of this design submittal).

7.1.1 Water Quality Criteria

During construction, Washington state water quality standards will need to be attained at a specified point of compliance. These criteria include general water use and criteria classes (WAC 173-201A-030) for turbidity, dissolved oxygen (DO), and toxic conditions, and the numeric toxic substances criteria (WAC 173-201A-040).

7.1.1.1 Point of Compliance

EPA's Water Quality Certification will specify an authorized mixing zone during in-water construction activities, and the point of compliance for meeting the water quality standards will be set at the boundary of this mixing zone. EPA has typically designated the mixing zone as an area extending 100 m (328 ft) radially from ongoing construction activities. For this project, it is anticipated that point of compliance measurements will occur at a fixed point 100 m (328 ft) directly upslip (southwest) of the western boundary of capping, rather than moving with the construction activities. This approach is favored because of the comparatively small size of the work area, the confined geometry of Slip 4, and the fact that the fixed location is less likely to be affected by turbidity from storm drain discharges. Additional monitoring points include ambient stations and discretionary stations, as defined in the WQMP.

7.1.1.2 Specific Criteria

Water quality standards (WQS) pertaining to the marine waters of Elliott Bay (Class A) (WAC 173-201A-140 Specific Classifications—Marine Waters) and the fresh waters of the Duwamish River (Class B) (WAC 173-201A-130 Specific Classifications—Freshwater) potentially could apply to this project. The lower reach of the Duwamish Waterway is a saltwater wedge estuary with a lower layer of nearly undiluted seawater moving upstream from Puget Sound and a surface layer of riverine fresh water mixed with saltwater. The saltwater wedge is present in the vicinity of Slip 4 throughout the year, and, in the vicinity of Slip 4, the waterway generally remains stratified with a distinct freshwater/low salinity surface layer overlying a saltwater bottom layer.

Circulation in the Duwamish Waterway is controlled by freshwater inflow and tidal action. In general, on a rising tide, water in both the bottom saltwater wedge and surface layer flows upstream. On a falling tide, the flow is downstream. Although water moves upstream and downstream with the tides, circulation in the vicinity of Slip 4 consists of a net downstream flow in the surface layer and a net upstream flow in the salt wedge layer (King County 1999).

Based on previous water quality certifications on the Duwamish River, it is expected that Class B marine water quality standards will apply to this project except within the authorized mixing zone, unless there is a practical reason why results should be compared to a different standard (e.g., results from the upper water column indicate that turbidity is an issue in the freshwater lens due to project activities – a freshwater standard could potentially be applied at EPA's discretion). The following are anticipated water quality standards for Slip 4.[3]

Dissolved Oxygen

At the point of compliance (edge of the mixing zone), DO shall exceed 5.0 mg/L. When natural conditions such as upwelling occur, causing the DO to be depressed near or below 5.0 mg/L, natural dissolved oxygen levels may be degraded by up to 0.2 mg/L by human-caused activities. If for any reason DO should drop below 3.5 mg/L within the dilution zone, in-water work should cease immediately.

Turbidity

At the point of compliance (edge of the mixing zone), turbidity shall not exceed 10 NTU over background turbidity when the background turbidity is 50 NTU or less, or have more than a 20% increase in turbidity when the background turbidity is more than 50 NTU.

[3] EPA's CWA 401 Water Quality Certification will set the final standards.

Chemicals of Concern (COCs)

At the point of compliance (edge of the mixing zone) chemical concentrations shall not exceed the numeric toxic substances acute criteria for marine water (WAC 173-201A-040).

7.1.2 Water Quality Impacts during Construction

7.1.2.1 Dredging

The process of dredging creates short-term turbidity in the water column. The anticipated dredging method is mechanical dredging with a clamshell bucket, which releases some sediment into the water column. Resuspension of sediment during clamshell dredging operations can result from any one of the following bucket actions:

- The bow wave effect from lowering the clamshell bucket
- Impact of the bucket with the bed
- Bucket closure and removal from the bed
- Sloughing of the cut bank
- Sediment spillage during ascent through the water column
- Drainage of turbid water from the bucket at the water surface
- Spillage and gravitational leakage from the bucket during hoisting and swinging from water to the haul barge.

At present, no fully verified empirical or predictive tools are available to quantify the predicted releases accurately (USEPA 2005b). Given the very shallow waters in the Slip 4 dredging area, it is estimated that generally less than 1% of the mass dredged may be resuspended, consistent with other studies (Hays and Wu 2001; Palermo and Averett 2003). However, the presence of debris in Slip 4 further complicates any quantitative prediction. Modeling of solids or contaminant releases (e.g., using USACE's DREDGE model) is not considered to add to the predictive ability at Slip 4.

Laboratory-scale predictive testing of contaminant releases during dredging using the DRET test (DiGiano et al. 1995) is not considered warranted. DRET testing on other Duwamish river sediments (King County 2003; Port of Seattle 2003) did not indicate the potential for released chemicals to exceed acute water quality standards at the point of dredging, and considerable dilution occurs between the point of dredging and the point of compliance. Empirical monitoring of water quality chemistry during dredging at the East Waterway Phase 1 Removal Action and the Duwamish/Diagonal cleanup action verified that chemicals did not exceed acute water quality standards in the water column at the point of compliance (Port of Seattle 2005).

Water quality monitoring will be conducted at Slip 4 to directly verify that short-term water quality impacts associated with dredging are in compliance with EPA's CWA 401 certification.

7.1.2.2 Excavation

As described in Section 4, excavation of bank material in-the-dry can minimize generated turbidity. The availability of daytime low-tide windows is the primary limiting factor on the practicability of excavation in the dry. Bank material will be excavated in-the-dry to the extent practicable, considering tidal stages, equipment draft requirements, and boom reach capabilities.

7.1.2.3 Capping

The potential for resuspension of bed sediment during capping operations is substantially lower than during dredging (USEPA 2005b). Specified placement methods include slow, uniform application that allows the capping material to accumulate in layers to avoid displacement of or mixing with the underlying sediments. The capping material itself may introduce some turbidity into the water column as the cap material is pluviated (i.e., settles as individual particles) in its descent to the bottom. The cap materials specifications include limits on the fines content of the capping materials to limit turbidity generated during capping.

7.1.2.4 Other Activities

Other activities that may generate short-term turbidity in the work area include:

- Piling/debris removal
- Workboat/tugboat activity
- Spudding and movement of barges
- Dewatering of excavated materials on barges.

7.1.2.5 Summary

All contractor activities must ultimately be conducted in such a way that they meet all applicable water quality standards at designated points of compliance that are defined as part of EPA's CWA 401 Water Quality Certification. Water quality monitoring requirements will vary in frequency and intensity for the various activities described above. These requirements are described in detail in the WQMP.

