Lower Duwamish Waterway Group

Port of Seattle / City of Seattle / King County / The Boeing Company

TECHNICAL MEMORANDUM: DRAFT PRELIMINARY SCREENING OF ALTERNATIVES FOR THE LOWER DUWAMISH WATERWAY SUPERFUND SITE

For submittal to

The U.S. Environmental Protection Agency
Region 10
Seattle, WA

The Washington State Department of Ecology
Northwest Regional Office
Bellevue, WA

September 27, 2006

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Technical Memorandum

Draft Preliminary Screening of Alternatives

Lower Duwamish Waterway
Seattle, Washington

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List of Acronyms

AOC	Administrative Order on Consent
AOI(s)	Area(s) of Interest
BMPs	best management practices
CAD	contained aquatic disposal
CDF	confined disposal fill
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
cfs	cubic feet per second
cm/yr	centimeters per year
COC	chemical of concern
COPC	chemical of potential concern
CSL	cleanup screening level
CSM	conceptual site model
CSO	combined sewer overflow
CTM	*Identification of Candidate Cleanup Technologies Memorandum*
cy	cubic yard
DMMP	Dredged Material Management Program
Dw	dry weight
EAA	sponsored Early Action Area
EBDRP	Elliott Bay / Duwamish Restoration Program
Ecology	Washington State Department of Ecology
ENR	enhanced natural recovery
EPA	United States Environmental Protection Agency
FS	feasibility study
ft	feet
GIS	geographical information systems
IDW	inverse distance weighting
kg	kilogram
km	kilometer
LDW	Lower Duwamish Waterway
LDWG	Lower Duwamish Waterway Group
m	meter
M	million

List of Acronyms

m^3/s	cubic meters per second
mg/kg	milligrams per kilogram
mg/kg dw	milligrams per kilogram dry weight
MLLW	mean lower low water
mm	millimeter
MNR	monitored natural recovery
MTCA	Model Toxics Control Act
NCP	National Contingency Plan
NPDES	National Pollutant Discharge Elimination System
OC	organic carbon (carbon normalized)
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PPA	Potential Priority Area
PSA	preliminary screening of alternatives
PSNS	Puget Sound Naval Shipyard
QAPP	quality assurance project plan
QEA	Quantitative Environmental Analysis LLC
RAL	remedial action level
RAO	remedial action objective
RI	remedial investigation
RM	river mile
ROD	Record of Decision
SCWG	Source Control Work Group
SMA	sediment management area
SMS	Sediment Management Standards
SQS	sediment quality standard
SWAC	spatially-weighted average concentration
TOC	total organic carbon
TSS	total suspended solids
USACE	United States Army Corps of Engineers
WAC	Washington Administrative Code
Windward	Windward Environmental LLC

1 Introduction

This preliminary screening of alternatives (PSA) document develops and screens preliminary remedial alternatives for the Lower Duwamish Waterway (LDW) Superfund Site in Seattle, Washington (Figure 1-1). Preliminary remedial alternatives are identified early in the Remedial Investigation/Feasibility Study (RI/FS) so that appropriate data can be collected or reviewed early in the FS process. Results of this screening will be used to inform the strategy to be developed in the FS work plan.

This document preliminarily identifies a working set of waterway-wide remedial alternatives by assembling representative process options. This preliminary evaluation does not preclude the further examination of different process options or different alternatives, either in the FS or potentially in the pre-remedy design phase. The configurations of the alternatives and the applications of specific technologies will be modified and refined in the FS or later in pre-remedy design documents.

The remaining subsections of this introduction provide background information on the LDW Superfund investigations, as well as the objectives, approach, and organization of this document.

1.1 Background and Regulatory Setting

In December 2000, the City of Seattle, King County, the Port of Seattle, and the Boeing Company (collectively referred to as the Lower Duwamish Waterway Group [LDWG]) signed a joint Administrative Order on Consent (AOC) with the United States Environmental Protection Agency (EPA) and the Washington State Department of Ecology (Ecology) (collectively referred to as *the agencies* herein) to conduct an RI/FS for the LDW. The LDW was subsequently added to EPA's National Priorities List (also known as Superfund) on September 13, 2001. The LDW Superfund study area comprises the downstream portion of the Duwamish River, extending from the mouth of the river (excluding the East and West Waterways around Harbor Island) at river mile (RM) 0.0[1] upstream to approximately RM 5.0. The boundaries of the study area are shown on Figure 1-1.

As specified in the AOC, the FS will be conducted in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), the associated National Contingency Plan (NCP), and the Washington State Model Toxics Control Act (MTCA). The scope of the FS was defined in the *Lower Duwamish Waterway Remedial Investigation/*

[1] River miles are referenced to the southern end of Harbor Island, which is defined as RM 0.0. East and West Waterways of Harbor Island are not included because they are part of a separate Superfund site.

Feasibility Study Statement of Work (LDWG 2000) and in the *Clarification of Feasibility Study Requirements* (EPA and Ecology 2003). These documents clarified that the FS would address the LDW as a whole, rather than as a collection of detailed analyses of individual action areas or operable units.

The waterway-wide FS will identify and screen remedial alternatives based on the general range of LDW sediment characteristics, waterway conditions, and the chemicals of potential concern (COPCs) identified in the Phase 2 risk assessments. The FS will develop alternatives to a sufficient level of detail to allow the selection of a remedy for the LDW as a whole. Following public comment on the FS and EPA and Ecology's proposed cleanup plan, the record of decision (ROD) will identify the selected remedy for the LDW. However, actual design and cleanup of individual areas may be accomplished as separate or phased cleanup actions and will consider detailed site-specific conditions.

The AOC identifies a series of documents that are required as part of the RI/FS process; this PSA is one such document. This PSA was identified as a pre-FS work plan deliverable in the *Remedial Investigation/Feasibility Study Integration Memorandum* submitted to EPA and Ecology (RETEC 2005a). Consistent with EPA Superfund guidance (EPA 1988), the *Integration Memorandum* identified FS activities and deliverables that will be undertaken concurrent with the RI and the technical memoranda that will be completed as part of the integration process. The rationale for conducting these activities is to ensure that: (1) data needed to complete the FS are collected during the RI to the extent possible, and (2) the FS is completed within the schedule established for the LDW RI/FS. It is acknowledged that decisions reached in this PSA may need to be modified as new information becomes available through the RI/FS process.

For the purposes of this PSA, the long-term remedial goals for contaminants in LDW sediments are referred to as "cleanup levels," and contaminant concentrations that may warrant active cleanup are referred to as remedial action levels (RALs). Cleanup levels and RALs have not yet been developed for the LDW. These levels will be one of the factors used to define the footprint of the sediment management areas (SMAs) requiring remediation. Preliminary RALs and SMAs will be developed in the FS after finalization of the *Sediment Transport Analysis Report* (Windward and QEA 2006), the Phase 2 risk assessments, the Phase 2 RI, and the Remedial Action Objectives (RAO) memorandum. Figure 1-2 shows the general RI/FS process for the LDW, and how this PSA fits into the overall schedule of activities and deliverables. The selection of cleanup levels and RALs, and designation of SMAs, will be finalized in the ROD.

In the absence of cleanup levels or RALs, and to allow development and analysis of a comparable set of alternatives in this document, the alternatives have been developed by identifying a number of hypothetical Potential Priority Areas (PPAs) and areas of interest (AOIs). As defined in Section 3, the areas have been developed in this PSA using varying hypothetical RALs for polychlorinated biphenyls (PCBs), and are used as surrogates for the areas that will ultimately be defined by the cleanup levels and RALs in the FS.

1.2 Objectives of the Preliminary Screening of Alternatives

This waterway-wide PSA is the second of several steps that will be taken to prepare the LDW FS (Figure 1-2). The objectives of this PSA are two-fold:

1) Complete this PSA early in the FS process to provide a useful forum for the exchange of ideas and expectations among LDWG, EPA, Ecology, and stakeholders.

2) Identify potential remedial alternatives early in the RI/FS so that appropriate data can be collected or reviewed early in the FS process. Results of this screening will be used to inform the strategy to be developed in the FS work plan.

This PSA process builds upon the *Identification of Candidate Technologies Memorandum* (CTM) (RETEC 2005b) and includes several steps: (1) select representative remedial technologies based on site-specific conditions and potentially actionable areas, (2) assemble combinations of selected technologies into preliminary waterway-wide remedial alternatives, and (3) screen alternatives relative to CERCLA and MTCA criteria (Figure 1-3). The retained remedial alternatives will be used to help identify additional data needs in the FS work plan. The FS work plan will also outline the process for evaluating these preliminary alternatives in the FS. The draft FS work plan is scheduled for submittal to the agencies in October 2006.

1.3 Limitations of this PSA

The screening of alternatives is one component of the FS. This first, preliminary screening relies upon the current knowledge of chemical distributions in surface and subsurface sediments and site-wide physical conditions that affect sediment stability. It is acknowledged that site conditions vary, particularly between intertidal and subtidal areas. As a better understanding of these site conditions is gained through the completion of the Phase 2 RI and the work identified in the FS work plan, the evaluations and applications of technologies or alternatives may be refined, either site-wide or at specific areas of the site. A final screening of remedial alternatives incorporating all the available information at that time will be conducted for the FS. In other words, this PSA is preliminary and has limitations, including, but not limited to, the following:

- Chemicals of concern (COCs), cleanup levels, RALs, and SMAs have not yet been identified. The baseline risk assessments have not yet been finalized, and RAOs have not yet been defined. This document uses multiples of the Washington State Sediment Quality Standards (SQS) for total PCBs as a surrogate for RALs. This approach provides a consistent basis for developing and evaluating conceptual remedial action alternatives independent of the final cleanup decisions. In addition to PCBs, all COCs identified in the risk assessments will be addressed in the FS. A process for identifying appropriate COCs, RALs and SMAs will be presented in the draft FS work plan.

- This PSA principally evaluates detected chemicals that are listed in the Washington State Sediment Management Standards (SMS) (WAC 173-204). At the time this document was developed, the composition of the baseline dataset was still under discussion between LDWG and the agencies. For this document, the baseline surface sediment SMS chemical concentrations were those compiled in December 23, 2005 by Windward Environmental LLC (Windward). Subsequently, the baseline surface sediment dataset (with both Phase 1 and 2 data) has been refined in consultation with the agencies. The potential changes to interpretations of chemical distributions in this PSA that result from changes in the baseline dataset are described in Appendix B.

- Potential remedial areas were developed based on detected SMS chemicals, and in particular the distribution of total PCBs. While the document demonstrates that most contaminants co-occur with total PCBs, and that the total PCB distribution can be used as a surrogate for this purpose, the approach may not fully address the requirements of the SMS. All COCs and pathways of human health or ecological risk identified by the risk assessments, including those not on the SMS list, must be addressed in the FS. Finalization of this list of chemicals and the baseline surface sediment dataset will occur prior to completion of the Phase 2 RI and that dataset will subsequently be carried forward in the FS.

- Preliminary alternatives are assembled in this document on a waterway-wide basis, with broad-brush assumptions used for large reaches of the waterway (e.g., RM 0 to 2, RM 2 to 3, and RM 3 to 5). Localized issues regarding accessibility, land ownership, habitat areas, structural or slope stability considerations, and erosional/depositional environments are not addressed on a site-specific scale in this document. It is understood that within these reaches these site characteristics can differ and different technologies may be applicable on smaller scales throughout the LDW.

- As a means of gauging the effectiveness of remedial alternatives in reducing risks, estimates of the spatially-weighted average concentration (SWAC) of total PCBs are presented in this document for baseline and post-remedy conditions. The SWAC estimates were developed using an interpolation method known as Inverse Distance Weighting (IDW). The SWAC estimates will likely be revised in the future, based on finalized input parameters to the IDW mapping model and the final baseline dataset used for the risk assessments and the RI. Development of this PSA was occurring concurrently with further exploration of IDW interpolation methods, and it is recognized that differences exist between the results of interpolations presented in this PSA and those recently developed and discussed with EPA and Ecology for the RI and risk assessments. While the differences are largely irrelevant because the interpolations used in this PSA are for illustrative purposes only, Appendix B to this PSA presents a discussion of the differences between SWACs and areas estimated using the different datasets and interpolation methods.

- The final FS will develop remedial action costs to an accuracy of minus 30 percent to plus 50 percent. The costs presented in this document may fall outside of that range, and do not include a number of costs that are common to all alternatives, For example, long-term compliance monitoring costs for the LDW as a whole are expected to be similar for all alternatives, but the monitoring program will be developed in the FS. As such, for the purposes of this PSA the estimated monitoring costs, while not insignificant, are not included in the costs of each alternative. LDWG will continue to refine and revise cost assumptions during the FS process. The remedial costs presented in the document are subject to change in the FS.

- For the purposes of this report, natural recovery processes are considered to be potentially active in all areas of the LDW. Natural recovery is expected to remain an active mechanism that will reduce COPC concentrations in surface sediments regardless of the remedial alternative that is ultimately selected. The rates of natural recovery are expected to vary significantly by location. The FS will include a more detailed analysis of natural recovery processes, to formulate alternatives that explicitly include natural recovery as a component. Further refinement of the potential for natural recovery will be made on an area-by-area basis in the FS. The FS will also provide estimates of post-cleanup SWAC reductions that will be expected to occur over time throughout the LDW as a result of the ongoing natural recovery processes. These site-wide SWAC reductions over time may be an important part of attaining the long-term RAOs for the LDW.

1.4 Approach and Organization

The approach used to develop and screen the alternatives includes the following key steps (Figure 1-3):

1) Identify characteristics of the LDW that affect the development of remedial alternatives and integrate those characteristics into a conceptual site model (CSM) based on the draft *Sediment Transport Analysis Report* (Windward and QEA 2006).

2) Identify potentially actionable areas. These include:

   - Sites that were previously identified as sponsored Early Action Areas (EAAs) (Windward 2003b)
   - Potential Priority Areas (PPAs), which exhibit similar characteristics to the EAAs and include non-sponsored EAAs (Windward 2003b)
   - Other Areas of Interest (AOIs) that exceed multiples of the SQS for total PCBs.

   The delineation of these areas will change as a result of the Phase 2 RI, the risk assessments, the draft *Sediment Transport Analysis Report*, full consideration of the SMS rule, and development of RALs for the site. However, focusing on a fixed set of areas for this document creates a consistent basis for developing remedial alternatives and for comparing costs among the different alternatives.

3) Select representative remedial process options from the CTM (RETEC 2005b). Representative remedial process options are assembled into a set of waterway-wide remedial alternatives. Each alternative, in turn, is developed to address progressively larger AOIs at different multiples of the SQS for PCBs.

4) Screen alternatives based on implementability, effectiveness, and cost.

5) Identify data and information gaps needed to complete the FS.

The presentation of this evaluation is organized as follows:

- **Section 2** describes the general physical environment of the LDW, how physical conditions could impact the selection of process options, and the uses and history of the waterway, which may also drive the design of the remedial actions. This section introduces a preliminary CSM based on physical conditions.

- **Section 3** describes the potential remedial areas based on chemical distributions and the physical CSM.

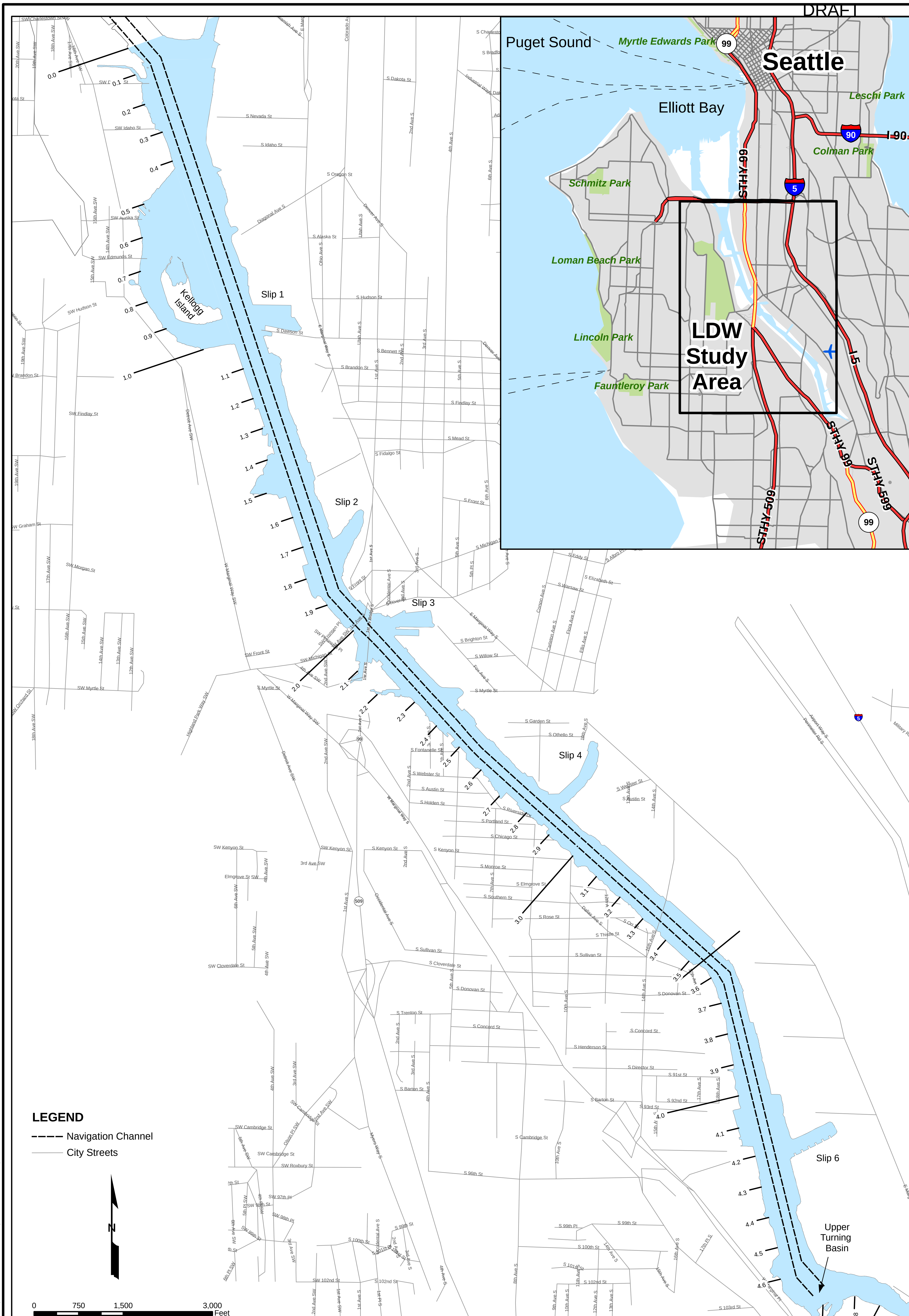
- **Section 4** selects representative remedial process options from the CTM (RETEC 2005b) and assembles these options and technologies into site-wide remedial alternatives.

- **Section 5** screens each remedial alternative in terms of implementability, effectiveness, and cost. Effectiveness is expressed as chemical and toxicity reductions at various cleanup levels. The rationale for and results of the screening analysis are presented in this section.

- **Section 6** presents a summary of alternatives retained for the FS. This section also identifies additional data or information needed to develop alternatives that will be addressed in the FS work plan.

- **Section 7** lists references cited.

Accompanying tables and figures are presented at the end of each section. Appendices are provided at the end of the document.



Basemap provided by Windward Environmental LLC and ESRI StreetMap USA.