7.1.3 Contractor Controls and Procedures—In Water Work

In addition to the performance and sequencing requirements described in Section 4.3.2.2, a number of BMPs are included as design requirements in the specifications to minimize sediment resuspension, dredge residuals generation, and water quality impacts during cleanup. These requirements include:

- Specification of stable cut slopes along the prism boundary and between internal dredging units to reduce the potential for sloughing.
- Requirements for excavation/dredging from the top of the slope down, and capping from the bottom of the slope upward, to reduce the potential for sloughing.
- Requirement for bulkhead demolition concurrent with bank excavation, to reduce the potential for sloughing.
- Use of an environmental dredge bucket to the extent practical, considering debris and other site conditions and with the overall goal of minimizing sediment resuspension during dredging.
- Elimination of multiple bites with the dredge bucket.
- Elimination of overfilling the dredge bucket.
- Specification of maximum cut thicknesses to limit any sloughing on the cut face.
- Elimination of stockpiling of dredged material on the bottom.
- Elimination of sweeping with the bucket or the use of grading equipment below the water line.
- Requirements for filtering of return water entering Slip 4 from the materials barge, using filter fabric, as material is dewatered on the barge. Material may be mounded on the materials barge to promote drainage.
- Eliminating overfilling of the materials barge.
- Avoiding or minimizing tug activity in Crowley's middle berth during dredging (to be coordinated between the City and Crowley).
- Anticipating relatively low dredge production rates of 500–1500 cy/day
- Specifying cap materials with low fines contents.
- Controlling liquids and minimizing spillage from transloading activities (Section 7.1.4).

The contractor will submit a RAWP that will identify additional BMPs, operational controls, and equipment options available for minimizing water quality concerns for both day-to-day operations as well as potential contingencies for addressing water quality exceedances. These elements will be implemented, if necessary, to control for turbidity/water quality impacts and may include:

- Operational Controls may include:

- – Dredging at the head of the slip during lower tidal stages, as practical.
- – Excavating bank areas in the dry, as practical.
- – Decreasing the rate of dredging. This may include decreasing the velocity of the ascending or descending bucket as it moves through the water column; pausing the bucket before digging, or pausing the bucket for longer periods at the water surface to facilitate drainage.
- – Limiting hours of operation to favorable tidal cycles (e.g., avoiding tides that appear to be associated with elevated turbidity at the compliance station).
- – Modifying the positioning of barge(s).
- – Modifying dredge bucket movement to dislodge adhering material.
- – Decreasing the rate of capping.
- – Releasing cap material from bucket just above the water surface.
- – Adjusting rate of release of cap materials, using smaller bucket or skip box, or increasing swing arc to better pluviate and create thinner lifts.
- – Placing a thinner first lift of capping materials.
- – Stopping work.

- Equipment Options and Engineering Controls may include:
  - – Using an enclosed or "environmental" bucket. This technology consists of specially constructed dredging buckets designed to reduce turbidity in the water by reducing suspended solids generated during digging and bucket ascent. As described in Section 4, the presence of extensive debris in Slip 4 limits the ability to use an environmental bucket, and a clamshell bucket will generally be required to successfully remove material containing debris. The specifications call for the use of an environmental bucket to the extent practical, considering debris and other site conditions and the overall goal of minimizing sediment resuspension during dredging.
  - – Using silt curtains/silt screens. Silt curtains are impermeable membranes used for control of turbidity, while silt screens are filtering devices that allow some water to pass through. In this discussion, the term "silt curtain" is generically used. The objective when using silt curtains is to create a physical barrier around the dredge equipment to allow the suspended sediments to settle out of the water column in a controlled area. Silt curtains are typically constructed of flexible, reinforced, thermoplastic material with flotation material in the upper hem and ballast material in the lower hem. The curtain is placed in the water surrounding the dredge

or disposal area, allowed to unfurl, and then anchored in place using anchor buoys. Silt curtains are most effective on projects where they are not opened and closed to allow equipment access to the dredging or disposal area. Because they are impermeable (or have limited permeability in the case of silt screens), silt curtains are easily affected by tides and currents and generally should not be used in areas with currents greater than about 50 cm/s (USEPA 2005b). Silt curtains should be deployed so that they maintain a clearance of 1-2 ft from the bottom (USACE 2005). Failure to maintain this clearance can result in burial of the curtain bottom, damage to the curtain, and resuspension of accumulated material when the curtain is moved. Larger clearances are typically needed due to water currents and tidal variations (tidal elevations in Slip 4 can vary more than 10 ft per day). Given the shallow bathymetry at Slip 4 and the tidal range, a silt curtain could only extend about 8 ft below the surface and could not extend all the way across the slip. The main advantage of silt curtains is that, if they are deployed correctly, they can reduce surface turbidity. The main disadvantages are that they have little effect on bottom turbidity, and limit navigation in the dredging vicinity (USACE 2005; Port of Seattle 2003). For Slip 4 the contractor will have the option of using silt curtains as an engineering control, if needed to address water quality exceedances.

– Using anchored silt screens (e.g, Gunderboom™). An anchored silt screen is similar to a silt curtain, except that the curtain is made of a permeable geotextile fabric that allows the water to pass through, while filtering out the particulates. While silt curtains are typically deployed so that they extend downward through part of the water column, anchored silt screens are designed to be installed from the water surface to the project bottom. The advantages of anchored silt screens are that they allow unlimited curtain depth and permit water flow, while the disadvantages are that they require engineering design, are more difficult to install and move around, and they can become clogged with silt, causing curtain drag or failure. Anchored silt screens have failed in environments with large tidal variability and will not be permitted in Slip 4.

7.1.4 Contractor Controls and Procedures—Transloading

Material will be dewatered on a barge in Slip 4 prior to transloading, with BMPs for filtering the dewatering liquids as described above.

A site will be chosen for a staging area for the transloading of the material to be disposed of upland. As described in Section 4, this transloading may occur at the pier in Slip 4 or at another location nearby. It is likely that a crane or long-stick hydraulic excavator will be used to transfer the material from the barge to the handling site on land, and that the material will be loaded directly into trucks. To minimize any potential for spillage from the rehandling bucket and from the staging area, the contractor will be required to provide methods for preventing sediment loss during offloading.

The contractor will be required to control the release of sediment and any associated liquids into the waters around the upland staging area. Actions may include:

- Constructing and maintaining a containment berm or other confinement method in the rehandling area.
- Using a tight-sealing crane rehandling bucket and monitoring for leakage.
- Minimizing the gap between the haul barge and the dock.
- Using a spill apron between the haul barge and the dock.
- Loading trucks or containers directly from the rehandling bucket.
- Decontaminating and inspecting trucks before they leave the loading area, and requiring immediate cleanup of any material tracked out.
- Collecting liquids from upland containment areas (potentially including any dewatering liquids generated upland, precipitation into "dirty" work areas, and decontamination liquids) and filtering it, treating it, analyzing it, and disposing of it in the municipal sewer system or into Slip 4:
  - Discharge of treated water will be to the municipal sanitary sewer system, under permit from King County, if practicable. The Contractor will obtain the permits and conduct all sampling, analysis, reporting, and attain all approvals for discharge. It is anticipated that EPA's CWA 401 certification will initially specify that no return flows of water from the transloading area to Slip 4 will be permitted.
  - Consistent with CWA 404 requirements, the preference is to avoid any return flow of water from the transloading operations to the slip. However, in the event that the Contractor can demonstrate that discharge to the sanitary sewer is impracticable (i.e., a permit cannot be obtained), discharge will be to Slip 4. In this case, EPA will modify its CWA 401

certification and set the sampling and compliance requirements. Sampling and analysis of the treated water will be conducted by Integral, and the WQMP will be modified to include the additional sampling and analysis requirements. Discharge into Slip 4 would be in accordance with EPA's CWA 401 Water Quality Certification. It is anticipated that the return flow would need to meet marine acute standards for COCs, and dissolved oxygen/turbidity criteria, at the end-of-pipe.

Requirements for management of transloading wastewaters are found in the Specifications. The contractor will be required to identify its methods for preventing sediment loss and managing liquids in the transloading process, as part of its RAWP.