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Lower Duwamish Waterway Group

Port of Seattle / City of Seattle / King County / The Boeing Company

LDW DRAFT PRELIMINARY SCREENING OF ALTERNATIVES (PORS5-18220-603)	LOWER DUWAMISH WATERWAY REMEDIAL INVESTIGATION AND FEASIBILITY STUDY AREA
DATE: 5/9/06 DWN. BY: KBL/ftc	FIGURE 1-1

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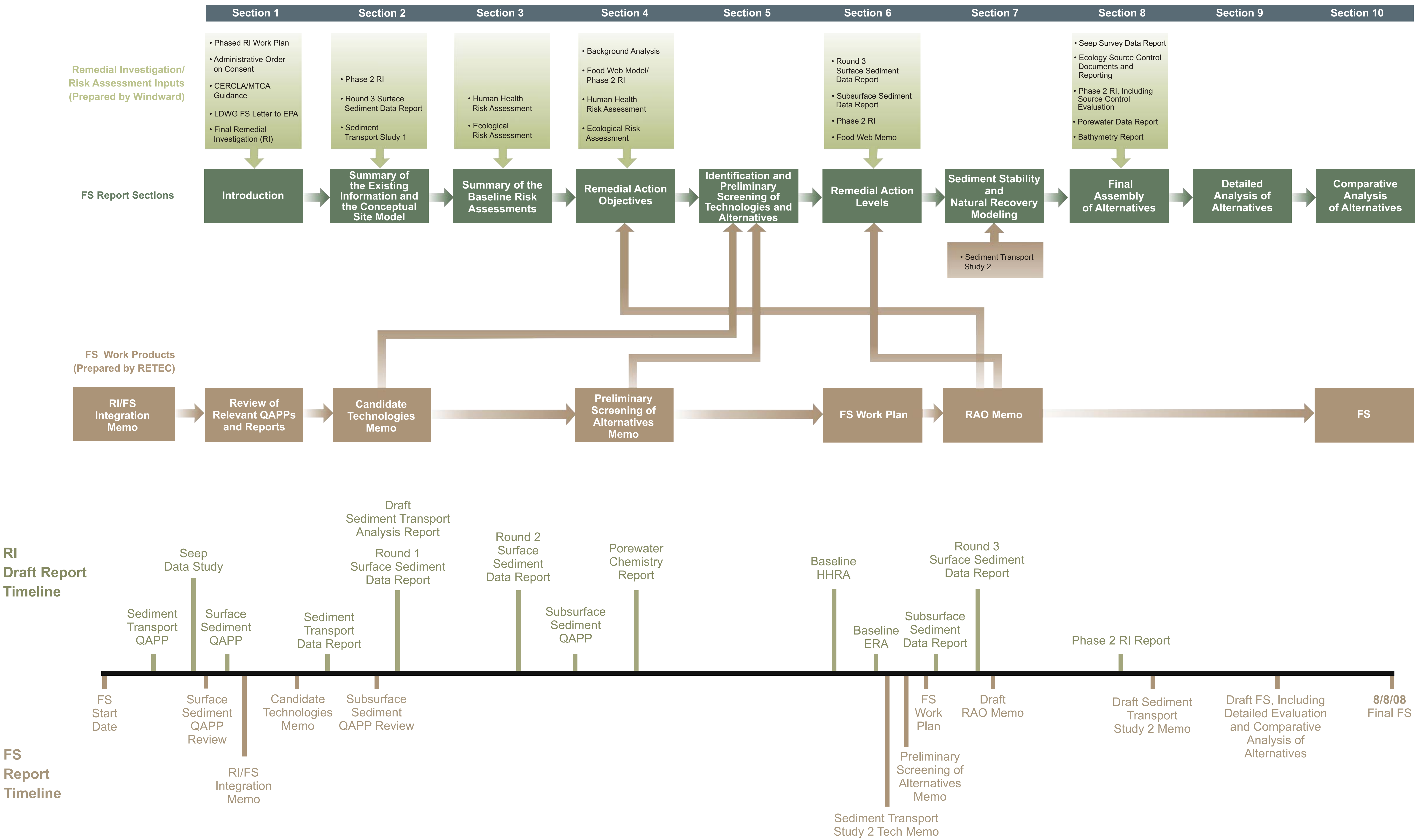
Figure 1-2 Feasibility Study Outline, Scope of Work, and Schedule



Retec/Duwamish/2006/August/Figure 2-1

Figure 1-3 Flow Chart for Preliminary Screening of Alternatives Process

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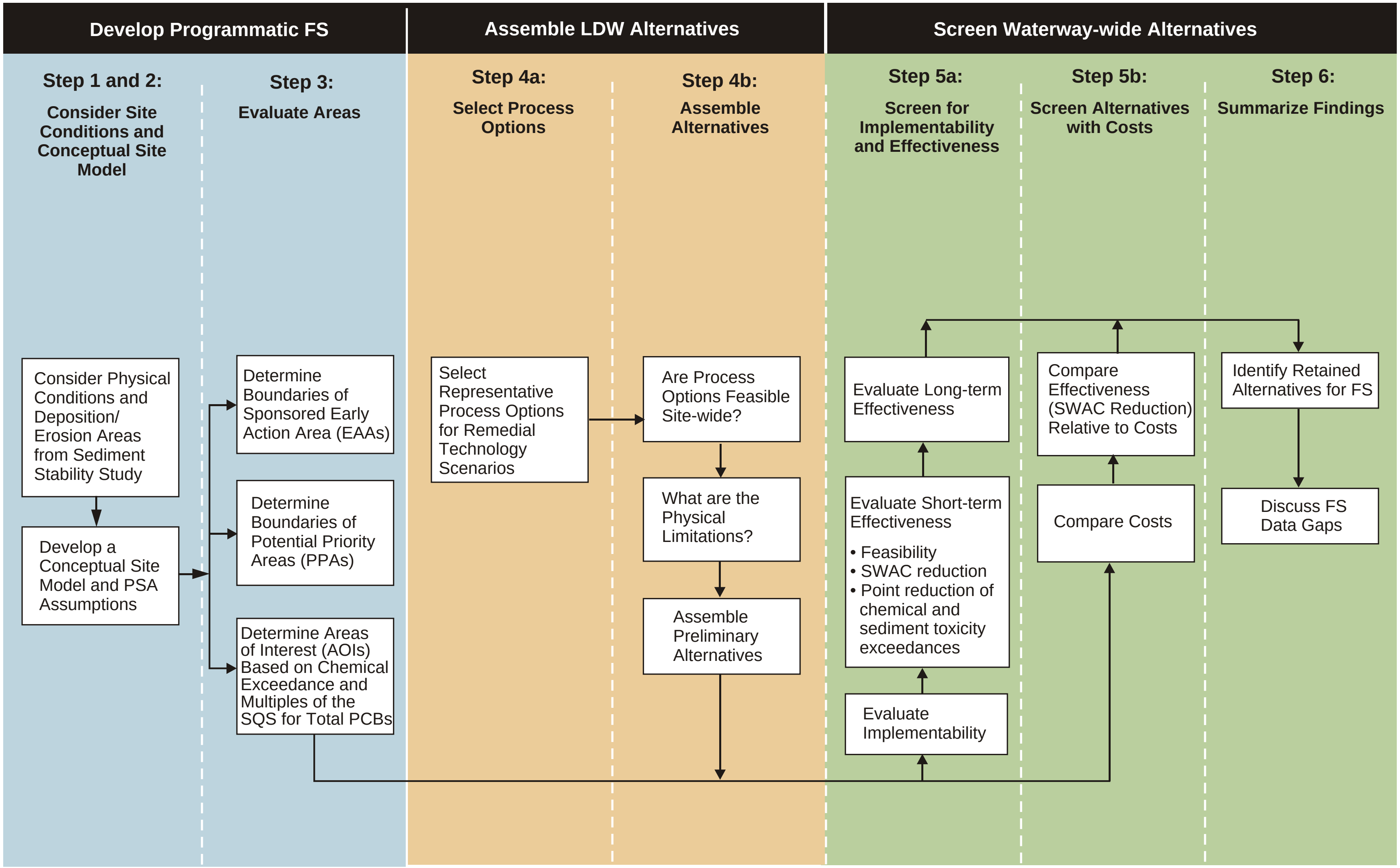


Note:
SQS = Sediment Quality Standards; FS = Feasibility Study; SWAC = spatially weighted average concentration

2 Basis for the Evaluation

This section summarizes information presented in previous RI documents and includes a description of the LDW physical characteristics and chemical distributions that influenced the development of remedial alternatives. A preliminary CSM is presented in Section 2.5, which summarizes key assumptions that are used for developing the remedial alternatives in Section 4. Preliminary findings of the draft *Sediment Transport Analysis Report* (Windward and QEA 2006) in relation to the CSM are also discussed.

In the context of the RI/FS process, a CSM typically describes sources, transport pathways, and potential receptors. At the conclusion of the Phase 2 RI, a comprehensive CSM should help formulate areas, chemicals, and sources of potential concern for the FS. Remedial alternatives should be designed around important components of a CSM. However, because this waterway-wide PSA is being developed ahead of the Phase 2 RI and risk assessments, the preliminary CSM is presented in the context of physical processes and conditions (i.e., geomorphology, sedimentation, and hydrology) and chemical distributions that might affect the development of remedial alternatives. The CSM will be further refined as part of the Phase 2 risk assessment and RI reports.

2.1 Physical Site Characteristics

Physical characteristics of the LDW considered in developing the CSM include geomorphology and hydrology, bathymetry, and sediment bed properties. These characteristics are described below.

2.1.1 Geomorphology and Hydrology

The LDW is a saltwater-wedge-type estuary that has been extensively modified through human activity. The LDW characteristics are also influenced by river flow and tidal effects, both of which fluctuate seasonally. The LDW, which extends from Harbor Island to just upstream of the upper turning basin (Figure 1-1), is approximately 5 miles (8 kilometers [km]) long (Figure 1-1). The system is influenced by the following notable characteristics:

1) The LDW was created in the early 1900s through extensive dredging and filling of the Duwamish River estuary.

2) The construction of the Howard Hanson Dam in 1961, which regulates flow through the LDW, resulted in substantial changes in LDW hydrology.

3) A saltwater wedge is present in the deeper portions of the LDW and this saltwater wedge affects river flow and sedimentation.

4) Channel bed characteristics, bathymetry, and physical structures affect sediment bed stability.

5) Frequent navigational and maintenance dredging events affect sediment loading and net sedimentation.

Creation of the LDW

In the late 1800s and early 1900s, extensive topographic modifications were made to the estuary of the Duwamish River. These modifications included filling tide flats and floodplains and creating a straightened river channel, which resulted in the abandonment of about 3.7 miles (6 km) of old riverbed (Windward 2003a). Many of the existing side slips are remnants of old riverbed meanders. The channel was dredged for navigational purposes, and the excavated waterway material was used to fill the old channel areas and the lowlands above flood levels. Construction of the LDW was completed in 1920.

The LDW in its present form is an engineered navigation channel located at the downstream end of a highly modified and engineered drainage basin. The past construction, present configuration, and ongoing maintenance of the LDW constrain the geomorphic processes that shape the river channel. On this man-made template, natural processes physically reconfigure the riverbed through sediment transport and deposition.

The engineered channel is substantially larger than it would be if it were allowed to form naturally in this setting. As a result, the LDW is net depositional, and in particular, sediments accumulate within the most upstream portion of the LDW. This area requires periodic dredging to maintain the channel for navigational purposes. Geomorphic conditions within the LDW will continue to be dominated by sediment deposition as long as the channel is maintained larger than it would have formed naturally.

Changes in Hydrology

The confluence of the Black and Green Rivers forms the Duwamish River at RM 12.0. More than 90 percent of the basin is drained by the Green River (Dexter et al. 1981). In 1961, the Howard Hanson Dam was constructed in the upper part of the Green River, primarily for flood control and low-flow augmentation to preserve fish life when river flows were naturally low (Sato 1997). As a result of the metered release of floodwaters stored behind the dam (King County 2000), the dam effectively decreased peak flows, which now do not exceed 340 cubic meters per second (m^3/s) or 12,000 cubic feet per second (cfs), but increased moderate flows from 85 to 140 m^3/s (3,920 to 6,460 cfs).

Saltwater Wedge

The LDW behaves as a stratified saltwater wedge estuary (Santos and Stoner 1972). Within a stratified estuary, the circulation of water includes a net upstream movement of water within a lower saltwater wedge and a net downstream movement of fresher water in the layer overriding the saltwater wedge (Prych et al 1976). The saltwater wedge, which has its source in Elliott Bay, oscillates upstream and downstream with the tides and river flow. During periods of low freshwater inflow and high tide, the saltwater wedge has extended as far upstream as the Foster Bridge, which is 10.2 miles above the mouth of the river. At moderate freshwater inflows (greater than 1,000 cfs), the saltwater wedge does not extend upstream beyond the East Marginal Way Bridge (RM 7.8) regardless of the tide height (Stoner et al 1975). Under high-flow conditions, the saltwater wedge is estimated to be pushed as far downstream as RM 3.0 during flood tides and RM 2.0 during ebb tides, with the area between RM 2.0 and 3.0 acting as a transitional area. The presence of the saltwater wedge dampens potential bed-scour effects caused during high-flow conditions (Windward and QEA 2006).

Saltwater is entrained within the interface between the overriding layer of fresher water and the saltwater wedge, which in turn causes the upstream movement of saltwater from Elliott Bay to replace saltwater entrained in the freshwater flow. There is little to no downward movement of water from the upper layer into the saltwater wedge; studies using fluorescent dye have shown that downward mixing in the stratified estuary is negligible (Santos and Stoner 1972). Also, at any given time and location along the estuary, the salinity at a given depth is nearly the same from one side of the channel to the other (Santos and Stoner 1972).

Channel Bed Characteristics

The average width of the LDW is 440 ft or 134 m, although it is wider downstream of the First Avenue Bridge at RM 2.0. The typical channel cross-section within the navigable waterway includes a deeper maintained channel at the middle of the waterway, with intermittent shallow bench areas along the margins of the channel. The dimensions and elevations of the bench areas vary along the waterway, but typically these bench areas exist within the intertidal and shallow subtidal range.

The banks of the LDW are predominantly occupied by structures, including bulkheads and over-water piers and buildings. Where they are not occupied by structures, the banks are often armored with a combination of riprap, concrete debris, and other forms of bank stabilization. Industrial land use dominates the downstream areas of the waterway, with some mixed commercial and recreational uses. The upstream area of the waterway contains mixed commercial and residential/recreational uses, with several stretches of intertidal restoration areas.

Remnant tidal marshes (totaling 5 acres) and intertidal mudflats (totaling 54 acres) are dispersed throughout the waterway. Kellogg Island, which was filled with dredge spoils by the United States Army Corps of Engineers (USACE) in the 1950s and 1960s, as well as an upland component created in 1974, has the largest contiguous intertidal area in the LDW (Windward 2003a).

Figure 2-1 presents an overlay of over-water structures and berthing areas along the LDW in relation to the navigation channel and intertidal areas. Public access areas along the shoreline, including parks, are also shown. The presence of extensive physical structures outside of the navigation channel affects the cost and feasibility of active remedial alternatives such as dredging. These factors will be considered further in Section 4 of this report.

Dredging Events

Portions of the LDW are dredged frequently to maintain the navigation channel and private berths. In addition, portions of the LDW have been dredged as part of sediment remedial actions. A history of dredging in the LDW over the past 20 years has been compiled using various sources, including:

- USACE year-end dredging summary and analysis reports
- USACE suitability determination memoranda
- Assorted sampling and analysis plans
- Assorted dredged material characterization reports
- Site closure reports.

Figure 2-2 and Table 2-1 present the dredging events that have occurred on the LDW since 1986. USACE maintenance dredging of the navigation channel has occurred periodically in the upper reaches of the waterway between RM 3.35 and 4.7, and especially near the upper turning basin (RM 3.9 to 4.5), which requires maintenance dredging every few years. Over the past 25 years, the largest quantity of sediment was removed from the upper turning basin during the 1992 winter dredging event. During this event, nearly 200,000 cubic yards (cy) of sediment were dredged from the navigation channel. No USACE maintenance dredging has occurred over the past 20 years in the downstream areas of the LDW (below RM 3.0).

The need for regular maintenance dredging in both the upstream portion of the navigation channel and the private berths is consistent with the high sediment loads and large localized net sediment deposition rates described in the Phase 1 RI (Windward 2003a). A large amount of the sediment load enters the LDW from upstream (especially bed load) and deposits in the area of the upper turning basin (Figure 2-1). The USACE effectively uses the upper turning basin as a sediment trap. This practice forces most of the deposition of sediments entering the LDW from upriver to occur within a limited zone, thereby reducing the amount and frequency of dredging necessary to maintain the navigation channel downstream of the upper turning basin. At the upper turning basin, the river channel cross section sharply expands from a somewhat natural section to an engineered channel maintained significantly larger than its natural analogue. The sharp transition and enlarged channel result in greatly reduced flow velocities, which promote sediment deposition.

Downstream of the upper turning basin, the saltwater wedge forms another hydrodynamic transition that affects sediment deposition. As freshwater encounters the toe of the saltwater wedge, it is forced to separate from the river bed and flow over the saltwater. During high-flow events that deliver sediment from upstream, the sharp velocity gradient between the freshwater lens and the saltwater wedge forces deposition of the bed load. The saltwater wedge migrates up and down the river with the tides and river flow. Its range and upstream extent are determined by the volume of freshwater delivered from upstream. The result is a migrating zone of rapid sediment deposition during high-flow events. By capturing most of the sediment load from upstream sources in the upper turning basin, the need for maintenance dredging downstream is greatly reduced.

A number of dredging events have occurred at private berths along the LDW. Most of these events were completed to maintain adequate depth for moorage and ship movement. The largest of these events occurred in 1999 at the Duwamish Yacht Club, during which 24,000 cy of sediment were removed (Figure 2-2 and Table 2-1).

Other dredging events have been undertaken to remove contaminated sediments. Two of these dredging events, completed as remedial actions, were part of the Elliott Bay/Duwamish Restoration Program (EBDRP). The first of these events, the Norfolk Combined Sewer Overflow (CSO) Project, took place upstream of the upper turning basin at approximately RM 4.9. Approximately 5,190 cy of sediment that contained high concentrations of mercury, bis(2)ethylhexyl phthalate, and PCBs were removed from this area in 1999. The second EBDRP event occurred in the winter of 2003/2004 at the Duwamish CSO and Diagonal Way CSO/storm drain. The project involved the removal of 68,250 cy of contaminated sediments and capping to restore the original bathymetric contours over seven acres (EcoChem and Anchor 2005). In addition, a thin-layer cap was placed over four acres immediately to the southwest of the dredged area in early 2005 to manage elevated residuals in surface sediment.

2.1.2 Bathymetry and Navigation Depths

The bathymetry of the LDW is not uniform (Figure 2-3). The bottom of the navigation channel varies from approximately -56 ft mean lower low water

(MLLW) near the mouth of the LDW to -10 ft MLLW near the upper turning basin. The shoreline also includes intertidal areas above -4 ft MLLW. Shallow subtidal areas are generally described as areas above -9 ft MLLW; and deep subtidal areas are described as being below -9 ft MLLW.

The navigation channel is periodically dredged so that depths suitable for commercial vessel traffic are maintained. The authorized maintenance depths for the navigation channel (about 150 ft wide) vary depending upon the location along the waterway (see table below).

Authorized LDW Navigation Channel Depths by River Mile

River Mile	From	To	Navigation Channel Depth (ft MLLW)
0.0 to 2.1	Harbor Island	First Avenue Bridge	-30 (9.1 m)
2.1 to 2.9	First Avenue Bridge	8th Avenue/Slip 4	-20 (6 m)
2.9 to 4.7	8th Avenue/Slip 4	Upper Turning Basin	-15 (4.6 m)

The navigation channel is periodically dredged to maintain these depths with a typical over-dredge depth of 2 ft below the authorized channel depth. The upper reaches of the waterway are generally dredged between RM 3.9 and 4.5, which requires maintenance dredging every few years.

The 2003 bathymetry survey (Windward and David Evans Associates 2004) showed that the average bathymetry depth within the navigation channel was shallower than the authorized channel depth in many areas, necessitating navigational dredging in these areas for safe vessel passage. Current bathymetry conditions are presented on Figure 2-3. For the purpose of this PSA, dredging will presumably be required in navigational areas where existing depths are shallower than authorized navigational depths.

Outside the navigation channel, certain landowners have navigation areas that are maintained at USACE-permitted depths. Similar to the navigation channel, dredging will likely be a required cleanup element if remediation is needed in any of these permitted navigation areas. These areas are discussed in Section 2.2.

2.1.3 Sediment Characteristics

The composition of sediment varies throughout the LDW, ranging from sand to mud (silt and clay). The sediment typically consists of slightly sandy silt with varying amounts of organic detritus. Coarser sediments are present in nearshore areas adjacent to CSOs and storm drain discharges, and where the channel morphology changes (Figure 2-4). Finer-grained sediments are typically located in remnant mudflats, along channel side slopes, and within deeper portions of the navigation channel. Sediments in the river upstream of the upper turning basin are generally coarser than those in the remaining downstream portion of the LDW (Windward 2003a; Windward and QEA 2006).

The Phase 1 RI (Windward 2003a) and the draft *Sediment Transport Analysis Report* (Windward and QEA 2006) state that the LDW system serves as a sink for sediments (i.e., it is a net depositional environment). Sediments deposited within the LDW have either contributed to the steady accretion of the bed or have been removed from the system (disposed of off-site) through routine dredging.

Grain Size and Sediment Organic Carbon

In the baseline surface sediment dataset[2], average concentrations for each grain size fraction throughout the study area are 4 percent gravel, 42 percent sand, 41 percent silt, 13 percent clay. Typical surface sediment consists of clayey, very sandy silt with trace gravel and varying amounts of organic detritus. The average total organic carbon (TOC) content among surface sediment samples is 1.97 percent, with a range of 0.03 to 12 percent. The average total solids content is about 57 percent. The distribution of percent fines is presented on Figure 2-4. In general, a higher percentage of silt is present in the navigation channel, and a higher percentage of coarse-grain material is present in the bench areas.

Generalized Sediment Profiles

The regional geology of the Duwamish Basin and the Duwamish River Valley is described in the Phase 1 RI (Windward 2003a; Section 2.2). A generalized representation of local geologic units observed in existing sediment cores (upper 10 ft) collected within the LDW includes these primary units:

- **Recent Soft Sediment Deposits:** This unit consists of soft, often flocculent, recently deposited fine-grained material. These sediments typically have low percent solids and varying amounts of silt, fine sand, and organic material. The mudflat areas include this unit.

- **Younger Alluvium and Transitional Unit:** This unit consists of medium-dense sand to silty sand and clays, often interbedded with abundant organic material typical of tidal marsh deposits.

- **Older Alluvium Unit:** This unit consists of dense estuarine deposits, sand with silty sand and silt interbeds. Typical of alluvium sequences, the unit grades finer upwards within the sediment

[2] Provided by Windward on December 23, 2005.

column and towards the mouth of the river (downstream).

For the purpose of this PSA, most of the sediments with chemical contaminants are assumed to be present in the upper, recent soft sediment deposits and possibly the transitional unit. These units typically extend to depths of about 4 to 6 ft below the mudline, based on Phase 1 sediment cores (Table 2-2 and Appendix A). Additional data on subsurface sediment characteristics are currently being collected and will be integrated into the FS.

2.1.4 Sediment Stability

Sediment transport and stability within the LDW are influenced by many variables, including hydrodynamic forces attributable to the saltwater wedge, sediment loading from upstream and upland sources, channel morphology, and resuspension processes, such as propeller scour, bioturbation, bed shear stress from storm events, and dredging.

Historical Studies

As summarized in the Phase 1 RI report (Windward 2003a), numerous studies of sediment deposition and transport within the LDW have been performed over the past several decades (Santos and Stoner 1972; Harper-Owes 1983; McClaren and Ren 1994; King County 1999). Over a 20-year study period (1960 to 1980), the predominant source of sediment loading to the LDW was the Green River, which contributed approximately 99 percent of the total sediment load. The other 1 percent was contributed by local sources, such as discharges and runoff along the LDW. The LDW retains an average of approximately 90 percent of the total incoming sediment load, particularly in the upper turning basin, where regular maintenance dredging is performed (Harper-Owes 1983; Windward 2003a).

Over the last four decades, the LDW system has served as a sink for sediments (i.e., net depositional environment or dynamic equilibrium environment) under measured river flow conditions (Windward 2003a; Windward and QEA 2005 and 2006). Historical sediment accumulation rates (1960 to 1980) have varied throughout the LDW. Net sedimentation rates were higher in the navigation channel (20 to 110 cm/yr) upstream near the upper turning basin and near the upstream extent of the saltwater wedge (RM 3.4 to 4.7) (Harper-Owes 1983). This upper reach typically has coarser, sandier material, which reflects the deposition of bedload from upstream sources (see Section 2.1.1). Net sedimentation rates were lower downstream toward the mouth of the river (1 to 25 cm/yr) as the river widens in the middle and lower reaches (RM 0.0 to 3.4). Finer-grained, silty sediments are typically found in the downstream reaches.

Sediment Transport Study

In 2004, a sediment transport study was initiated as part of the Phase 2 RI process (Windward and QEA 2006). This study had four objectives aimed at developing a CSM: (1) to assess sedimentation rates in bench areas (and supplement existing Phase 1 data), (2) to assess the episodic erosion potential from the effects of natural and anthropogenic forces throughout the waterway, (3) to evaluate Phase 1 and Phase 2 sedimentation data to refine the Phase 1 CSM for sediment transport, and (4) to determine if additional field data or modeling are needed to further refine the CSM for sediment transport and sediment bed stability in the LDW (Windward and QEA 2006).

The scope of the sediment transport study included: (1) the collection of sediment cores for sedimentation rate and radioisotope profiling using cesium-137 and lead-210, (2) the collection of sediment cores for Sedflume sediment bed erosion analysis, (3) the evaluation of changes in bathymetry over time, (4) the development and calibration of a three-dimensional hydrodynamic flow model, and (5) the analysis of ship-induced bed scour. Together, the information developed in this study provides the basis of the CSM of the LDW (Section 2.5).

Net sedimentation rates in the bench areas were estimated from LDW geochronology cores. Estimated net sedimentation rates ranged from 0.2 to >2 cm/yr in 11 out of 14 cores, which is consistent with sedimentation rates from previous Elliott Bay and LDW studies. The lower sedimentation rates were generally associated with the intertidal and shallow subtidal bench areas. These sedimentation rates are preliminary estimates that will be revised with additional lines of evidence after the sediment transport report is finalized and data from the Phase 2 subsurface cores that were collected earlier this year (Windward 2006a) have been analyzed.

The propeller wash model indicated that ship movement likely has negligible effects on bed stability between RM 0.5 and 2.0 because of the depth of the channel. The potential for bed scour from vessel propellers increases (typically less than 2 cm but up to 6 cm of bed scour from passing vessels) as the water depth decreases, which has the effect of reworking a thin surface layer (Windward and QEA 2006)). These conclusions are draft and subject to change after review by the agencies and the sediment transport report is finalized. The hydrodynamic model showed that bottom shear stresses (indicators of bed-scour potential) tend to be about two to three times higher in the navigation channel than in the bench areas, and that significant increases in bottom shear stress do not occur in the LDW areas occupied by the saltwater wedge during high-flow events. The saltwater wedge, which is denser than freshwater, sits between out-flowing river water and the sediment bed. On a site-wide basis, this means that the saltwater wedge essentially acts as a buffer to bottom shear stresses, resulting in less disturbance of the sediment bed.

Draft findings with respect to sediment bed stability from the Phase 1 RI report (Windward 2003a) and the draft *Sediment Transport Analysis Report* (Windward and QEA 2006) include:

- The LDW is a net depositional environment on a site-wide basis over annual timescales.
- Current sedimentation rates are highest in the navigation channel. The highest sedimentation rates in the channel are upstream of RM 3.0 (20 to 110 cm/yr). Downstream of RM 2.0, the sedimentation rates in the channel are estimated to range between 1 and 15 cm/yr.
- Lower sedimentation rates are estimated on the benches. Intertidal benches (>-4 ft MLLW), have the lowest estimated sedimentation rates (<1 cm/yr). Subtidal benches (<-4 ft MLLW) generally have estimated sedimentation rates between 1 and >2 cm/yr. In contrast to the navigation channel, there does not appear to be a pronounced difference in estimated rates between upstream and downstream benches.
- Bed erosion is an episodic process that may be active during high-flow events. Episodic bed scour occurs to the greatest extent upstream of RM 3.0, is moderate between RM 2.0 and 3.0, and is minimal downstream of RM 2.0.
- Within reaches of the LDW where erosion is predicted to occur, the potential for erosion tends to be higher in the navigation channel than in the bench areas, especially in the upstream areas. Within the bench areas, the potential for erosion tends to be higher near the navigation channel and decreases toward the shoreline.
- Ship-induced bed scour from passing vessels tends to behave as a mixing process for surficial sediment primarily within both the navigation channel and bench areas upstream of RM 2.0, and in the bench areas downstream of RM 2.0. The frequency of such ship-induced mixing is about 100 to 250 events per year, largely within the navigation channel (ship-induced bed scour in bench areas is more localized in the vicinity of active berthing areas).

2.2 General Human and Ecological Waterway Uses

2.2.1 Industrial/Commercial Use and Navigation

Because the LDW serves as a shipping route for containerized and bulk cargo, large portions of the shorelines along the LDW have been developed for industrial and commercial operations. Shoreline features are consistent with site-use needs, such as deep-draft berthing areas, bulkheads and over-water structures for off-loading supplies and materials, and rafting areas for barges and other vessels (Figure 2-1).

Since about 1916 to 1920, when the waterway was formed, the LDW has served as a critical navigation corridor for the movement of industrial and commercial materials. Many of the industrial and commercial facilities on the LDW require year-round vessel access. Table 2-3 lists the frequency of tugboat and barge activity and the dock destinations for each major tugboat company operating in the LDW. Most of the activity occurs between RM 0.0 and 2.9 and can be separated into the following general use patterns:

- **RM 0.0 to 2.0 –** daily tugboat traffic near the mouth, decreasing to two to five times per week towards RM 2.0
- **RM 2.0 to 3.0 –** tugboat traffic two to five times per week
- **RM 3.0 to 5.0 –** minimal tugboat traffic.

Based on these observations and conversations with tugboat operators, most of the potential erosion events associated with these operations would likely be localized around docking operations, with more activity expected near the mouth of the waterway.

2.2.2 Recreational and Tribal Uses

Traditional and recreational uses of the LDW are also important. Native Americans have treaty-reserved fishing rights and have traditionally used the LDW for subsistence, ceremonial, and commercial fishing. Recreational uses of the LDW include boating, fishing, and shoreline/riverbank activities, and are facilitated by public access points. These access points include marinas, motorboat launches, hand boat launches, and various other shoreline public access sites (Figure 2-1).

2.2.3 Residential, Industrial, and Commercial Upland Uses

Although the LDW is often viewed as an industrial corridor, two residential neighborhoods are adjacent to the LDW. The population (approximately 21,000) within the LDW corridor is lower than in many other Seattle neighborhoods, reflecting the mixed land use of the area (Windward 2003a). Predominant human uses of the LDW and immediately adjacent areas are for commercial, industrial, and residential purposes. These human site use areas are not directly evaluated in this preliminary document, but will be evaluated as high-value areas in the FS.

2.2.4 Ecological Functions

Numerous infaunal and epibenthic invertebrate species inhabit the intertidal and subtidal substrates of the LDW. Larger invertebrates also inhabit the LDW; these include crabs (Dungeness crabs, red rock crabs, and slender crabs), arthropods, and echinoderms. Diverse populations of fish, including 33 anadromous and resident fish species, also reside in or use the LDW as a migration corridor. The LDW habitats support a diversity of wildlife species. Previous studies have reported 87 species of birds and 6 species of mammals that use the LDW at least part of the year to feed, rest, or reproduce (Windward 2003a). These functional habitats and valued species are considered in this PSA in terms of the physical nearshore environment (e.g., effects of the alternatives on existing mudline elevations and substrates) and in terms of the allowable in-water work windows to protect migrating juvenile salmonids.

2.3 Distribution of Chemical Exceedances

Both the horizontal and vertical distributions of COPCs within the sediments are considered in this PSA, primarily to estimate the area and depth of sediments containing concentrations of chemical contaminants that might require remediation.

2.3.1 Surface Sediments: Baseline Chemical Dataset

The baseline surface sediment dataset includes both Phase 1 (historical) and Phase 2 (LDW RI/FS) surface sediment samples collected from 1990 to 2005 that meet data quality objectives for the project. Baseline conditions are represented by the sum total of the Phase 1 and Phase 2 surface sediment samples, with the exception of two early removal actions: (1) the Duwamish/Diagonal project (dredging and thin-layer capping) performed by King County in 2003/2004 and 2005 under EBDRP (RM 0.5E), and (2) the sediment removal near the south storm drain of Boeing's Developmental Center (RM 4.9E) that was performed in 2003 under Ecology's Voluntary Cleanup Program. (An exception also occurred where chemical samples were collected for sediments dredged from the LDW. Any samples representing sediments dredged before 2000 (the date of the start of the RI) were excluded from the baseline dataset.) Because pre-remedial surface sediment chemical concentrations were used for these areas (Windward 2006b), the term baseline condition is assigned instead of current condition. Per agreement with the agencies, data that characterize areas prior to remedial activities at early action areas are included in the baseline human health and ecological risk assessments to represent baseline conditions. Post-removal and monitoring data associated with these early action areas will be discussed in the Phase 2 RI and the FS.

For clarification, a previous removal action was conducted by King County in 1999 at the Norfolk CSO early action area (RM 4.9) as part of EBDRP. Because this action occurred before the start of the LDW RI/FS, the baseline surface sediment dataset reflects post-removal conditions in the area where the 1999 removal and subsequent capping occurred (Windward 2006b).

Table 2-4 shows the frequency of detection for SMS chemicals in baseline surface sediment samples collected from the LDW. These chemicals are arrayed in decreasing order of detected frequency for a particular chemical. The five chemicals with the most frequent SQS exceedances (those with at least a 4.4 percent frequency of exceedance) include (in decreasing order of the frequencies of exceedances): total PCBs (total calculated), bis(2-ethylhexyl)phthalate, butyl benzyl phthalate, zinc, and mercury.

Other SMS chemicals detected above the SQS in at least five or more stations included: polycyclic aromatic hydrocarbons (PAHs), phenol, other SMS metals, benzoic acid, and hexachlorobenzene. Table 2-4 shows that total PCBs were detected at the greatest number of stations (1,211 stations) and had the highest frequency of SQS exceedances among those stations (475 stations)[3]. Bis(2-ethylhexyl)phthalate had the second most SQS exceedances, with detections at 644 stations and 106 SQS exceedances among those stations. For the purposes of this PSA, the SMS chemical suite is considered to be the preliminary list of COPCs, including PCBs, metals, phthalates, and some other semi-volatile compounds.

PCBs are a good indicator of the extent of contamination because they have the broadest spatial distribution of any of the COPCs in surface sediments. Over 90 percent of the stations that exceeded an SQS value for one or more chemicals other than PCBs were co-located with PCB concentrations above the SQS. Therefore, for the purpose of this PSA, PCBs are used as an indicator chemical (Section 3). In Figure 2-5, the baseline distribution of total

[3] It should be noted that although the baseline data set has over 300 stations where surface sediments were analyzed only for total PCBs, the conclusion that total PCBs were detected at the greatest number of stations is still valid.

PCBs in surface sediments is shown as multiples of the SQS. Appendix B provides details on how the spatial distribution of PCBs in surface sediments was interpolated using the baseline dataset. Areas where other chemicals are not co-located with PCBs will be addressed in the FS. The use of PCBs as an indicator chemical does not imply that other COPCs will not be considered as part of the final FS. Once the Phase 2 risk assessments and RI are completed, assumptions made in this report regarding COPCs, RALs, and cleanup areas will be re-evaluated.

2.3.2 Subsurface Sediment Data

Approximately 314 sediment cores have been collected in the LDW over the past 15 years. The average core drive depth among Phase 1 cores was 4.9 ft (149 cm), and the maximum drive depth was 17.8 ft (543 cm), as presented in Table 2-2 and detailed in Appendix A. The average maximum depth, from among the maximum depths of samples with detected chemical concentrations exceeding SQS and cleanup screening level (CSL) values of the SMS, was about 4 ft below the sediment surface; the maximum depth with SQS or CSL exceedances was 13 ft. Approximately 61 and 44 percent of the sediment cores had SQS or CSL exceedances, respectively, to the bottom of the analyzed core.

For the purpose of evaluating sediment volumes in areas requiring remediation and the associated conceptual-level costs in this PSA, the vertical extent of contaminated sediments is assumed to be up to 6 ft below mudline. The vertical extent of sediments potentially requiring remediation will be re-evaluated after compilation of the Phase 2 subsurface sediment data that were collected earlier this year (Windward 2006a).

2.4 Status of Source Control Efforts

The LDW Source Control Work Group (SCWG), which includes Ecology as the lead, EPA, King County, the City of Seattle, and the Port of Seattle is responsible for source control efforts. The group continues to focus its efforts on upland sources to the EAAs, and then plans to focus on other areas of concern identified through the RI/FS process. Future source control efforts will be implemented through a tiered approach beginning with drainage basins and shoreline and near-shore facilities that discharge to (1) high priority areas associated with priority sediment cleanups; (2) areas associated with longer-term cleanup goals; and (3) basins that may not drain directly to an identified sediment cleanup area. In addition, the group will focus source control efforts to address any recontamination identified by the monitoring of sediment cleanups (Ecology 2005a). The scoping of these efforts by Ecology is ongoing. Actions will be determined by Ecology on a site-by-site basis.

Ongoing source control activities include business inspections, agency file reviews, research on possible sources of contamination, and delineation of the drainage basins that discharge into the LDW. All of the agencies have improved their pollution control programs considerably in the past 20 to 30 years as federal and state pollution control requirements have expanded and as new methods of monitoring and analyzing wastes have been developed. Since the LDW Superfund listing, the agencies have increased their efforts in the LDW basin focusing on specific COPCs (e.g., PCBs, phthalates, and metals) and the sources of those chemicals.

Recent successes in the control of potential point sources has been achieved in the drainage basins where King County and the City of Seattle conduct joint inspections of storm drain or combined sanitary/storm sewer systems. The City of Seattle (Seattle Public Utilities) maintains a database for tracking all inspections. Ecology is working to develop a database that will enable comparison of the city-maintained inspection database with Ecology's records in order to facilitate the coordination of source control efforts.