7.1.5 Water Quality Monitoring and Performance Requirements

Short-term water quality impacts will be monitored and managed during cleanup to ensure protection of the environment. For this project, Integral will monitor water quality during construction. The contractor's performance requirement will be to conduct all operations in such a way that they meet all applicable water quality standards at designated points of compliance that are defined as part of EPA's CWA 401 Water Quality Certification. The WQMP (an ancillary document of this design submittal) presents the water quality standards and specific monitoring requirements.[4] Additionally, the CQAP discusses the implementation of water quality monitoring, and reporting and feedback mechanisms, as part of the overall quality assurance process during implementation of this design.

Based on the monitoring results, if DO, turbidity, or a COC acute standard is exceeded at the point of compliance (boundary of the mixing zone), EPA will be notified and the contractor will be directed to modify its operations. If the contractor's modifications continue to result in water quality exceedances, EPA may direct the activity to cease. The reporting and feedback loops for this communication are described in the WQMP.

Freshwater inflows from storm drains also enter Slip 4 and may introduce turbidity not associated with construction. Specific monitoring elements may be included if turbidity exceedances are observed at the point of compliance and are suspected of being a turbid freshwater lens not associated with construction.

In accordance with the criteria in the WQMP, total suspended solids (TSS) and COC samples will be obtained from the compliance location at the depth in the water column with the greatest *in situ* turbidity reading (excluding any turbid freshwater lens not associated with construction), with both field-measured parameters and laboratory results reported for that location.

[4] EPA's CWA 401 Water Quality Certification will be issued prior to construction and may contain provisions that supersede those described in the WQMP.

7.2 CONSTRUCTION IMPACTS TO ADJACENT SEDIMENTS

The specification requirements, BMPs, operational controls, engineering controls, and monitoring requirements described in Section 7.1 will all act in concert to minimize the potential for resuspension of contaminated sediments. Collectively, these elements will greatly reduce any potential for contamination of sediments south of the removal action boundaries as a result of the construction. In addition, the design is inherently engineered to reduce impacts to adjacent sediments in the following ways:

- **Separation of dredging activities from project boundaries.** Dredging of the most highly contaminated material at the head of the Slip is separated from the removal boundary by approximately 400 ft. Any fugitive residuals from dredging at the head are expected to be minimal and would largely settle out within the area that will subsequently be capped.
- **Avoidance of disturbance to subsurface materials.** No dredging of deeper, buried sediments will occur near the project boundary. The existing clean layers of near-surface sediments will isolate the deeper contaminated material during construction.
- **Cutting of pier piling.** Cutting rather than pulling the concrete pier piling will reduce any disturbance of deeper contaminated sediments.
- **Placement of a boundary berm.** Prior to dredging, a rock berm will be placed at the southern boundary of the removal action (at Station 6+70). This may reduce any offsite transport of "mud wave" turbidity, although such turbidity is considered unlikely to extend to the project limits. This berm also functions to maintain long-term cap stability at the boundary.

To document any effect of the construction activities on adjacent sediments, boundary documentation sampling will be conducted as described in the CQAP. This will involve collection of surface (0–10 cm) samples from the area south of the removal boundary, both before initiation of construction and after completion of construction.

In the unlikely event that contaminant concentrations in sediments in the boundary area exceed the SQS and are higher than pre-construction concentrations, corrective actions may be taken at the direction of EPA. The corrective actions may include placement of a thin layer of clean capping material, as described in the CQAP.

7.3 SHORT-TERM IMPACTS TO THE COMMUNITY

The Slip 4 construction area is not directly adjacent to any residential areas. Onsite construction activities are not expected to generate any noise impacts to nearby residential areas. Most construction will be accomplished with water-based equipment, which is regularly employed throughout the LDW. Imported capping materials would be brought to the site on barges.

The primary short-term impact to the community will be overland transport of contaminated sediments to a landfill or to a nearby transfer station. As discussed in Section 4, approximately 10,256 cy (or approximately 14,000 tons) of material will be transported to the landfill. Assuming an average load of 30 tons per truck, roughly 450–500 truck loads would leave the transloading site over approximately 4–6 weeks. At least four haul possibilities exist:

- The material could be trucked from Slip 4 to a transfer station at Alaska Street (for subsequent rail transport and disposal at Waste Management's Columbia Ridge Landfill near Arlington, Oregon). The likely truck transportation route would be north on 8th Avenue South, northwest on East Marginal Way S., north on Ohio Avenue South, east on South Hudson Street, and north on Colorado Avenue South to the transfer station (70 South Alaska Street).
- The material could be trucked from Slip 4 to a transfer station on Third Avenue South (for subsequent rail transport and disposal at Roosevelt Regional Landfill near Goldendale, Washington). The likely truck transportation route would be north on 8th Avenue South, northwest on East Marginal Way S., and then north on 4th Avenue South to the transfer station (2733 3rd Avenue South).
- The material could be trucked from an alternate transloading location (outside of Slip 4) to either of the two disposal options above.

The contractor's RAWP will identify the proposed transloading location and disposal facility, and will include a transportation and disposal plan (including haul routes) for EPA approval.

8 ACCESS AND REGULATORY AND PERMIT REQUIREMENTS

This section describes the temporary access and staging requirements for implementation of the Slip 4 cleanup, and summarizes how the design complies with regulatory and permit requirements identified in the Action Memorandum.

8.1 CONSTRUCTION ACCESS AND EASEMENT REQUIREMENTS

8.1.1 Summary of Access Requirements

The majority of the work will occur on City-owned property (see Figure 1-3). However, to accomplish the Slip 4 removal action, the contractor, City employees, City consultants, and EPA representatives will require access to the site through (or on) property owned by Crowley Marine Services, First South Properties, and The Boeing Company. The City has been and will continue to work with these property owners through the design and contracting phase to secure the required access. Tenants of these properties (includingFirst Student, Organics Fuel Processing and Kelly Ryan Marine) will be affected by the construction access.

The primary access requirements relate to the contractor's operations, including:

- Navigable access of equipment to the head of Slip 4 through Crowley's berthing areas
- Land access to Crowley's upland areas, for pier demolition, vehicle access, and potentially transloading
- Land access to First South Properties upland areas, potentially for bank excavation and vehicle access.

Figures 8-1 and 8-2 conceptually depict the site access and staging requirements under offsite and onsite transloading scenarios, respectively. (**Note:** These figures are for illustrative and planning purposes only; access requirements and negotiations will continue throughout the design and contracting phase of the project. Actual contractor staging and access areas will be shown on the final issued-for-construction drawings and will supersede any information on these DAR figures.)

8.1.2 Specific Navigation Access Issues

8.1.2.1 Crowley's Middle Berth

The City will work with Crowley and its tenant and subtenantss () to avoid or minimize any tug activity in Crowley's middle berth during marine construction. Propwash currents from tug activity in the middle berth could increase the potential for fugitive dredge residuals to be transported out of the immediate dredge area; further, access to the middle berth area is regularly needed for water quality monitoring. Kelly Ryan Marine normally moors a barge in the middle berth and/or outer berth; the City is coordinating with Kelly Ryan Marine to provide alternative moorage during construction so the middle berth remains clear.

8.1.2.2 Tribal Access

Accommodations for tribal fishing may also be required and will be coordinated between the City and the Muckleshoot Tribe.

8.1.3 Contractor Requirements and Access Coordination

The specifications require the contractor to plan the construction activities to minimize conflict with commercial operations. Where such conflicts cannot be avoided, the required coordination will be effected through the City and, if necessary, the EPA. The contractor will be required to describe vessel management procedures as part of their RAWP, including the numbers and types of vessels to be used, berthing/tie-up areas, vessel routes, updated schedules of planned vessel movements, etc. The specifications include requirements for the contractor to temporarily move the Sampson barge as needed to gain access for the contractor's equipment and vessels.

During construction, the contractor will be required to:

- Set up and maintain all required temporary facilities
- Decontaminate and inspect all vehicles leaving the transloading areas that have come into contact with waste materials
- Immediately clean any visible track-out from transloading areas
- Coordinate daily vessel movements with Sampson (through the City) to ensure access
- Coordinate with Crowley and First South Properties (through the City) on land access timing and areas, and Crowley's intermittent use of the rail spur near the pier
- Maintain temporary fencing around work areas in designated locations
- Provide a traffic supervisor to direct traffic on onsite haul routes during all periods of truck operations
- Restore access and staging areas to existing conditions following construction.

Accommodations for tribal fishing will be coordinated through the City Project Manager. The contractor will immediately notify the City of any impediments to access that it cannot directly resolve with the landowners or tenants.

8.2 REGULATORY AND PERMIT REQUIREMENTS

The USEPA Action Memorandum (2006a) for Slip 4 requires that removal actions comply with ARARs and "To Be Considered" standards (TBCs) to the extent practicable. However, since that the Slip 4 EAA is part of the LDW Superfund Site for which there will be at least one Record of Decision (ROD), and since the Slip 4 removal action is intended as final action for the Slip 4 EAA, all ARARs will be met for the Slip 4 EAA removal action as documented in this section. ARARs and TBCs are discussed below as they pertain to the removal action. Requirements for offsite actions (e.g., material transportation, dredge material disposal, wastewater discharge to a publicly owned treatment works) are also presented.

ARARs are promulgated federal and stricter state environmental or facility siting laws and regulations which are either 1) applicable, or 2) relevant and appropriate requirements. EPA in conjunction with the state as support agency, as set forth in the NCP, is required to identify ARARs that will be met during the implementation of the removal action.

TBCs include other than formally promulgated federal and stricter state standards, local government requirements in ordinances and regulations, and other pertinent published criteria, that are "to be considered" by EPA in the implementation of the removal action. TBCs are discretionary rather than mandatory, but compliance is recommended.

For CERCLA actions such as Slip 4, regulatory permits are not required for onsite actions, but onsite actions must be conducted in a manner that meets the substantive provisions of applicable regulatory requirements. Actions that take place offsite are subject to all applicable requirements, including any administrative (e.g., permit approval or reporting) requirements.

8.2.1 Federal Requirements (ARARs)

8.2.1.1 Sections 401 and 404 of the Federal Clean Water Act - Water Quality Certification and Dredge and Fill Requirements (33 USC 1340,1344; 33 CFR Parts 320 through 330 and 40 CFR Parts 230 and 231)

Sections 401 and 404 of the CWA set forth requirements for water quality certification, and for dredging and placing fill materials into the waters of the United States, respectively, and are applicable to in-water actions at Slip 4. Because these actions will take place onsite, only substantive requirements of these laws and implementing regulations apply.

Section 401 requires that a certification of water quality be issued by the state that cleanup actions will meet applicable water quality standards. EPA and Ecology are examining the removal design and will make that determination. Further discussion of the specific state water quality criteria and establishment of a mixing zone is presented in Section 7 of this design report. Prior to construction, EPA will issue a finding that substantive requirements of the 401 certification have been met.

Concurrent with the Action Memorandum, a Section 404(b)(l) evaluation was completed for the project which determined that the in-water removal action will be in compliance with the requirements of CWA Section 404 (USEPA 2006b).

A key element of this compliance is evaluation of fill material qualities. 40 CFR Part 230 sets forth specific standards to implement CWA Section 404(b)(l) requirements for evaluation and testing of dredged or fill material placed into navigable waters of the U.S**.** Placement of fill material at Slip 4 from upland sources is CERCLA onsite action, and hence, the substantive requirements of 40 CFR Part 230 must be met. EPA will meet the requirements of 40 CFR Parts 230.60 and 230.61 (Evaluation and Testing) through consideration of such factors as the nature of material being placed, experience, and the results of import material tests that are required by the specifications. No material will be placed in the water until EPA has reviewed the characterization results.

8.2.1.2 Section 10 of the Rivers and Harbors Appropriations Act (33 USC 403; 33 CFR Part 320,322)

Section 10 of this statute prohibits the unauthorized obstruction or alteration of any navigable waters of the U.S., which includes the subject area. Procedures set forth by USACE in 33 CFR Parts 320 and 322 require an examination of the impact of the action, in this case *in situ* capping. The requirements of Section 10 have been addressed by EPA at the same time it addressed the requirements of Section 404 of the CWA.

8.2.1.3 Fish and Wildlife Coordination Act (16 USC 661 et seq.)

This statute establishes criteria to protect fish and wildlife that could be affected by proposed or authorized federal projects involving "impounding, diverting, or controlling waters." EPA is consulting with the USFWS and the WDFW regarding the potential effects of the project on fish and wildlife and measures that would minimize or mitigate those impacts. Also, the statute requires that adequate provision be made for the conservation, maintenance, and management of fish and wildlife resources and their habitats.

8.2.1.4 Resource Conservation and Recovery Act (Subtitle C) Hazardous Waste (42 USC 6921 through 6939[e]) and (40 CFR 261.4[g])

In 1998, EPA exempted dredged contaminated sediments subject to CWA Section 404 requirements from regulation as a hazardous waste for disposal within water or on land where there is discharge back to surface water. The disposal of dredged sediments in an upland facility where there is no connection to surface water is not exempt from regulation. This exemption has been adopted by Ecology.

Testing of the sediments for TCLP chemical constituents (Appendix A) indicates that the sediments dredged for offsite disposal will not designate as hazardous waste. Some debris may require additional testing if required by the landfill.

8.2.1.5 Resource Conservation and Recovery Act (Subtitle D) Solid Waste (42 USC 6941 through 6949[a]) and (40 CFR Parts 257,258)

The upland disposal of dredged contaminated sediments is not exempt from federal and state solid waste management requirements. The requirements of the federal regulations have been incorporated into Ecology's solid waste regulations, which are presented in Section 8.2.2.

8.2.1.6 Native American Graves Protection and Repatriation Act (NAGPRA) (25 USC. 3001 et seq., 43 CFR Part 10)

It is possible that disturbance of Native American materials from earlier times may occur as a result of sediment dredging. NAGPRA and implementing regulations are intended to protect Native American graves from desecration through the removal and trafficking of human remains and "cultural items" including funerary and sacred objects. To protect Native American burials and cultural items, the regulations require that if such items are inadvertently discovered during excavation, the excavation must cease and the affiliated tribes notified and consulted.

The specifications require the dredging contractor to cease excavation should such items be observed in the materials being loaded onto the barges. Such materials are not known to exist at the site.

8.2.1.7 National Historic Preservation Act (NHPA) (16 USC §470f, 36 CFR Parts 60, 63, and 800); American Indian Religious Freedom Act (42 USC 1996 et seq.)

If Native American or other cultural materials are unearthed as part of the dredging process, NHPA and implementing regulations require that federal agencies consider the possible effects on historic sites. If an agency finds a potential adverse effect on historic sites or structures, the agency must evaluate alternatives to "avoid, minimize, or mitigate" the impact, in consultation with the State Historic Preservation Officer.

The specifications require the dredging contractor to cease excavation should such materials be observed in the materials being loaded onto the barges.