2.5 Conceptual Site Model

The physical factors described in previous sections were used as the foundation for developing a draft conceptual site model (CSM). This CSM will be revised once the draft *Sediment Transport Analysis Report* is finalized (Windward and QEA 2006), the Phase 2 subsurface sediment data have been analyzed, and the sediment stability and natural recovery modeling has been completed. The draft CSM separates the LDW into three spatial reaches based on bathymetry, the location of the saltwater wedge during high-flow conditions, sediment deposition characteristics, and predicted locations of episodic erosion events. Sediment deposition characteristics are divided into three categories:

- **Lower Net Depositional:** net sedimentation rates are less than 0.5 cm/yr; in small, isolated areas within this category, the net sedimentation rate is minimal (less than 0.1 cm/yr)
- **Intermediate Net Depositional:** net sedimentation rates range from 0.5 to 2.0 cm/yr
- **Higher Net Depositional:** net sedimentation rates greater than 2.0 cm/yr.

In areas with intermediate and higher net depositional rates, the sediment bed is aggrading. In areas with lower net depositional rates, the sediment bed may approach a state of dynamic equilibrium (i.e., minimal change in bed elevation over annual time scales).

Within the LDW, the CSM describes three separate reaches in which combinations of characteristics apply depending upon location, water depth, erosion potential, and site use characteristics. These reaches include:

- **Reach 1: RM 0.0 to 2.0**. The downstream reach of the LDW is net depositional in both the navigation channel and the adjacent bench areas. The navigation channel is classified as higher net depositional and the bench areas as intermediate net depositional. This reach is occupied by the saltwater wedge under all flow conditions. This reach would not likely be subject to scour during the 100-year, spring-tide, high-flow event except in localized areas.

- **Reach 2: RM 2.0 to 3.0.** The middle reach of the LDW is net depositional on annual time scales. The navigation channel is classified as higher net depositional and the bench areas primarily intermediate net depositional, but variable with some small bench areas being lower net depositional and some higher net depositional. This middle reach is a transition zone between the upper and lower reaches, with the saltwater wedge being pushed downstream of this reach only under extreme flow events (100-yr high-flow event and greater).

- **Reach 3: RM 3.0 to 5.0.** The upstream reach of the LDW is net depositional on annual time scales. The high sedimentation rates in the navigation channel indicate that the channel is higher net depositional. In the bench areas, sedimentation rates are variable, with some areas being lower, intermediate, and higher net depositional. Higher episodic erosion may occur in this reach than in the other reaches during high-flow events. This reach is characterized as being occupied by the saltwater wedge during average flow conditions, but largely freshwater during high-flow events.

Figure 2-6 presents a plan view of the three reaches. Schematic cross-sections of these CSM reaches are presented on Figures 2-7 through 2-9 for Reaches 1, 2, and 3, respectively. These figures illustrate the variety of critical physical characteristics, site use considerations, and scour potential that affect the selection of appropriate remedial technologies.

Additional characteristics associated with these three reaches are summarized in Table 2-5, which also summarizes key sediment stability parameters measured or modeled in the draft *Sediment Transport Analysis Report* (Windward and QEA 2006) for each of the segments described by the CSM. Remedial implications of the CSM that affect the selection of remedial technologies are briefly summarized in this table and described in detail in Section 4.

PSA Assumptions

Based on the physical framework discussed above for the CSM, this PSA relies on several waterway-wide assumptions, including:

- **Elevation Ranges of Interest:** The draft *Sediment Transport Analysis Report* (Windward and QEA 2006) identified that for each reach there are three depth ranges of interest: shallow bench areas (<-9 ft MLLW), deep bench areas (>-9 ft MLLW to the navigation channel), and the navigation channel. For the purpose of this document, the intertidal area is shallower than -4 ft MLLW (Nightingale and Simenstad 2001), and the shallow subtidal area is between -4 and -9 ft MLLW. Together, the intertidal and shallow subtidal areas make up the "shallow bench area." Between the shallow bench area and the navigation channel is the deep subtidal bench area.

- **Habitat Areas:** Habitat areas are considered to be of particular importance to juvenile salmonids in shallow bench areas between about +12 ft MLLW and -9 ft MLLW. It is assumed that remedial alternatives for these areas will generally be required to maintain existing mudline grades and footprints within these elevation ranges. Habitat enhancements (i.e., thick caps, changes to the distribution of habitat elevations, expansion of intertidal habitat areas, etc.) may be considered on a localized scale in the design phase of individual remedial actions.

- **Physical Structures:** There are extensive structures present within the subtidal bench areas, such as docks and pilings, which can greatly complicate the implementation of dredging or capping alternatives and increase costs. The development of site-specific, localized approaches for these areas is outside the scope of this PSA. For the purposes of costing in this PSA, these areas are considered readily accessible, with minimal additional costs for limited access. Costs for pre-removal debris sweeps are included for all dredging alternatives.

- **Bathymetry:** Different types of dredging or excavation equipment will be appropriate, as determined by the bathymetry and other physical site features. For the purposes of cost and feasibility analyses in this PSA, it is assumed that removal actions in the intertidal areas, subtidal bench areas, and navigation channel can all be accomplished with conventional mechanical dredging equipment.

- **Required Navigation Depths:** At locations where remediation is required in the navigation channel or other areas with permitted navigation depths, dredging will need to be conducted to maintain the authorized or permitted depth. Therefore, capping is excluded as a stand-alone alternative for the navigation channel; however, it could be used in combination with dredging, provided that the final cap surface would not interfere with future navigation dredging. For the purposes of this PSA, it is assumed that any dredging in channel areas would be designed to expose a clean surface, and no capping in the navigation channel is assumed. However, the FS may identify areas of deeper contamination where capping in combination with dredging may be appropriate in the navigation channel or other areas with permitted navigation depths.

- **Vertical Depth of Contaminated Sediment:** For the purpose of evaluating sediment volumes in areas requiring remediation and the associated conceptual-level costs in this PSA, the vertical depth of contaminated sediments is assumed to be up to 6 ft. The vertical extent of sediments potentially requiring remediation will be re-evaluated after compilation of the Phase 2 subsurface sediment data that were collected earlier this year (Windward 2006a).

- **Cap Erosion Protection (Propeller wash and other erosive forces):** Any alternative involving capping will include consideration of an armoring component during the design phase, if site-specific analyses suggest that there is a significant likelihood of scour as a result of either propeller wash or high-flow events. An analysis of the potential for effects of propeller wash, outfall scour, ship wakes, high-flow events, and other events on a localized scale is beyond the scope of this PSA, but will be considered later in the design process.

- **COPCS:** Total PCBs are the most widely distributed chemical in the LDW; therefore, total PCBs are used in this document as the primary indicator chemical for estimating the spatial extent of areas that may require remediation under different scenarios. Additional remediation requirements for other COPCs will be further defined in the FS.

- **Areas Applicable for Dredging and/or Capping:** Based on the physical aspects of the CSM summarized in Table 2-5, dredging technologies are considered applicable to all areas of the LDW. Capping is considered applicable to all shallow and deep bench areas of the LDW. Capping may also be applicable in the navigation channel provided that the final cap surface is at least 2 ft below the authorized navigation depth to allow for periodic maintenance dredging.

- **Sediment Stability and Implications for Monitored Natural Recovery (MNR):** Natural recovery processes are active to varying degrees in all areas of the LDW, and are expected to remain an active mechanism that reduces COPC concentrations in surface sediments regardless of the remedial alternative that is ultimately selected. The rates of natural recovery are expected to vary significantly by location, as indicated by the varying sedimentation rates and erosion potentials in Table 2-5. The FS will include a more detailed analysis of natural recovery processes to formulate alternatives that explicitly include MNR and enhanced natural recovery (ENR) as a component. The FS will also provide estimates of post-cleanup SWAC reductions that will be expected to occur over time throughout the LDW as a result of the ongoing natural recovery processes.

- **Areas Amenable for ENR:** ENR is considered to be applicable in all areas of the downstream reach (RM 0.0 to 2.0) and in the bench areas of the upstream reaches (RM 2.0 to 5.0) where moderate net deposition presumably occurs. Because of the periodic maintenance dredging that occurs in the upper reaches of the navigation channel, ENR is not considered a viable process option for these areas. The rationale for employing MNR/ENR as alternative components will be refined in the FS as the natural recovery processes are better quantified.

Table 2-1 Dredging Event History in the LDW (1986 to Present)

Project/Site Name	River Mile	Dredge Date	Volume Dredged (CY)	Paydepth / Overdepth (feet MLLW)	Purpose	Source
Maintenance, Navigation and Construction Dredging Events						
Navigation Channel						
USACE	RM 3.35 to 4.65	02/06/1992 to 03/21/1992	199,361	-15 / -17	Maintenance dredge event	[2]
USACE	RM 3.35 to 4.65	03/11/1999 to 06/29/1999	165,116	-15 / -16	Maintenance dredge event	[2]
USACE	RM 4.0 to 4.2	03/11/1986 to 03/29/1986	33,637	-16 / -18	Maintenance dredge event	[2]
USACE	RM 4.0 to 4.65	02/28/1990 to 03/30/1990	127,619	-17	Maintenance dredge event	[2]
USACE	RM 4.18 to 4.65	02/22/1996 to 03/30/1996	90,057	-15 / -16	Maintenance dredge event	[2]
USACE	RM 4.2 to 4.65	03/07/1994 to 03/28/1994	57,243	-15 / -17	Maintenance dredge event	[2]
USACE	RM 4.2 to 4.65	02/05/1997 to 03/31/1997	89,011	-15 / -16	Maintenance dredge event	[2]
USACE	RM 4.3 to 4.65	01/14/2002 to 02/09/2002	96,523	-15 / -16	Maintenance dredge event	[2]
USACE	RM 4.3 to 4.65	01/15/2004 to 02/16/2005	75,770	-15 / -17	Maintenance dredge event	[2]
USACE	RM 4.4 to 4.65	06/19/1986 to 07/15/1986	126,470	-16 / -18	Maintenance dredge event	[2]
USACE	RM 4.4 to 4.65	02/24/1987 to 03/24/1987	80,160	-18 / -20	Maintenance dredge event	[2]
Port of Seattle Terminals and Private Berthing Areas						
Terminal 103	RM 0.0 to 0.07	2005	—	—	—	—
Lehigh Northwest	RM 1.0 to 1.1	2004	9,000	—	Maintenance dredge event	[1]
Glacier NW	RM 1.42 to 1.55	2005	9,920	-35 / -36	Maintenance dredge event	[1]
Lone Star Northwest	RM 1.42 to 1.55	1992	3,900	—	Maintenance dredge event	[1]
James Hardie Gypsum	RM 1.58 to 1.75	1999	10,000	-31	Maintenance dredge event	[1]
Lone Star-Hardie	RM 1.6 to 1.75	1995	18,000	-30 / -31	Maintenance dredge event & dock upgrade	[1]
Terminal 115	RM 1.9	1993	3,000	-15	Maintenance dredge event & dolphin construction	[1]
Boyer	RM 2.4 to 2.5	1998	8,000	-10	Maintenance dredge event	[1]
Boyer	RM 2.4	2004	—	—	Dock replacement	[1]
Hurlen	RM 2.65 to 2.75	1998	15,000	-10	Maintenance dredge event	[1]
Crowley	RM 2.8 to 2.85	1996	13,000	-15	Maintenance dredge event	[1]
Morton	RM 2.86 to 2.97	1992	7,990	Variable	Maintenance dredge event	[1]
South Park Marina	RM 3.4	1993	15,500	-8	Maintenance dredge event	[1]
Duwamish Yacht Club	RM 4.1	1999	24,000	-8	Maintenance dredge event	[1]
Delta Marine	RM 4.2	2002	7,000	—	Maintenance dredge event	[1]
Sediment Remediation and Other Dredging Events						
Duwamish Diagonal (3)	RM 0.5 to 0.65	11/14/2003 to 1/20/2004	68,250	Variable	Remediation	[2]
Norfolk CSO	RM 4.9	1999	5,190	-3	Remediation	[2]
Boeing Development Center South Storm Drain (3)	RM 4.9	2003	100	—	Remediation	[2]

Notes:

[1] Only pre-dredge documents have been reviewed. These documents include: Sampling and Analysis Plans, Suitability Determination Reports, Dredged Materials Characterization Reports, and Sediment Characterization Reports.

[2] Post-dredge documents have been reviewed. These documents include: Remediation Reports and Dredging Summary and Analysis Reports.

[3] Early Action Areas

"—" = Unknown at this time.

USACE = United States Army Corps of Engineers.

Table 2-2 Summary Statistics of Phase 1 Sediment Core Depths and SQS and CSL Exceedances

Phase 1 and Historical Sediment Core Summary Statistics[1]	Unit	Result
All cores		
Number of core locations	count	314
Average core drive depth	cm (ft)	149 (4.9)
Maximum drive length	cm (ft)	543 (17.8)
Cores exhibiting a SQS exceedance		
Number of core locations	count	248
Average maximum depth of interval exhibiting an exceedance[2]	cm (ft)	116 (3.8)
Maximum depth of interval exhibiting an exceedance[2]	cm (ft)	396 (13.0)
Cores exhibiting a CSL exceedance		
Total number of sediment core locations	count	241
Average maximum depth of interval exhibiting an exceedance[2]	cm (ft)	102 (3.3)
Maximum depth of interval exhibiting an exceedance[2]	cm (ft)	287 (9.4)
All cores exhibiting exceedances and no exceedances		
Total number of sediment core locations	count	314
Average depth of interval exhibiting an SQS exceedance[3]	cm (ft)	91 (3.0)
Average depth of interval exhibiting a CSL exceedance[3]	cm (ft)	86.2 (2.6)

Notes:

[1] Only the Phase 1 (historical) sediment core data are included in these calculations; Phase 2 core data collected in February 2006 have not yet been compiled. Many of the cores reported here are focused in areas with known contamination and may not represent typical LDW-wide subsurface conditions.

[2] Of cores exhibiting multiple intervals with exceedances, only the deepest interval per core exhibiting an exceedance was included in the calculation of average maximum depths among core stations.

[3] A depth of zero (0) ft used for cores with no exceedances.

Table 2-3 Tugboat and Barge Activity in the LDW

Tugboat Operator	Destination (Client)	Location (River Mile)	Frequency
Island Tug & Barge Company	Lehigh (Tilbury) Cement Co., Harbor Island	Not in study area	Barge storage; tug activity infrequent
	General Construction, Yard 1	RM 0-0.1W (T-103)	2-5 days/week
	Glacier Northwest, Seattle Yard	RM 0-0.1W (T-103)	Twice daily
	Ashgrove Cement	RM 0-0.2E	Weekly
	Birmingham Steel Corp. (all faces, T-105)	RM 0.2-0.5W	Daily
	T-108	RM 0.2-0.5E	2-4 times/week
	Lehigh (Tilbury) Cement Co. / Cadman, Inc.	RM 1.0E	2-4 times/week
	LaFarge Cement	RM 1.0-1.1W	Once monthly
	Duwamish Shipyard	RM 1.3-1.4W	6-7 times/year
	General Construction, Yard 2	RM 1.4-1.6E	Often daily; once a week other times
	Glacier Northwest, Duwamish Plant	RM 1.7-1.8E(Slip 2)	2-3 times/week
	SeaTac Marine Services	RM 2.0-2.1E (Slip 3)	2-3 times/week
	Boyer Alaska Barge Lines, Inc.	RM 2.1-2.2W	Barge storage; tug activity infrequent
	Seattle Iron & Metals Corp.	RM 2.1-2.2E	Barge storage; tug activity infrequent
	Hurlen Construction	RM 2.6-2.8W	Often daily; once a week other times
	KRS Barge Storage	Unknown	6-7 times/year
Western Towboat Company, Inc.	Glacier Northwest, Duwamish Plant	RM 1.7-1.8E (Slip 2)	2-3 times/week
	Lehigh (Tilbury) Cement Co./ Cadman Co., Inc.	RM 1.0E	2-3 times/week
	Northland Services, Inc.	RM 2.0-2.1E (Slip 3), RM2.8-2.9E (Slip 4)	2-3 times/week
	Alaska Marine Lines, Inc.	RM 1.2-1.3W, RM 2.1-2.2W	2-3 times/week
Crowley Maritime Corporation	British Plaster Board	Unknown	2 tugs, 2-3 times/month
	Glacier Northwest	RM 0-0.1W (T-103), RM 1.7-1.8E (Slip 2)	2 tugs, 2-3 times/month
	LaFarge Cement	RM 1.0-1.1W	2 tugs, 2-3 times/month
Foss Maritime Company	Seaspan International	Unknown	Not available
	Ashgrove Cement Co.	RM 0-0.2E	Not available
	General Construction Co.	RM 0-0.1W (T-103), RM 1.4-1.6E	Not available
	Manson Construction Co.	RM 0.9-1.0E (Slip 1)	Not available
	Northland Services, Inc.	RM2.8-2.9E (Slip 4)	Not available

Table 2-4 Number of Stations with Detected Chemical SQS Exceedances Arrayed by Chemical

SMS Parameter Name	# of Stations Analyzed for Parameter	Baseline Conditions		
		# of Stations Where Parameter Detected	# of Stations >SQS	Percent of SQS Exceedances Relative to Total Stations Analyzed for Parameter
PCBs (total calc'd)	1294	1211	475	36.7%
Bis(2-ethylhexyl)phthalate	801	644	104	13.0%
Butyl benzyl phthalate	792	410	72	9.1%
Zinc	820	819	41	5.0%
Mercury	838	726	37	4.4%
Fluoranthene	797	767	33	4.1%
Phenanthrene	797	734	26	3.3%
Phenol	800	272	26	3.3%
Lead	821	821	21	2.6%
Chrysene	797	749	20	2.5%
Dibenzo(a,h)anthracene	797	415	20	2.5%
Acenaphthene	797	320	19	2.4%
Indeno(1,2,3-cd)pyrene	793	703	19	2.4%
Total HPAH (calc'd)	798	775	18	2.3%
Fluorene	797	387	14	1.8%
Arsenic	821	762	13	1.6%
Benzo(g,h,i)perylene	792	656	12	1.5%
Cadmium	804	574	12	1.5%
Copper	821	821	12	1.5%
Dibenzofuran	796	249	10	1.3%
Benzo(a)anthracene	798	728	9	1.1%
Chromium	818	818	9	1.1%
Silver	789	492	9	1.1%
Benzofluoranthenes (total-calc'd)	792	736	7	0.9%
Benzoic acid	789	87	7	0.9%
Hexachlorobenzene	789	46	7	0.9%
Benzo(a)pyrene	797	732	6	0.8%
Total LPAH (calc'd)	797	737	5	0.6%
4-Methylphenol	800	78	4	0.5%
Benzyl alcohol	779	15	4	0.5%
1,2-Dichlorobenzene	786	23	3	0.4%
1,4-Dichlorobenzene	786	52	3	0.4%
1,2,4-Trichlorobenzene	786	6	2	0.3%
2-Methylnaphthalene	787	139	2	0.3%
Anthracene	797	562	2	0.3%
2,4-Dimethylphenol	782	1	1	0.1%
Dimethyl phthalate	792	137	1	0.1%
Naphthalene	787	146	1	0.1%
Pentachlorophenol	755	12	1	0.1%

sorted by

Notes:

Shading denotes 5 or more stations with SQS exceedances among detected chemicals.

The 12-23-05 baseline surface sediment dataset used for calculations.