8.2.1.8 Archaeological Resources Protection Act (ARPA) (16 U.S.C. § 470 et seq., 43 CFR Part 7)

Should cultural materials be discovered in dredged sediments, the requirements of ARPA and its implementing regulations apply. They prohibit the unauthorized disturbance of archaeological resources on public and Indian lands. Archaeological resources are "any material remains of past human life and activities which are of archaeological interest," including pottery, baskets, tools, and human skeletal remains. The unauthorized removal of archaeological resources from public or Indian lands is prohibited, and any archaeological investigations at a site must be conducted by a professional archaeologist.

The specifications require the dredging contractor to cease excavation should such items be observed in the materials being loaded onto the barges.

8.2.1.9 Magnuson-Stevens Fishery Conservation and Management Act (16 USC 1801 et seq., 50 CFR Part 600)

Consideration of the effects of federal actions on Essential Fish Habitat (EFH) for covered species including salmon is required under the Magnuson-Stevens Fishery Conservation and Management Act (16 USC 1801 et seq.) and its implementing regulations (50 CFR Part 600), finalized January 17, 2002. Typically state or federal agencies planning actions that might adversely affect an EFH-managed species must formally consult with NOAA Fisheries regarding the action.

EPA prepared an evaluation of EFH and concluded that the proposed Slip 4 action is not likely to adversely affect EFH for salmonid and groundfish. A copy of EPA's evaluation was provided to NOAA Fisheries (USEPA 2006b).

8.2.1.10 Toxic Substances Control Act (TSCA) (40 CFR 761)

This regulation is applicable to excavated or dredged materials containing PCBs. The removal action will comply with TSCA by disposing of any soils and/or sediments with total PCB concentrations greater than 50 mg/kg at a TSCA landfill. However, predesign investigations do not indicate that such material exists.

Disposal of soils and/or sediments with total PCB concentrations less than 50 mg/kg will follow the substantive requirements of 40 CFR 761.61, cleanup and disposal requirements for PCB remediation waste. Material meeting the definition of PCB remediation waste (761.3) must be disposed of pursuant to one or a combination of the three options under Section 761.61 (self-implementing option; performance-based option, and a risk-based option). As described in the Action Memorandum, the risk-based option under Section 761.61(c) will be followed at this site. PCB remediation wastes containing less than 50 mg/kg may be disposed of at non-TSCA municipal or solid waste landfills.

8.2.1.11 Migratory Bird Treaty Act (16 USC 703-712)

This act governs the taking, killing, possession, transportation, and importation of migratory birds, their eggs, parts, and nests. This act is applicable to cleanup actions at Slip 4.

During the removal action, actions will be taken as needed to protect habitat for migratory birds and avoid disturbances of their nests and eggs.

8.2.2 State Requirements (ARARs)

8.2.2.1 Solid Waste Management Act (Ch. 70.95) and Regulations

These requirements are applicable to the disposal of non-hazardous waste generated during removal activities. These standards set minimum functional performance standards for the proper handling and disposal of solid waste, identify functions necessary to ensure effective solid waste handling at both the state and local level, and follow priorities for the management of solid waste.

Because the disposal of the dredged sediments and debris will take place in a permitted solid waste landfill that is outside the site boundaries, both substantive and administrative requirements of applicable regulations must be met for this activity.

The offsite rule (40 CFR 302.440) of the NCP requires that solid and hazardous waste offsite landfills to which CERCLA hazardous substances are being sent must be acceptable to EPA. The project specifications require the contractor to obtain EPA approval of the proposed disposal facility.

In practical terms, the requirements for disposal of dredged sediments will be found in the permit of the landfill that agrees to accept the waste. For example, the Roosevelt Regional Landfill's permit allows it to accept sediments that, while dewatered, do not need to pass the paint filter test (to limit free-draining liquids) before disposal.

8.2.2.2 Model Toxics Control Act Regulations (MTCA) (WAC 173-340-440)

MTCA is an ARAR. With regards to the institutional controls, MTCA regulations address the use of institutional controls at cleanup sites. The institutional controls identified in the ICIP (Section 10 of this DAR) will be implemented in accordance with these regulations.

8.2.2.3 Water Quality Standards for Surface Waters (Ch. 90.48 and 90.54 RCW; WAC 173-201A)

WAC 173-201A sets forth water quality standards that must be met in Slip 4. The most important standards for sediment capping and dredging activities are turbidity, dissolved oxygen (DO), and toxic substances limits. These water quality standards must be met is at the boundary of the mixing zone.

Water quality monitoring during construction (defined in the WQMP) will include DO and turbidity, and chemistry. The specifications require the contractor to modify operations if exceedances of these criteria occur at the mixing zone boundary. EPA will determine the final mixing zone boundaries and monitoring requirements consistent with the requirements of the CWA.

8.2.2.4 Point Source Discharges to Surface Water (Ch. 90.48 and Ch. 90.54 RCW) and Regulations (Ch. 173-220 WAC)

These regulations govern the point source discharge of pollutants to surface water. The dredged sediments will be dewatered onsite on a barge during the course of the dredging activities. Collected water from upland transloading areas will be collected, analyzed, and discharged either back to the waterway (subject to requirements of the CWA) or to the sanitary sewer (under a permit from King County).

The substantive requirements of the state National Pollutant Discharge Elimination System (NPDES) program will be satisfied with EPA's finding that substantive requirements of the CWA 401 Certification have been met. The discharge must not cause a violation of surface water quality standards outside the established mixing zone.

8.2.2.5 Construction Projects in State Waters (Ch. 77.55 RCW) and Hydraulics Project Approval Regulations (Ch. 220-110 WAC)

Hydraulic code rules for construction projects in state waters have been established for the protection of fish and shellfish, and are applicable to Slip 4 construction activities. The removal action will comply with these substantive requirements by implementing BMPs for the protection of fish and shellfish, as recommended by the Washington Department of Fish and Wildlife.

8.2.2.6 Shoreline Management Act (Ch. 90.58 RCW)

According to SMA regulation WAC 173-27-060, federal agency actions within a coastal county such as King County must be consistent to the maximum extent practicable with the approved Washington state coastal zone management program, subject to certain limitations set forth in the Federal Coastal Zone Management Act, 16 U.S.C. 145 1 et seq. (CZMA) and regulations adopted pursuant to it.

Seattle Municipal Code (SMC) Chapter 23.60 and its regulations implement the State Shoreline Management Act, and are applicable to all building, excavation, dredging, and filling within 200 ft of regulated shorelines. Changes to the shoreline resulting from cleanup have been evaluated and will be in compliance with these implementing regulations.

8.2.2.7 Puget Sound Clean Air Agency Requirements

The Puget Sound Clean Air Agency (PSCAA) requires control of fugitive dust emissions generated by activities within its region. Specifically, Regulation I, Section 9.15 (Fugitive Dust Control Measures) prohibits visible emissions of fugitive dust unless reasonable precautions are employed to minimize these emissions. Examples of reasonable precautions are listed in the regulations.

Clean materials brought to the site to construct the sediment cap will be managed in accordance with the requirements of this regulation. Dust from demolition will be controlled by the contractor.

8.2.2.8 Washington State Sediment Management Standards (SMS) (Ch. 173-204 WAC)

The SMS establish a narrative standard with specific biological effects criteria and numerical chemical concentrations for Puget Sound sediment.

Under the SMS, the cleanup of a site should result in the elimination of adverse effects on biological resources and any health threats to humans. SMS has numerical standards for biological resources, and narrative standards for protection of human health.