Table 2-5 Conceptual Site Model and Potentially Applicable Remedial Technologies

Reach	Segment	Material Type	Vessel Activity	Estimated Net Sedimentation Rate (cm/yr)	Relative Erosion Potential (100-year high-flow event) [1]	Potentially Applicable Remedial Technologies [2]
RM 0.0 to 2.0	Bench area (Intertidal and shallow subtidal)[3]	Sand/Silt	Low to Moderate	0.5	Low	• Excavation / Dredging • MNR • Capping
	Bench area (Deep subtidal)[4]	Sand/Silt	High	0.5 to >2	Low	• Dredging • MNR • Capping
	Navigation channel	Silt	High	>2 to 15	Low	• Dredging • ENR • MNR
RM 2.0 to 3.0	Bench area (Intertidal and shallow subtidal)	Sand	Low to Moderate	No data	Low	• Excavation / Dredging • ENR • Capping
	Bench area (Deep subtidal)	Sand/Silt	Moderate to High	0.5 to >2	Moderate	• Dredging • ENR • Capping
	Navigation channel	Silt	High	>2 (10 to 25)	Moderate	• Dredging • MNR

Reach	Segment	Material Type	Vessel Activity	Estimated Net Sedimentation Rate (cm/yr)	Relative Erosion Potential (100-year high-flow event) [1]	Potentially Applicable Remedial Technologies [2]
RM 3.0 to 5.0	Bench area (Intertidal and shallow subtidal)	Sand	Low	0.5	Moderate	• Excavation / Dredging • ENR • Capping
	Bench area (Deep subtidal)	Sand/Silt	Low	0.5 to >2	High	• Dredging • ENR • Capping
	Navigation channel	Silt	Moderate	>2 (20 to 110)	High	• Dredging • MNR

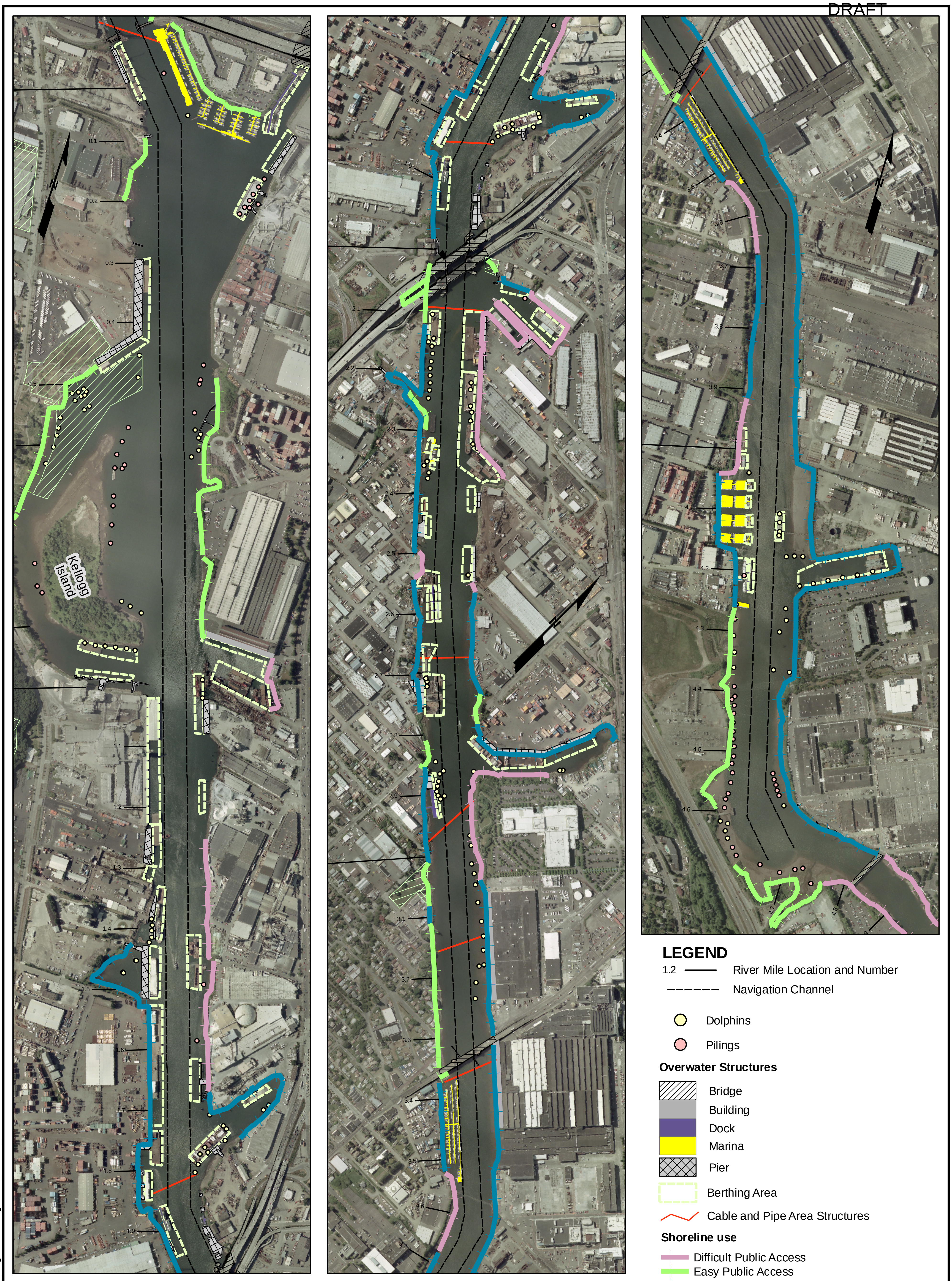
NOTES:

(1) Based on Excess Shear Stress and Normalized Scour Depth in the draft *Sediment Transport Analysis Report* (Windward and QEA 2006) for the 100-yr storm event. Categories are defined as:
Low potential: normalized scour depth < 0.001 and excess sheer stress < 1.
Moderate potential: normalized scour depth > 0.001 and < 0.1 and excess shear stress > 1.
High potential: normalized scour depth > 0.1 and excess shear stress > 2.

(2) MNR and ENR may both be applicable in all areas. Preliminary designations are provided for the purposes of PSA analyses.

(3) Bed elevation between +12 ft and -9 ft MLLW.

(4) Bed elevation below -9 ft MLLW and outside the navigation channel.



LEGEND

1.2 —— River Mile Location and Number
- - - - - - Navigation Channel

Dolphins
Pilings

Overwater Structures

Bridge
Building
Dock
Marina
Pier
Berthing Area
Cable and Pipe Area Structures

Shoreline use

Difficult Public Access
Easy Public Access
Restricted Access
Parks

1. USGS 2002 photo provided by Windward Environmental LLC.
2. Berthing area data collected from USACE, Port Series No.36 Revised 2002; Port of Seattle, Washington.
3. Over-water data created 2004 by TerraLogic GIS, Inc. and Landau Associates, Inc., Duwamish Waterway Shoreline Inventory, Washington, 2004.

0 400 800 Feet

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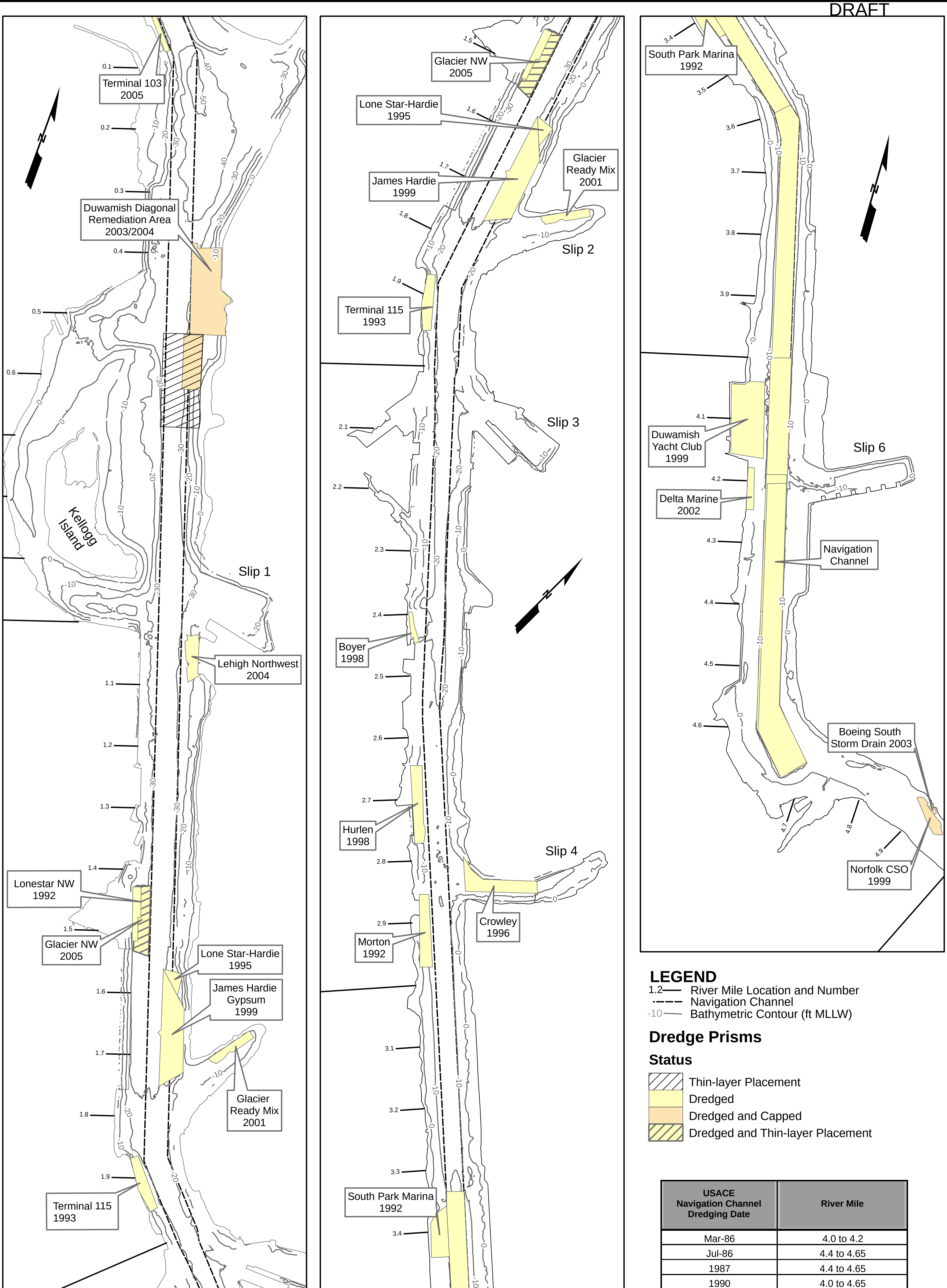
LDW DRAFT PRELIMINARY SCREENING OF ALTERNATIVES (PORS5-18220-603)	LOCATION OF OVER-WATER STRUCTURES, BERTHING AREAS AND RIVER ACCESS POINTS IN THE LDW
DATE: 8/16/06 DWN. BY: KBL/ftc	FIGURE 2-1

FILE: T:/LDWG_Duwamish/Projects/PSAfinal_Aug06/BerthingAreas_Access_INT.MXD



Data provided by Windward Environmental, LLC and USACE records.

LEGEND

1.2 — River Mile Location and Number

- - - Navigation Channel

-10 — Bathymetric Contour (ft MLLW)

Dredge Prisms

Status

- Thin-layer Placement
- Dredged
- Dredged and Capped
- Dredged and Thin-layer Placement

USACE Navigation Channel Dredging Date	River Mile
Mar-86	4.0 to 4.2
Jul-86	4.4 to 4.65
1987	4.4 to 4.65
1990	4.0 to 4.65
1992	3.35 to 4.65
1994	4.2 to 4.65
1996	4.18 to 4.65
1997	4.2 to 4.65
1999	3.35 to 4.65
2002	4.3 to 4.65
2004	4.3 to 4.65

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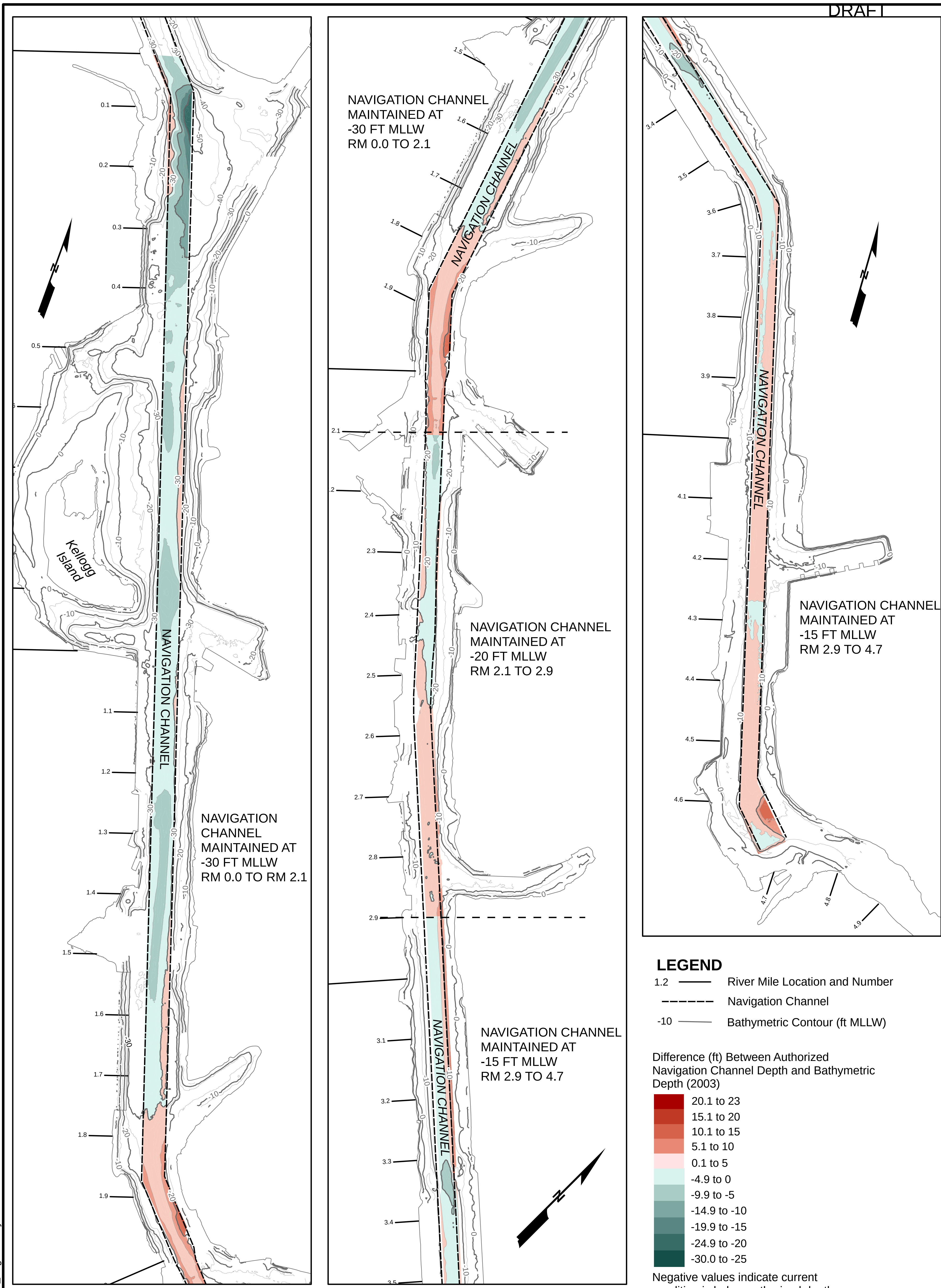
LDW
DRAFT PRELIMINARY SCREENING OF ALTERNATIVES
(PORS5-18220-603)

DREDGING EVENT LOCATIONS
(1986 to PRESENT)

DATE: 9/12/06 | DWN. BY: KBL/ftc

FIGURE 2-2

FILE: T:/LDWG_Duwamish/Projects/PSA_Oct06/DregdeEvents.MXD



1. Bathymetry data provided by Windward Environmental LLC based on waterway-wide October 2003 survey.

0 400 800 Feet

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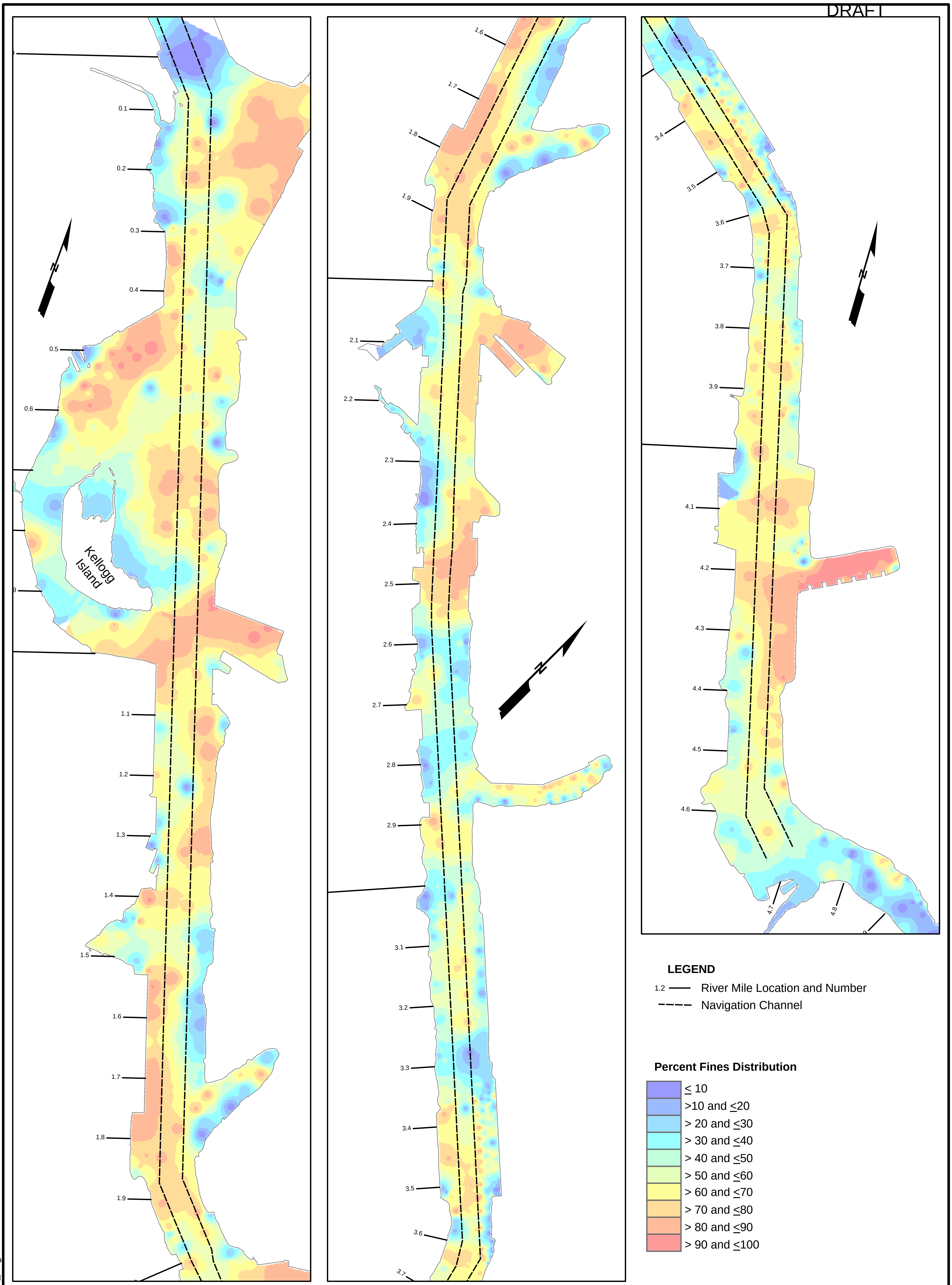
LDW
DRAFT PRELIMINARY SCREENING OF ALTERNATIVES
(PORS5-18220-603)

CURRENT BATHYMETRIC CONDITIONS (2003) RELATIVE TO AUTHORIZED NAVIGATION CHANNEL DEPTHS

DATE: 8/15/06 | DWN. BY: KBL/ftc

FIGURE 2-3

FILE: T:/LDWG_Duwamish/Projects/PSAfinal_Aug06/BathyNav.MXD



1. Mapping uses the 12-23-05 dataset provided by Windward Environmental LLC.
2. Percent fines is the sum of silt and clay size particle fractions.

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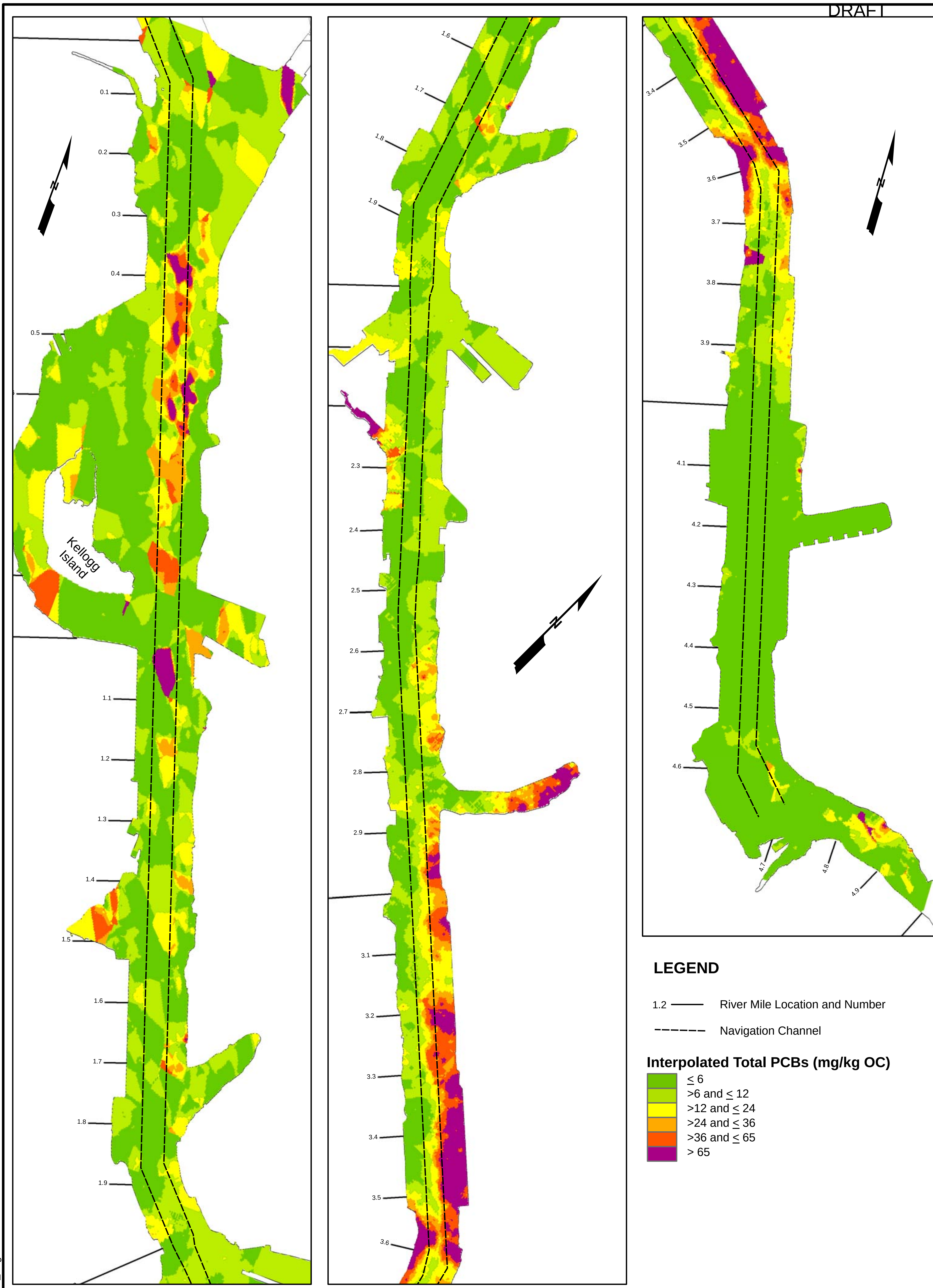
LDW DRAFT PRELIMINARY SCREENING OF ALTERNATIVES (PORS5-18220-603)	DISTRIBUTION OF FINE GRAIN SURFACE SEDIMENTS IN THE LDW
DATE: 5/9/06 DWN. BY: KBL/ftc	FIGURE 2-4

FILE: T:/LDWG_Duwamish/Projects/PSAfinal_Aug06/PercentFines.MXD

DRAFT



1. Mapping uses the 12-23-05 dataset provided by Windward Environmental LLC.
2. Total PCB isopleths were set at multiples of the SQS (12 mg/kg OC) and the CSL (65 mg/kg OC) for total PCBs.

0 400 800 Feet

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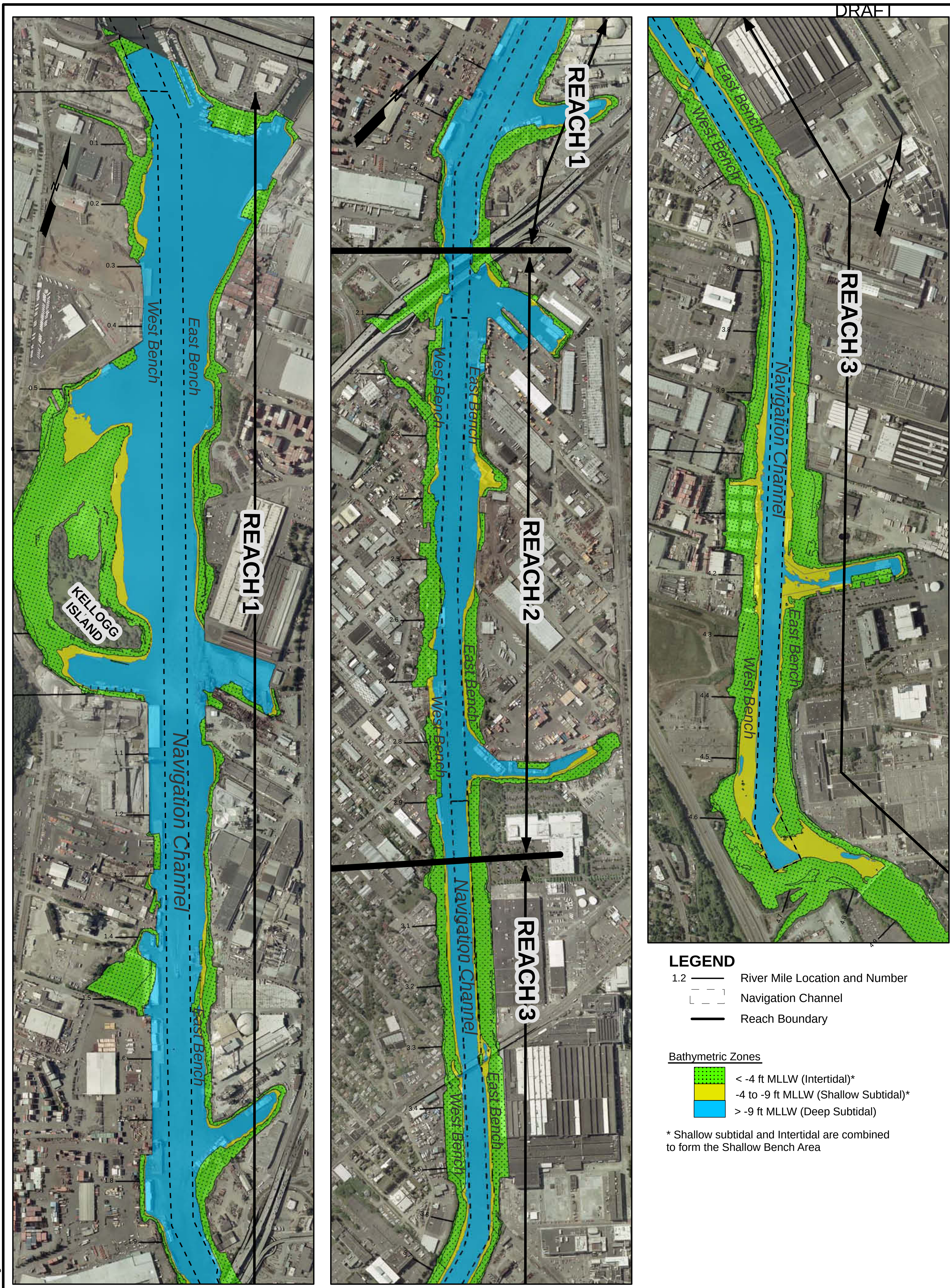
LDW DRAFT PRELIMINARY SCREENING OF ALTERNATIVES (PORS5-18220-603)	BASELINE DISTRIBUTION OF TOTAL PCBs IN SURFACE SEDIMENT
DATE: 5/9/06 DWN. BY: KBL/ftc	FIGURE 2-5

FILE: T:/LDWG_Duwamish/Projects/PSAFinal_Aug06/CurrentCondition.MXD



1. Bathymetry data provided by Windward Environmental LLC based on waterway-wide October 2003 survey.
2. USGS 2002 photo provided by Windward Environmental LLC.
3. Conceptual site model represents 9 CSM segments comprised of 3 reaches with 3 different bathymetric zones.
4. Reach 1 is from river mile (RM) 0.0 to 2.0. Reach 2 is from RM 2.0 to 3.0. Reach 3 is from RM 3.0 to 5.0.

0 400 800 Feet

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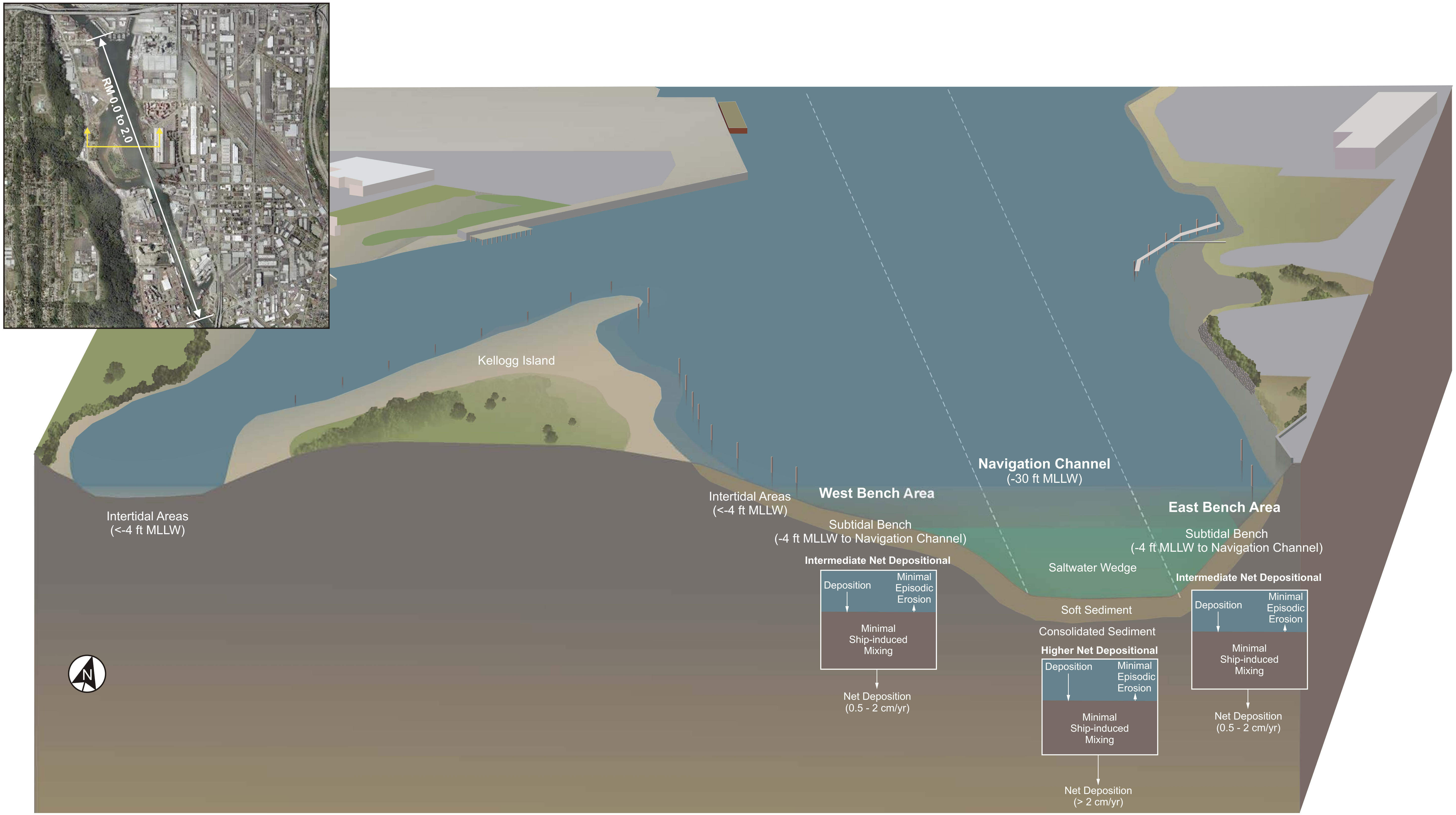
LDW DRAFT PRELIMINARY SCREENING OF ALTERNATIVES (PORS5-18220-603)	CONCEPTUAL SITE MODEL OF LDW REACHES
DATE: 9/12/06 DWN. BY: KBL/ftc	FIGURE 2-6

FILE: T:/LDWG_Duwamish/Projects/PSAfinal_Aug06/RivSections_Aerial.MXD

Figure 2-7. LDW Conceptual Site Model for Reach 1 (RM 0.0 - 2.0)

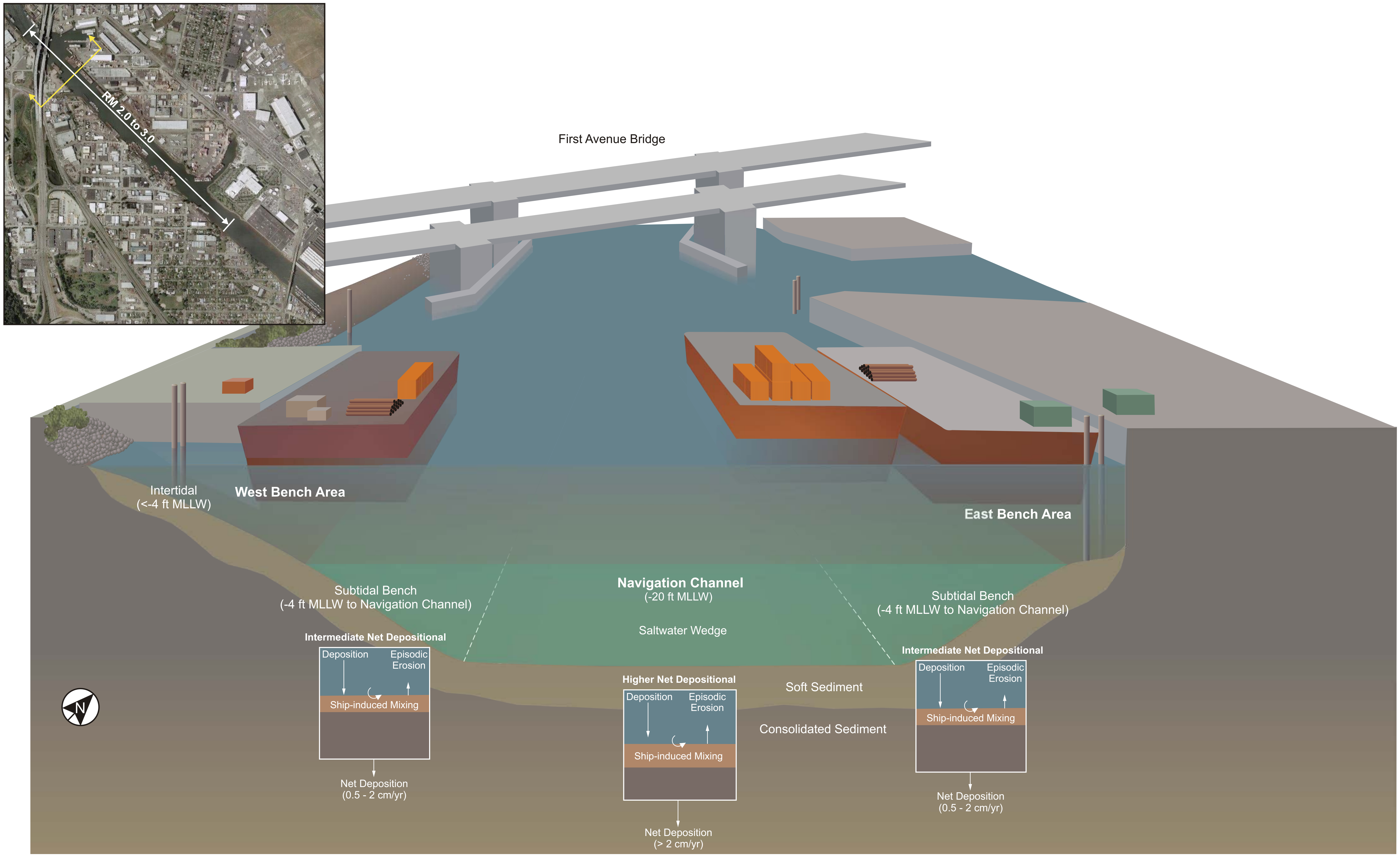


Notes: 1. Approximate net depositional rates from Sediment Transport Analysis Report, 2006.
2. Inserts are qualitative illustrations and are not to scale.