Attainment of the overall cleanup objectives, as specified in the Action Memorandum, will be measured by compliance with the Sediment Quality Standards (SQS) on the surface of the completed cap, which is to be placed over the entire cleanup area. Further, the design requires the use of imported "clean" sand, gravel, and rock for capping materials, and the clean capping materials will be tested prior to placement as a sediment cap. Cap materials will be required to have concentrations that are no greater than ½ the SQS, as described in the design documents, but it is anticipated that many concentrations will be undetected. All capping material (with the exception of coarse-grained rock such as armor materials) will be sampled. The final surface of the constructed cap will also be sampled to demonstrate that the cap has been successfully placed, resulting in SQS or lower concentrations throughout the capped area.

8.2.2.9 Washington State Dangerous Waste Regulations (WAC 173-303)

These rules regulate the generation, handling, storage, treatment and disposal of dangerous waste, Washington's stricter, more expansive term for federal hazardous waste.

Because the disposal of the dredged sediments and debris will take place in a permitted solid waste landfill outside the site boundaries, and thus the dredged sediment exclusion (see earlier RCRA discussion) does not apply, both substantive and administrative requirements of applicable regulations must be met for this activity. Dredged material will be evaluated for dangerous waste designation in accordance with these regulations.

8.2.3 Local Requirements (TBCs)

8.1.3.1 City of Seattle Noise Ordinance (SMC Chapter 25.08)

The City of Seattle's noise ordinance (SMC, Ch. 25.08, Noise Control) sets maximum noise emission levels for two time periods: 1) daytime (7 a.m. to 10 p.m.); and 2) weeknights (10 p.m. to 7 a.m.) and weekends and holidays (10 p.m. to 9 a.m.). The site and its immediate area are within the ordinance's industrial zone. The contractor will control noise emissions to within the maximum 70 Decibels.

8.1.3.2 King County Wastewater Discharge Permit (KCC Title 28)

Discharge from construction dewatering into the King County sewerage system is governed by these regulations which are designed to prevent discharge of substances that degrade wastewater treatment processes or impact surface-water quality.

In accordance with King County Code Title 28, the City of Seattle is required to apply for a King County Wastewater Discharge Permit. As required by the permit, the City will provide pre-treatment of wastewater to levels in accordance with King County's established discharge limits. Local King County (Title 28) as well as federal (40 CFR 403) limits apply to construction dewatering discharges and will be met by the removal action.

8.2.4 Federal Endangered Species Act (16 USC 1531 et seq.; 50 CFR Parts 17, 200, 402)

As noted in the EE/CA, several federally threatened or endangered (T/E) wildlife and fish species may be present in the site area. In accordance with Section 7 of the Act, EPA has been consulting with the U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) (collectively "the Services") about the potential effects of the proposed removal activities and ways to minimize those effects. A biological assessment has been prepared with EPA oversight.

USFWS and will issue a biological opinion outlining any jeopardy the removal action may represent for listed species. The Services may suggest project modifications to reduce adverse effects below the "jeopardy" threshold and allow the activity to proceed. If a no-jeopardy opinion is issued the removal action may be conducted as planned.

Based on ongoing consultation, allowable periods of in-water work have been identified and specific habitat enhancement measures, including the use of specific substrates, and optimal grades and elevations for biological resources, have been incorporated into the removal design. The biological opinion may include additional conservation measures (such as restrictions on allowable work periods in certain areas, or monitoring for presence of listed species) to further minimize impacts.

9 CONSTRUCTION SEQUENCING, SCHEDULE, AND COST ESTIMATE

9.1 CONSTRUCTION SEQUENCING

The specific sequencing of the construction will be defined in the contractor's RAWP, and will be dependent on (among other things) the transloading proposed by the contractor. Assuming onsite transloading, construction sequencing will be generally as follows:

- Mobilization and setup of temporary facilities, including transloading area
- Preconstruction survey
- Boundary area documentation sampling (preconstruction)
- Removal of piling and debris from the dredge area
- Placement of a boundary berm at the southern cap limits
- Dredging at the head of Slip 4
- Bank excavation
- Bank documentation sampling
- Acceptance survey
- Bank capping
- Outfall area capping
- Pier demolition
- Waterway capping
- Acceptance survey
- Cap verification sampling and boundary area documentation sampling (post construction)
- Prefinal and final inspections
- Corrective measures (if needed)
- Demobilization and cleanup.

In some cases, multiple activities may be occurring at the same time, such as bank capping and outfall area capping. The contractor will maintain an up-to-date detailed schedule of activities in accordance with the specifications.

9.2 CONSTRUCTION SCHEDULE

Figure 9-1 presents the target construction schedule for implementing the remedy for the Slip 4 EAA. The target construction schedule has been developed based on experience in production rates for similar work at other sites, assumptions regarding contractor crew and equipment resources that may be dedicated to the project (such as the number of working shifts), and best professional judgment. Utilizing these assumptions and considering the City's contract procurement process, it is estimated that construction can be completed by early February, 2012. Contractors bidding the work will propose their own schedules and will develop detailed schedules in their RAWP submittal.

The actual schedule may vary depending on the means and methods the contractor uses. The Contractor will submit a detailed schedule with the RAWP, which will also consider specific tidal stages during the construction tasks.

The preliminary target schedule presented in Figure 9-1 was developed on the basis of the following specific assumptions and considerations:

1. An onsite transloading area will be used by the contractor and will be designed with throughput that does not limit dredging/excavation rates
2. The construction window, during which in-water work is allowed, is between October 1, 2011 and February 14, 2012
3. One 12-hour working shift per day, Monday through Friday, was assumed for construction. No overlap of construction tasks was assumed
4. Pier demolition must precede any waterway capping
5. Dredging and excavation must precede any capping
6. All estimated work durations calculated based on production rates have been rounded up to the nearest day
7. The City is assumed to give notice to proceed for mobilization after the draft RAWP is submitted and the preconstruction meeting is held. Contractor mobilization will take 10 working days from the City's Notice-To-Proceed, and demobilization and cleanup will take five working days from the final inspection
8. Boundary documentation sampling (pre-construction), mobilization, and pre-construction survey will begin before the October 1, 2011 construction window
9. Bank excavation documentation sampling will not delay the work. Cap verification and boundary area documentation sampling (post-construction) will require seven calendar days to complete and make determinations on the need for any corrective actions

10. Pre-construction survey will require eight working days, and each acceptance survey (post-dredging and post-capping) will require five working days each
11. No in-water construction can begin until: a) EPA issues their notice to proceed; b) the boundary area documentation sampling (pre-construction) is complete; and c) the pre-construction survey is complete and accepted
12. Removal of piling and debris from the dredge area (i.e., "debris sweep") will require five working days
13. Pier demolition can be completed in 15 working days.

The following conservative production rates were used to calculate durations:

1. Dredging: 600 cy/day
2. Bank Excavation: 400 cy/day
3. Placement of Filter Material: 400 cy/day
4. Placement of Cap Armor: 400 cy/day
5. Placement of Heavy Loose Riprap: 200 cy/day
6. Placement of Waterway Cap material: 1,000 cy/day
7. Placement of Habitat Mix: 500 cy/day
8. Only one operation placing upland material at any given time (i.e., for slope cap, placement of all filter material followed by placement of cap armor).
9. Any corrective measures required between pre-final and final inspections can be completed in five working days.

9.3 ENGINEER'S ESTIMATE

The total estimated project cost is comprised of direct removal action (RA) construction contract costs, plus indirect costs. Details on the development of the cost estimate are provided in Appendix G. Cost estimates are based on recent experience at similar sites, engineering cost guidance, and best professional judgment.