Figure last updated on September 26, 2006

Figure 2-8. LDW Conceptual Site Model for Reach 2 (RM 2.0 - 3.0)

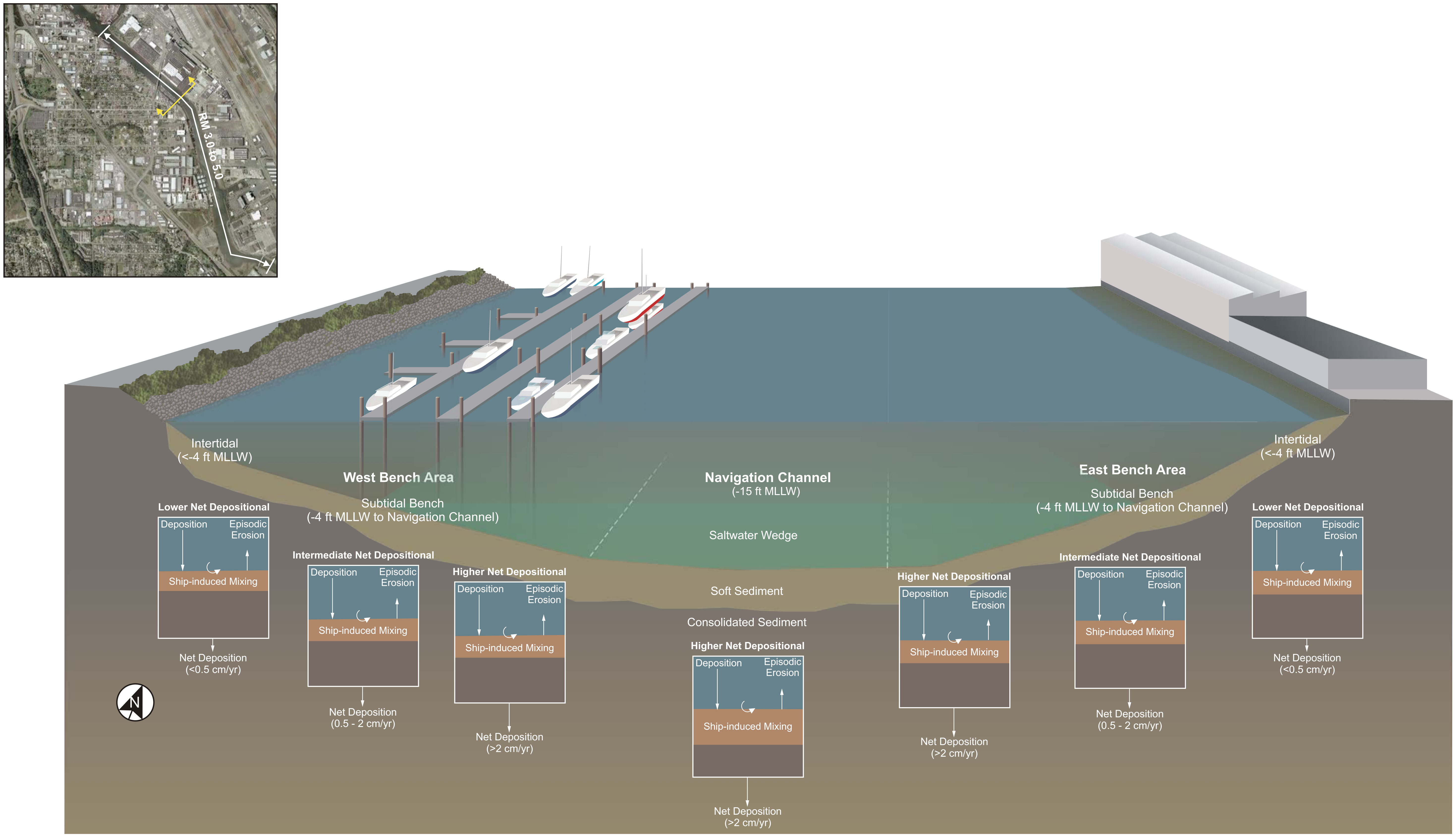
DRAFT



Notes: 1. Approximate net depositional rates from Sediment Transport Analysis Report, 2006.
2. Inserts are qualitative illustrations and are not to scale.

Figure last updated on September 26, 2006

Figure 2-9. LDW Conceptual Site Model for Reach 3 (RM 3.0 - 5.0)



Notes: 1. Approximate net depositional rates from Sediment Transport Analysis Report, 2006.
2. Inserts are qualitative illustrations and are not to scale.

Figure last updated on September 26, 2006

3 Preliminary Evaluation of Potentially Actionable Areas

This section identifies potentially actionable areas within the LDW for which remedial alternatives are developed in this PSA. These areas are referred to as potential because they are not intended to indicate the final list or extent of actionable areas, but were selected to provide a conceptual basis from which to build the effectiveness and cost comparisons for this PSA. An estimate of the spatial extent of areas that may require management is necessary to develop a range of potential remedial alternatives.

The identification of potentially actionable areas will be further refined as part of the FS process once all of the surface and subsurface data are compiled and analyzed, the risk assessments are completed, and RAOs are identified.

3.1 Identification of Potentially Actionable Areas

Three general types of areas were identified for purposes of completing this analysis:

- Sponsored Early Action Areas (EAAs), where one or more individual LDWG members have made a commitment to conduct removal actions. For purposes of this document, these areas are referred to as sponsored EAAs (Windward 2003b).

- PPAs, including non-sponsored EAAs (Windward 2003b) for which no entity has accepted or been assigned responsibility for sediment remediation, and other identified areas having similar characteristics to the sponsored EAAs based on the additional Phase 2 RI sampling.

- Other AOIs within the remainder of the LDW with elevated PCB concentrations (expressed as multiples of the SQS and the CSL). These AOIs are defined as areas where total PCBs in surface sediments exceed multiples of the SQS and CSL. Total PCBs were used as an indicator constituent because they have the broadest spatial coverage within the LDW and other COPCs are generally co-located with PCBs.

The criteria and methods used for calculating the spatial extent of each of these areas are presented in this section. The boundaries of the EAAs are based on current estimates presented in early action documents. The preliminary boundaries of the PPAs were estimated solely for the purposes of this PSA using best professional judgment and are subject to change.

3.1.1 Sponsored Early Action Areas

The sponsored EAAs are the first areas where remedial actions have been or will be undertaken in the LDW (Figure 3-1). These sponsored EAAs are those areas at which one or more individual LDWG members have made a commitment to conduct remedial actions. There are five sponsored EAAs in the LDW that together amount to approximately 31 acres (Table 3-1):

- Diagonal/Duwamish removal, which was conducted in 2003/2004 as part of EBDRP
- Planned Slip 4 CERCLA non-time-critical removal action
- Planned Terminal 117 CERCLA non-time-critical removal action
- Planned Boeing Plant 2 sediment remediation to be undertaken as a Resource Conservation and Recovery Act corrective action
- The Norfolk Area: the sediment removal action at the Boeing Developmental Center south storm drain, completed in 2003 under the MTCA Voluntary Cleanup Program; and the Norfolk CSO, where a sediment removal was completed in 1999 as part of EBDRP.

The boundaries of these five areas are shown on Figure 3-1 and described in Table 3-1. Although the Norfolk CSO is part of the "Norfolk Area" EAA it does not have remedial acres associated with it because the area was remediated prior to the LDW AOC. The map shown on Figure 2-5 illustrates baseline conditions in terms of total PCB concentrations; that is, the surface sediment concentrations that existed before implementing any of the sponsored EAAs. Figure 3-2 shows interpolated total PCB concentrations in surface sediments after completion of the removals at the sponsored EAAs. Although details of the Terminal 117, Slip 4, and Boeing Plant 2 early actions are being developed with the implementing parties with oversight by EPA, the PSA assumes they are complete for the purposes of estimating post-cleanup conditions. Boundaries of these sponsored EAAs may be modified as these cleanups are designed and implemented.

3.1.2 Potential Priority Areas

Additional remedial actions that are likely to occur within the LDW include both the non-sponsored EAAs and areas with similar characteristics to those used to define EAAs (Windward 2003b). Non-sponsored EAAs are those EAAs previously identified (Windward 2003b) for which no entity has accepted or been assigned responsibility for remediation. Additional PPAs are other areas within the LDW that exhibit similar characteristics to the EAAs, based on the results of additional Phase 2 sediment chemical analyses and site-specific toxicity testing. Specifically, the PPAs were delineated based on those detected SMS chemicals according to the following criteria:

- Non-sponsored EAAs previously identified in the *Identification of Candidate Sites for Early Action* (Windward 2003b)
- A cluster of at least three stations each with one or more CSL chemical exceedances
- A cluster of at least three stations with one or more SQS chemical exceedances and either a single CSL toxicity test failure or two or more SQS toxicity test failures.

Preliminary individual site boundaries were drawn (solely for the purposes of this PSA) to encompass all spatially contiguous SQS and CSL exceedances for the same chemical. Based on these criteria, eight PPAs were identified totaling 19.3 acres (Table 3-1). The locations and preliminary boundaries of these areas are shown on Figure 3-1. During the FS and/or remedial design phase of the project, these PPAs could be combined into larger actionable areas depending upon the sequence of remedial activities and/or delineation of SMAs. For the purposes of this PSA, these PPAs were delineated separately as smaller incremental areas if the above criteria were met on a smaller scale.

Table 3-2 shows that over 50 percent of the LDW has total PCB concentrations of 6 mg/kg OC or lower. The sponsored EAAs and PPAs together represent 50.5 acres of the overall 428.9 acres of the LDW. Figure 3-3 shows interpolated total PCB concentrations in surface sediments after completion of the removals at the sponsored EAAs and PPAs. The PPAs are considered to be potential priority remediation areas because of relatively high concentrations of total PCBs or other SMS chemical and toxicity exceedances. Additional PPAs may be identified, and the boundaries of the PPAs assumed for the purposed of this PSA may be modified as part of the FS.

3.1.3 Other Areas of Interest

For the remainder of the LDW, other AOIs were identified as those areas where total PCB concentrations in surface sediments exceed multiples of the SQS. These AOIs are shown on Figure 3-3. As discussed previously, total PCBs were selected as an indicator chemical, because most other COPCs are often co-located with total PCBs, and total PCBs have the broadest spatial extent of all the COPCs. The FS will consider all chemicals shown in the risk assessments to have unacceptable human health or ecological risks, and those that exceed the chemical criteria of the Washington State SMS. The multiples of the total PCB SQS are used as a surrogate for evaluating risk-based concentrations. Baseline surface sediment concentrations of total PCBs were interpolated to represent the PCB concentrations that existed in the LDW before conducting any of the sponsored EAA removals. The interpolation analyses were completed using the Inverse Distance Weighting (IDW) algorithms built into ArcView and Spatial Analyst 9.0 (ESRI®). To facilitate the evaluation of remedial alternatives for the AOIs, multiples of the SQS for total PCBs were used to set the concentration isopleths for the PCB distribution maps. These included one half, one, two, and three times the total PCB SQS of 12 mg/kg organic carbon (OC), and the CSL of 65 mg/kg OC. Thus, the isopleths represent total PCB concentrations of 6, 12, 24, 36, and 65 mg/kg OC. PCB interpolation methods are presented in Appendix B. For purposes of PCB interpolation and mapping, the LDW was divided into three reaches based on waterway orientation.

3.2 Estimating Spatially-Weighted Average Concentrations of Total PCBs by Area

The concept of area-weighted averaging is widely used in sediment management and is used in the determination of cleanup levels for the protection of human seafood consumption risks. A spatially-weighted average concentration (SWAC) is similar to a simple arithmetic average of the empirical values, except that each individual empirical value is weighted in proportion to the sediment area it represents. Remediating contaminated sediments above a given PCB RAL will result in a reduction in the SWAC for total PCBs in surface sediments.

A SWAC value for total PCBs is an important indicator for evaluating relative risk reduction. Over time, a reduced SWAC is expected to result in a corresponding decrease in seafood tissue concentrations and associated risks to human health. Changes in the SWAC may represent a proportional change in risk; therefore, it is a valuable metric for evaluating relative effectiveness. In this PSA, the effects of each remedial alternative on the SWAC were evaluated after completing remediation of the sponsored EAAs, PPAs, and AOIs. The SWACs were calculated by assuming that the sponsored EAAs and PPAs are remediated first, followed by the remaining AOIs in descending order of total PCB concentration.

3.2.1 SWAC Methodology

The assumptions and methods used for the PCB interpolations and SWAC analysis are presented in Appendix B. As noted previously, both the final baseline dataset used for the risk assessments and the methodology for spatial interpolation were under discussion with the agencies in parallel with the development of this document. A final dataset and IDW parameters have been agreed upon (Windward 2006b,c) that result in changes to the actual estimated acres and SWACs presented in this document. These modifications will be carried forward into the FS. The changes result in a greater number of acres estimated for the total PCB concentration range between 6 and 12 mg/kg OC and a higher estimated SWAC for baseline conditions than those presented in this PSA (Appendix B).

For the purposes of this document, an interpolation area of 429 acres covering about five miles of the LDW study area extending from shore to shore was used in the SWAC analysis. Using a geographic information system (GIS), total PCB surface sediment concentrations were interpolated for baseline, post-EAA, and post-PPA conditions. Distributions of total PCBs in surface sediment were not re-interpolated for each multiple of the SQS in the AOIs.

After the station mapping and spatial interpolation process (described in Appendix B), the GIS program produces a grid file that assigns a concentration value to each "pixel" of the interpolation area. The number of pixels having concentrations within each user-defined range are summed and multiplied by the area of each pixel (about 10 by 10 ft) in Microsoft Access, resulting in a surface area for each concentration range. The areas and concentrations then become variables in a calculation that produces one concentration value for the entire interpolation area: a SWAC. In summary, GIS is used to generate the interpolations and a database file is used to replace the grid cells with post-remedy concentrations within each grid cell, and then the SWACs are calculated.

3.2.2 Changes in SWAC

Immediately following active cleanup, remediated areas may have very low concentrations of PCBs or other COPCs. However, the remediated areas will still be surrounded by ambient sediments that are subject to resuspension and transport. Sediment transport and other ongoing processes, including upland source loadings, atmospheric deposition, etc, will all result in the remediated areas eventually reaching equilibrium or "area background" concentrations similar to those in nearby sediments.

To calculate a post-cleanup SWAC for the LDW in this analysis, each point within a remediated area was replaced with an assumed equilibrium value of 5 mg/kg OC total PCBs (approximately 0.1 mg/kg PCBs on a dry weight (dw) basis). The selection of a post-remedial total PCB replacement value of 5 mg/kg OC was used as an approximation of the ambient concentrations that may be expected as remediated areas approach "area background" or equilibrium concentrations. The value is based upon the following considerations, and may be refined in the FS:

- Over 50 percent of the total area in the LDW currently has total PCB concentrations in surface sediments less than 6 mg/kg OC (see Table 3-2)

- Areas above RM 4.0 generally have total PCB concentrations in surface sediments less than 6 mg/kg OC (see Figure 3-3); however, samples collected within the upper turning basin and in upper sections of the navigation channel, where dredging has repeatedly occurred, have total PCB concentrations up to 120 mg/kg dw or 5.1 mg/kg OC.

Use and application of the SWAC for evaluating long-term effectiveness is presented in Section 5.0. As stated previously, the assumed areas of the PPAs are for comparative purposes only. The AOIs are shown for illustrative purposes only, and assume that it would be possible to remediate all areas with PCB concentrations within the specified ranges. In reality, the small sizes of some areas shown on the maps within certain PCB concentration ranges might make remediation impractical. SMAs based on several lines of evidence, including practicality, will be developed after the Phase 2 RI and risk assessment results are available.

After source control and sediment remedy completion, natural recovery is expected to further reduce the waterway-wide PCB SWAC over time, primarily as a result of natural deposition of cleaner sediment from upstream. Eventually, surface sediments may equilibrate to area background conditions. It is anticipated that different timeframes will be required for individual areas of the LDW to approach area background concentrations. Additional analyses of these natural recovery processes will be presented in the FS.

3.3 Application of the CSM to the Potentially Actionable Areas

Figure 3-1 illustrates the location of the sponsored EAAs and PPAs. As discussed in Section 2, various physical considerations affect the implementability and effectiveness of response actions. A physical CSM has been developed as part of the draft *Sediment Transport Analysis Report* (Windward and QEA 2006) that includes considerations related to bathymetry, deposition, and episodic erosion. Table 2-5 summarizes the segments of the LDW described in the physical site model and identifies potential technologies according to these segments. In Section 4, alternatives are developed for each of these areas. For the purposes of this PSA, the reaches and segments described in the CSM are used as the foundation for developing site-wide alternatives. The LDW is divided into the following nine CSM segments:

- **Three Reaches:** downstream (RM 0.0 to 2.0), middle (RM 2.0 to 3.0), and upstream (RM 3.0 to 5.0)

- **Three Bathymetric Zones Within Each Reach Based on Elevation:** intertidal and shallow subtidal bench areas (< -9 ft MLLW), deep subtidal bench area (> -9 ft MLLW), and the navigation channel.

The distribution of contaminated sediment for the AOIs within these reaches and segments is shown graphically on Figure 3-4. The acres are arrayed by multiples of the SQS for total PCBs for the AOIs. The largest area of contaminated sediment for the AOIs is found downstream between RM 0.0 and 2.0. Further upstream, most of the contaminated areas are found in the shallow bench areas, where episodic erosion events may be less pronounced. The least amount of contaminated sediment among the segments (expressed as acres) is found in the navigation channel between RM 2 and 5.

Preliminary delineation of these areas provides a foundation for developing SMAs in the FS. SMAs are a common tool used in FS documents to define sub-areas of a site that have similar physical, chemical, and biological characteristics; and subsequently, common remedial technologies applied to them.

Table 3-1 Identified Sponsored Early Action Areas and Potential Priority Areas in the LDW

Identified Areas	River Mile	Acres	Rationale for Selection
Sponsored Early Action Areas (EAAs)			
Boeing Plant 2	3.4 E	14.9	Identified EAA in the *Identification of Candidate Sites for Early Action* (Windward 2003b).
Duwamish/Diagonal	0.5 E	11.1	
Slip 4	2.8 E	2.9	
T-117	3.6 E	2.2	
Norfolk Area: Boeing Development Center South Storm Drain 2003	4.9 E	0.06	Identified EAA. Cluster of PCB CSL exceedances. This EAA is collectively called the "Norfolk Area."
Norfolk Area: Norfolk CSO 1999	4.9 E	0.0	Identified EAA, but completed prior to the LDW AOC and therefore pre-remedy conditions are not included in the baseline dataset. No acres are associated with this EAA. This EAA is collectively called the "Norfolk Area."
	Total Acres	**31.2**	
Potential Priority Areas (PPAs) [1]			
Area 1 (RM 0.4 E)	0.4 E to 0.6E	7.9	Extension of identified EAA. Cluster of multiple CSL and SQS exceedances for PCBs and phthalates. CSL bioassay failure at SS-22.
Area 2 (RM 0.6E)	0.6 E	0.9	Extension of identified EAA. Cluster of multiple CSL and SQS exceedances for PCBs and phthalates. CSL bioassay failure at SS-22 in nearshore triangle area.
Area 3 (RM1.3W)	1.3 W	0.3	Cluster of CSL exceedances for metals.
Area 4 (RM1.3W)	1.35 W	0.8	Cluster of CSL exceedances for metals. CSL bioassay failure at S-49.
Area 5 (RM 1.4 W)	1.4 W	3.6	Cluster of elevated dioxins concentrations and CSL exceedance for PCBs. SQS and CSL exceedance for phthalates. CSL bioassay failures at SS-57 and SS-58 in nearshore triangle area.
Area 6 (RM 2.2 W)	2.2 W	1	Identified EAA (non-sponsored). Cluster of PCB CSL exceedances. CSL bioassay failure at SS-158.
Area 7 (RM 3.6 E)	3.6 E	1.6	Portion of originally identified EAA (non-sponsored). Cluster of PCB CSL exceedances. CSL bioassay failure at SS-158
Area 8 (RM 3.8 E)	3.8 E	3.2	Identified EAA (non-sponsored). Original EAA boundary expanded based on additional samples and cluster of CSL exceedances. CSL bioassay failure at SS-158. This area is essentially contiguous with Area 7 but represented separately based on exceedences at separate stations.
	Total Acres	**19.3**	

Notes:

[1] Potential Priority Areas delineation based on the early action site criteria defined in the *Identification of Candidate Sites for Early Action* (Windward 2003b).