9.3.1 Direct Construction Costs

Table 9-1 presents the 100% Design Engineer's estimate of probable construction costs. Construction costs were estimated to be approximately $4,310,000 plus applicable tax. Direct RA construction costs were estimated for each of the bid items defined in the specifications, Section 01270—Measurement & Payment, and include:

Payment Items:

1. Mobilization, including demobilization and contractor's general conditions (e.g., field expenses, insurance, and bonds)
2. Maintenance and protection of traffic
3. Environmental pollution protection control
4. Removal Action Work Plan
5. Demolition and removals, including pier demolition and general debris removal
6. Dredging, bank excavation, and disposal of material at a Subtitle "D" landfill
7. Waterway cap material, including import and placement
8. Filter material, including import and placement
9. Cap armor, including import and placement
10. Habitat mix, including import and placement
11. Heavy, loose riprap, including import and placement
12. Beach sand, including import and placement
13. Large woody debris
14. Survey and survey control
15. Record drawing and closeout documentation.
16. Disposal of material at Subtitle C landfill (0–30 tons)
17 Disposal of material at Subtitle C landfill (31–90 tons)
18. Standby for site access (0–5 days)
19. Thin-layer capping (0-830 tons).

Items 16-19 are established for contracting purposes to handle possible scope contingencies, and are included in the Engineer's Estimate to facilitate bid evaluation. The City may delete these items from the contract if there are no actual quantities required during implementation.

9.3.2 Total Project Costs

Table 9-2 presents the overall project cost estimate summary, including all indirect costs associated with the project. Overall project costs are estimated to be approximately $8,145,000. In addition to the direct construction costs, the estimated indirect costs include:

1. Engineering Design
2. Land acquisition and implementation of institutional controls

3. Owner surveys (which may be needed as a contingent verification method for payment or acceptance purposes)
4. Construction Quality Assurance contractor
5. Project management
6. Construction engineering and management
7. Washington State sales tax.
8. Contingency (5% scope and 10% bid)
9. Long-term monitoring and maintenance costs

10 INSTITUTIONAL CONTROLS IMPLEMENTATION PLAN

The Action Memorandum for Slip 4 includes institutional controls (ICs) as part of the overall remedy for the Slip 4 Early Action Area (EAA) (USEPA 2006a). The term "institutional controls" refers to non-engineering measures intended to ensure the protectiveness of the remedy and to affect human activities and ecological receptors by preventing or reducing the potential for exposure to contaminated media (USEPA 2000a). At Slip 4, ICs are intended to augment and not substitute for active response measures.

This section presents the plan for implementing specific controls to help ensure the long-term integrity of the remedy. Documentation that these ICs have been implemented will occur in the Institutional Controls Implementation Report, to be submitted after removal action construction.

Figure 10-1 depicts the parcels and areas that will have engineered caps that will require institutional controls. The parcels are currently owned by Crowley Marine Services, First South Properties, and The Boeing Company; however the City of Seattle (City) will purchase the Crowley property prior to commencement of Removal Action construction (Figure 10-1 reflects this purchase). The engineered caps are of three general types: sediment caps, slope caps, and soil covers. It is important to note that documentation sampling (during construction) of slope cap and soil cover areas may identify certain locations where the slope caps or soil covers are being placed on clean soils. In these cases and locations, the slope caps or soil covers may not need to be maintained as a containment remedy, and ICs may not need to be implemented. The documentation sampling is described in detail in Appendix A of the CQAP.

Appendix J provides additional background information on the objectives and types of ICs.

10.1 PURPOSE AND OBJECTIVES OF INSTITUTIONAL CONTROLS FOR SLIP 4

The specific objectives of the ICs for the capped sediments in Slip 4 are defined in the Action Memorandum (USEPA 2006a) and include:

- Prevent any uncontrolled excavation or construction that may compromise the cap integrity.
- Prevent any current or future land uses that could compromise the cap integrity.
- Require notification of EPA and Washington Department of Ecology (Ecology) prior to any development or redevelopment of the site.

- Ensure that certain restrictions will run with the land.

In addition, the sediment capping is designed to avoid the need for any shellfish harvest restrictions in Slip 4. In consultation with the tribes, the cap has been designed to meet this specification.

10.2 APPLICATION OF GENERAL IC CATEGORIES

According to USEPA (2005c), institutional controls are generally divided into four categories:

1. **Government Controls**—include local laws or permits (e.g., zoning, building permits, and Base Master Plans at military facilities)
2. **Proprietary Controls**—include property use restrictions based on private property law (e.g., easements and covenants)
3. **Enforcement Tools**—include legal documents that require parties to conduct or prohibit specific actions (e.g., environmental cleanup consent decrees, unilateral orders, or permits)
4. **Informational Devices**—include deed notices or public advisories that alert and educate people about a site.

The use of institutional controls at EPA cleanup sites is further described in USEPA (2005c, 2004, 2000b, 1999b) guidance. ICs in all four of these categories will likely apply to the Slip 4 EAA. Each of the applicable ICs is evaluated below to determine which ones are best suited for the Slip 4 EAA (see Table 10-1).

10.3 EVALUATION OF INSTITUTIONAL CONTROLS

In the selection process for the possible ICs to be utilized for Slip 4 EAA, consideration was given to the following attributes:

- Long-term effectiveness
- Implementability
- Enforceability
- Cost.

Long-Term Effectiveness: For an IC to be an important element of the overall protection objectives, it is critical for it to be effective in the long term with no foreseeable termination.

Implementability: In order for an IC to be effective it must be feasible to enact or implement. ICs that require agreement between contentious parties or the creation of new policies or legislation are examples of ICs with poor implementability.

Enforceability: When ICs impose restrictions or establish rights, they are only effective to the extent they are enforceable. Governmental controls are the responsibility of authorized governmental entities to enforce. Proprietary controls are typically enforced by benefited private parties. For each selected IC, it is important to determine who has the responsibility for enforcement and whether that party is likely to or may be compelled to enforce the IC. Zoning, for example, is subject to wide local government enforceability variability, and to variance or exception by local boards which may lack resources and environmental sophistication.

Cost: Costs for ICs include legal fees associated with obtaining easements or restrictive covenants, the costs of purchasing property rights, and the costs of monitoring an IC to ensure that it has not been violated. These costs were considered generally speculative, and so quantitative cost estimates were not made.

Table 10-1 lists the ICs considered for implementation at Slip 4 EAA under each of the four IC categories described in Section 10.3. Each of the ICs was assessed according to the attributes listed above, and the general strength of the IC, relative to other options, was noted as "very good," "good," "neutral," "poor," or "very poor." A quantified rating system was not used as the final selection method because the method also considered the importance of the overall layering or succession of ICs. This means that although an IC by itself may not have received a high assessment, it may provide an important control aspect that other selected ICs may not offer. An example of this is a Deed Notice. Also, an IC that by itself received a high assessment may be duplicating another IC and does not provide any additional protection. State Use Restrictions (statutes that give land owners the authority to establish use restrictions) are an example of this situation. The ICs selected from this assessment are described in further detail as the Proposed ICs in the next section.

10.4 PROPOSED ICS FOR SLIP 4

The ICs proposed for implementation at Slip 4 EAA are summarized in Table 10-2 and are presented in detail below. These ICs offer an overall layered approach as well as a succession of applicable time frames.

10.4.1 Governmental Controls

10.4.1.1 Agency Permits

Current permitting requirements under Section 404 of the CWA and the Washington State SMA are well-established and address any proposed in-water construction activities, and no modifications are necessary for these permitting requirements to provide an effective IC for Slip 4 EAA. This also means the cost of this IC is relatively insignificant.

These permits require appropriate design elements such as (but not limited to) requirements for handling and disposal of contaminated sediments, restoration of the cap following dredging, or dredging to remove all sediments above the SQS. Similarly, these existing regulatory programs (along with ESA requirements) would address any changes to habitat quality or quantity should such future projects be proposed. For example, a future project could not eliminate or adversely affect aquatic habitat in the Slip 4 removal area without requiring mitigation under CWA Section 404. The Washington Department of Ecology and USACE will be responsible for receiving permit applications, conducting site inspections, approving the permits and responding to reports of permit violations.

Consistent with the above, any prospective changes in stormwater and/or wastewater/sewer conveyance, utility easements and such other contingencies such as fiber optic cable and/or other technological conveyances that might involve disturbance of the sediment cap would be subject to these existing permit requirements.

10.4.1.2 Zoning

Because the cap will be protective of human health and the environment regardless of zoning, and this protectiveness will be ensured through the layering of the other ICs, zoning restrictions are not considered a necessary element of the Slip 4 ICIP.

10.4.2 Proprietary Controls

10.4.2.1 Property Purchase

The City's purchase of the inner slip from Crowley enables the City to control the use of the property as fee owner. Although the purchase has a significant cost, the City of Seattle can then directly manage land use, continue monitoring activities, prevent trespassing and determine appropriate ICs for the parcel without the need to negotiate with other landowners.

10.4.2.2 Restrictive Covenants

The City of Seattle proposes that the Department of Ecology will be the Grantee with EPA as a beneficiary with full enforcement rights of MTCA Restrictive Covenants on all three separately owned parcels within the removal action area subject to institutional controls.

The three parcels include the bed of the Slip purchased by the City from Crowley , and the small parcels owned by First South Properties and The Boeing Company.

Specifically, the restrictive covenants will prevent the owners of the property subject to the covenants from conducting (or allow to be conducted) any activity that could result in the release or exposure to the environment of the contaminants contained by the cap or cover. Prohibited activities include, among others: altering, modifying, or removing the cap or cover; piling removal and/or installation; dredging and excavation, and anchoring. The covenants will also include, in addition to other requirements, the following provisions:

1. The owner must give advance written notice to EPA and Ecology of any pending sale of the property, and ensure that the covenant requirements are passed on to the new owner.
2. The owner must notify EPA and Ecology of any use of the property inconsistent with the terms of the covenants, and that providing such notice, whether either Agency responds to such notice, does not in any way relieve anyone from the obligation to fully comply with the covenants.
3. The owner must allow EPA, Ecology and the City of Seattle the right to enter the property at reasonable times to inspect, perform operations and maintenance activities, and collect samples to evaluate the effectiveness of the remedies and compliance with the covenants.
4. The owner must restrict leases of the property to uses consistent with the covenant requirements, and must notify all lessees of the restrictions on use of the property. A copy of the restrictive covenant must be included in any lease, deed, license, easement or other use authorization.
5. The owner must record the restrictive covenant with the King County Recorder's Office within 10 days of the execution date of the covenant.

It is anticipated that the restrictive covenants will be established through mutual agreement between the City and each of the two other parcel owners. The City is currently in negotiations with First South Properties and The Boeing Company to secure restrictive covenants on their respective parcels. If agreements are not reached, the City and County would confer with EPA regarding alternatives, such as agency enforcement orders (see below), local government exercise of eminent domain, and resort to litigation.

The owners will have the responsibility of drafting, signing, and filing the covenants for the affected portions of their properties, as well as enforcing them independent of EPA or Ecology enforcement rights or authority.

10.4.3 Enforcement Tools and Administrative Orders

EPA and Ecology have independent statutory enforcement authority that can be used in lieu of, or in addition to, other ICs. Should any parcel owner not agree to place a MTCA Restrictive Covenant on its respective parcel , EPA and/or Ecology could use its statutory authority to obtain access to inspect, monitor and sample to ensure the integrity of the removal action or for any other authorized purpose..

The City and King County are performing the Slip 4 removal action under an Administrative Settlement Agreement and Order on Consent which requires long-term monitoring to be implemented by the City. EPA will review the effectiveness of the remedy, including monitoring results and IC implementation, no less frequently than every five years, as required under CERCLA. This review process is an important Slip 4 IC component.

10.4.4 Informational Devices

10.4.4.1 Deed Notices

The City will file and record a notice in the King County Recorder's Office and file a copy with the Seattle Department of Planning and Development upon completion of the removal action. The notice will describe the restrictions on the property to protect the cap and will remain in effect until EPA and/or Ecology states in writing that a change in site condition(s) warrants its revocation.

State Registry

The objective of a state registry is to compile contaminated site information in a central database that is available for public research. There are two mechanisms managed by Ecology that currently provide public information about Slip 4 and the Lower Duwamish Waterway. The first is the Hazardous Sites list. This list provides a current status of remedial plans for listed sites. The second is the Site Register. This semi-monthly publication provides notices of enforcement tools, document releases, public meetings, public comment periods, hearings and any other information related to the study and cleanup of a site. These mechanisms are effective to the extent that they are widely published and well established as informational tools for interested members of the public. They will actively provide information about the site until a No Further Action notice is issued by Ecology.

10.4.4.2 Advisories

The remediation of the Lower Duwamish Waterway Superfund Site (LDW) may include fish consumption advisories to reduce human health risks associated with consumption of seafood. There is currently a Washington State Department of Health (WDOH) public health fish advisory recommending no consumption of resident fish (e.g., shiner perch, rockfish, English sole), shellfish or clams from the Duwamish River due to chemical contamination (WDOH 2005). Nonresident fish such as salmon are not included in this advisory.

Fish consumption advisories are an IC subject to informed voluntary compliance. The advisory referenced in the preceding paragraph currently applies to the Slip 4 EAA, and is anticipated to remain in effect at least until the completion of LDW remedial action Monitoring and maintenance related to this advisory fall outside of the scope of the Slip 4 removal action and are being addressed in the LDW decision-making process.

10.4.5 Summary of Proposed ICs

The proposed ICs are:

- Local Permits
- Property Purchase
- Restrictive Covenants
- Agency Enforcement Tools and Administrative Orders
- Deed Notices
- State Registry
- Fish Consumption Advisories.

Local Permitting and Fish Consumption Advisory authorities are already established. The remainder of these ICs will require implementation which will be documented in the Institutional Controls Implementation Report.

The proposed ICs will provide layers of protection to support the long-term integrity of the cap and covers, allow for periodic monitoring, and expand the public information available.

10.5 IC IMPLEMENTATION REPORT COMPONENTS AND SCHEDULE

The Removal Action Completion Report, due after completion of the construction phase of the removal action, will contain a description of the ICIP implementation to date, with copies of all implementing documentation, a description of the review process and stakeholder input to the ICIP, a schedule for completion of all outstanding ICIP tasks, and a proposed submittal date for a draft and final Institutional Control Implementation Report.

The Institutional Control Implementation Report will document complete implementation of the ICIP, including copies of all relevant paperwork (e.g., permit application forms, easements, covenants, deed notices, state registries, and public advisories). This report will be submitted to EPA and Ecology under requirements of the Administrative Settlement Agreement and Order on Consent for Removal Action for the Slip 4 EAA.

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