Table 3-2 Acres and Percent of Total LDW Area by Multiples of the SQS and CSL for Total PCBs

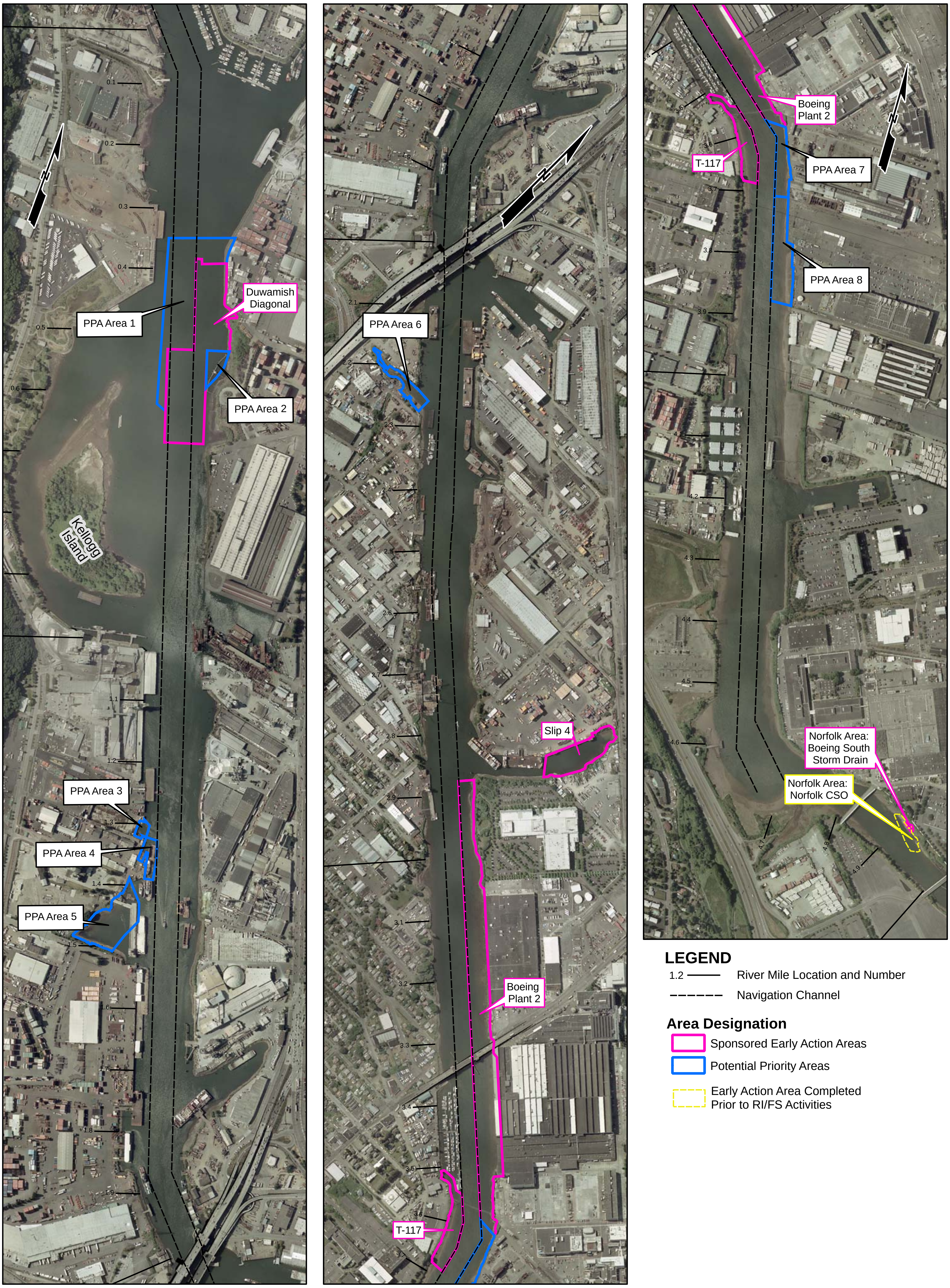
Total LDW Area				
Multiple of the Total PCB SQS/CSL (mg/kg OC)	**Acres**	**Percent of Total LDW Study Area**	**Cumulative Acres**	**Cumulative Percent of Total LDW Study Area**
Baseline Conditions				
>65 (CSL)	13.7	3.2%	13.7	3.2%
> 36 and ≤ 65	15.2	3.6%	28.9	6.7%
> 24 and ≤ 36	16.7	3.9%	45.6	10.6%
> 12 (SQS) and ≤ 24	49.6	11.6%	95.2	22.2%
> 6 and ≤ 12	112.0	26.1%	207.2	48.3%
≤ 6	221.7	51.7%	428.9	100.0%
Total Area of LDW	**428.9**	**100.0%**	**428.9**	**100.0%**
Areas of Waterway				
EAAs	31.2	7.3%	31.2	7.3%
PPAs	19.3	4.5%	50.5	11.8%
Rest-of-Waterway	378.4	88.2%	428.9	100.0%
Total Area of LDW	**428.9**	**100.0%**	**428.9**	**100%**

AOI Areas*				
Multiple of the Total PCB SQS/CSL (mg/kg OC)	**Acres**	**Percent of LDW Study Area Outside the EAAs and PPAs with Total PCB Concentrations > 6 mg/kg OC**	**Cumulative Acres**	**Cumulative Percent of LDW Study Area Outside the EAAs and PPAs with Total PCB Concentrations > 6 mg/kg OC**
Areas of Interest (AOIs) with Total PCBs > 6 mg/kg OC				
>65 (CSL)	2.1	1.4%	2.1	1.4%
> 36 and ≤ 65	3.4	2.3%	5.5	3.7%
> 24 and ≤ 36	8.8	5.9%	14.3	9.6%
> 12 (SQS) and ≤ 24	32.4	21.6%	46.7	31.2%
> 6 and ≤ 12	102.9	68.8%	149.6	100.0%
Total AOIs (>6)	**149.6**	**100.0%**	**149.6**	**100.0%**

Notes:

Acres generated in GIS using the baseline surface sediment dataset provided by Windward Environmental LLC on 12/23/05.

* Areas of the AOIs exclude the EAAs and PPAs, and are a subset of the Rest-of-Waterway Area.



1. USGS 2002 photograph provided by Windward Environmental, LLC.

0 400 800 Feet

FILE: T:/LDWG_Duwamish/Projects/PSA_Oct06/EAAs.MXD

DRAFT

RETEC

Lower Duwamish Waterway Group
Port of Seattle | City of Seattle | King County | The Boeing Company

LDW
DRAFT PRELIMINARY SCREENING OF ALTERNATIVES
(PORS5-18220-603)

LOCATION OF SPONSORED EAAs AND PPAs

DATE: 9/12/06 | DWN. BY: KBL/ftc

FIGURE 3-1

1. Mapping uses the 12-23-05 dataset provided by Windward Environmental LLC.
2. Total PCB isopleths were set at multiples of the SQS (12 mg/kg OC) and the CSL (65 mg/kg OC) for total PCBs.
3. For sediments within remediated areas, the post-remedial surface sediment total PCB concentration was set at 5 mg/kg OC.

0 400 800 Feet

DRAFT

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Port of Seattle / City of Seattle / King County / The Boeing Company

LDW DRAFT PRELIMINARY SCREENING OF ALTERNATIVES (PORS5-18220-603)	INTERPOLATED TOTAL PCB DISTRIBUTION WITHIN THE LDW AFTER SEDIMENT REMOVALS AT THE SPONSORED EAAs
DATE: 9/12/06 DWN. BY: KBL/ftc	**FIGURE 3-2**

FILE: T:/LDWG_Duwamish/Projects/PSA_Oct06/T1_replaced_P5.MXD

1. Mapping uses the 12-23-05 dataset provided by Windward Environmental LLC.
2. Total PCB isopleths were set at multiples of the SQS (12 mg/kg OC) and the CSL (65 mg/kg OC) for total PCBs.
3. For surface sediments within remediated areas, the post-remedial surface sediment total PCB concentration was set at 5 mg/kg OC.

0 400 800 Feet

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Port of Seattle / City of Seattle / King County / The Boeing Company

LDW
DRAFT PRELIMINARY SCREENING OF ALTERNATIVES
(PORS5-18220-603)

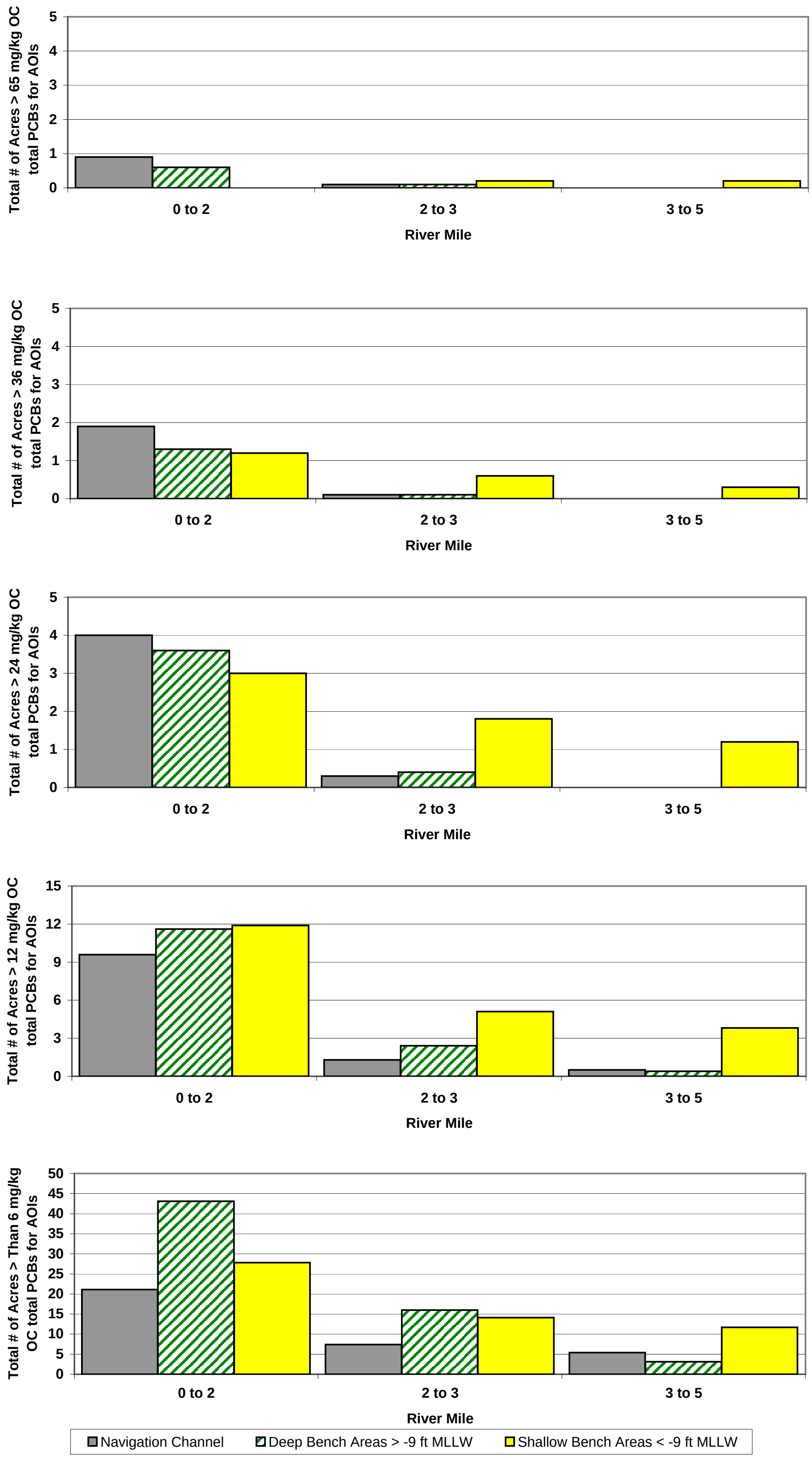
INTERPOLATED TOTAL PCB DISTRIBUTION WITHIN THE LDW AFTER SEDIMENT REMOVALS AT THE SPONSORED EAAs AND PPAs

DATE: 9/12/06 | DWN. BY: KBL/ftc

FIGURE 3-3

FILE: T:/LDWG_Duwamish/Projects/PSA_Oct06/T2_replaced_P5.MXD

Figure 3-4 Distribution of Areas within the AOIs Exceeding Multiples of the SQS for Total PCBs, Arrayed by CSM Segments



4 Assembling Preliminary Remedial Alternatives

This section identifies and develops a preliminary set of site-wide remedial alternatives based on the general range of LDW conditions identified in the previous two sections. The alternatives assembled in this section are carried into Section 5 and screened on the basis of relative effectiveness, implementability, and cost.

Remedial process options identified in the CTM (RETEC 2005b), and listed in Table 4-1, are linked to the conditions described in Section 2 to develop a set of waterway-wide, preliminary remedial alternatives. These conditions include general sediment characteristics, the CSM for sediment stability, physical structures and uses of the waterway, and the nature and extent of COPCs. The preliminary remedial alternatives are based on waterway-wide conditions in the LDW as a whole, rather than as a collection of detailed analyses of individual action areas. These factors are identified under each remedial alternative, as appropriate. The detailed alternative assumptions and cost evaluations are presented in Appendix C.

The preliminary remedial alternatives will facilitate development and selection of a waterway-wide remedy in the ROD for the LDW. However, actual design and cleanup of individual areas, however, will consider detailed site-specific conditions.

4.1 Technical Approach

The CTM (RETEC 2005b) identified and screened a comprehensive set of general response actions (GRAs), technology types, and process options that are potentially applicable to contaminated sediments in the LDW (Table 4-1). GRAs are broad categories of possible remedial actions that include institutional controls, natural recovery, containment, removal, treatment, and disposal. Each GRA may have one or more potentially applicable technologies. Dredging or dry excavation are examples of potential technologies considered under the GRA category of removal. A technology may have more process options or types of equipment that can be applied depending on site-specific circumstances. Mechanical and hydraulic dredging are examples of process options that are included under dredging technologies in the CTM (RETEC 2005b).

Each of the retained process options in the CTM was considered to have the potential to be effective for managing the COPCs in the LDW and the potential to be implemented given overall site conditions. However, these preliminary evaluations did not consider site-specific constraints, such as the expected volumes of materials, the ability to locate treatment facilities, or the ability of treatment process options to handle multiple COPCs.

As described in the CTM (RETEC 2005b), the development of specific remedial alternatives requires the development of appropriate assemblages of general response actions, specific technology types, and process options into a set of comprehensive, site-wide alternatives that consider the overall site conditions.

For the FS and for this PSA, and consistent with CERCLA guidance (USEPA 1988), *representative* process options are selected to represent each technology type in order to develop cost estimates for the remedial alternatives. Selecting a representative process option does not preclude re-examining other similar process options later in the FS or the design phase of the project. The actual remedial systems will be designed, bid, and implemented after EPA and Ecology have selected a remedy in the ROD for the LDW.

For this PSA, the assembly of preliminary site-wide remedial alternatives included the following steps:

1) Recommendations from the CTM (RETEC 2005b) were reviewed to select representative, effective, and implementable process options that could be used to develop comprehensive alternatives.

2) Representative process options from the CTM list were selected considering their effectiveness, implementability, and cost, based upon past and current applications at sediment remediation projects in the Puget Sound region, Washington State, or elsewhere in EPA Region 10, and site-specific factors discussed in Sections 2 and 3. Where appropriate, national experience was also drawn upon.

3) The process options were assembled into LDW-specific, waterway-wide remedial alternatives based on physical constraints, hydraulic conditions, and navigation and habitat uses.

4) Total PCBs is used as an indicator chemical for other COPCs in developing remedial alternatives based on contaminant distribution (described in Section 3).

5) Costs were developed independently for the sponsored EAAs, the PPAs, and the AOIs. For each of the alternatives retained for the AOIs, costs were developed at the individual multiples of the SQS for total PCBs (in Section 5). CERCLA guidance requires that the cost estimate in the FS for a representative system be accurate

within +50 to -30 percent. At this preliminary phase, PSA cost estimates may fall outside this range.

6) The preliminary set of assembled remedial alternatives was then evaluated with respect to effectiveness, implementability, and cost (in Section 5).

This process is consistent with CERCLA (EPA 1988) and MTCA (Ecology 2001) FS guidance, and simplifies development and evaluation of remedial alternatives.

4.2 Selection of Representative Process Options and Remedial Technologies

For each of the remedial technologies retained at the conclusion of the CTM (RETEC 2005b), one or two process options were selected to represent each technology for assembly into remedial alternatives. Table 4-1 lists the process options retained in the CTM. Technologies and specific process options[4] representing all the typical general response actions (e.g., removal, treatment, disposal, containment) were included in the set of technologies retained for further consideration and potential inclusion as site-wide remedial alternatives.

Consistent with CERCLA FS guidance (EPA 1988), one representative process option was selected where multiple process options are feasible and substantial differences in effectiveness and implementability are not anticipated. Table 4-2 summarizes the evaluation to select representative process options. During remedial design, other process options may be selected if they are found to be more advantageous as a result of technology advances or design/operational constraints that favor a process option variant. A discussion of the representative process options for each of the following GRAs is provided below:

- Institutional controls
- Monitored natural recovery (MNR)
- Enhanced natural recovery (ENR)
- Containment
- Removal
- Treatment technologies
- Disposal of contaminated sediments (on- and off-site)
- Beneficial use (following treatment).

[4] Processes were defined in the CTM as specific processes within each technology type. For example, chemical treatment, which is a technology type, includes such process options as solvent extraction and slurry oxidation.

4.2.1 Institutional Controls

Institutional controls are legal or administrative measures that restrict human use of or access to a site, thereby preventing or reducing exposure to contaminants (OSWER 2006). Any alternative that results in contaminants remaining on-site above levels allowing for unrestricted exposure will require some form of institutional controls. In the LDW, this could include continuation of the fish consumption advisories until risks to human health are ameliorated, restrictions on use of the LDW, deed restrictions, and access restrictions. Additionally, both short- and long-term institutional controls are expected to be required in association with MNR/ENR, capping, or contained aquatic disposal as means of ensuring the integrity of these remedies.

4.2.2 Monitored Natural Recovery

Natural recovery is the reduction of chemical concentrations in contaminated sediments over time as a result of natural processes such as biodegradation, burial, or dilution. A remedy including MNR typically includes site-specific monitoring to assess whether risks are being reduced as expected, and assessment of progress toward attainment of long-term cleanup levels and RAOs. As with any risk-reduction approach that takes a period of time to reach remediation goals, remedies that include MNR frequently rely upon institutional controls, such as fish consumption advisories, to control human exposure during the recovery period (OSWER 2006).

Natural recovery processes are active in all areas of the LDW, and are expected to remain an active mechanism that reduces COPC concentrations in surface sediments regardless of the remedial alternative that is ultimately selected. The rates of natural recovery are expected to vary significantly by location, as indicated by the varying sedimentation rates and erosion potentials in Table 2-5. The FS will include a more detailed analysis of natural recovery processes using a predictive tool to formulate alternatives that explicitly include MNR or ENR as a component. The FS will also provide estimates of post-cleanup SWAC reductions that will be expected to occur over time throughout the LDW as a result of the ongoing natural recovery processes. These site-wide SWAC reductions over time may be an important part of attaining the long-term RAOs for the LDW.

MNR in the LDW may be most effective in areas with high to intermediate net deposition rates. Biodegradation of PCBs and metals is not anticipated to be a significant contributing mechanism to natural attenuation; burial is expected to be the principal attenuation mechanism for these chemicals. Biodegradation may be a significant process for certain other COPCs.

4.2.3 Enhanced Natural Recovery

ENR builds upon the natural mechanisms of recovery through application of thin layers of clean material to provide a faster restoration time frame over what is possible by MNR alone (OSWER 2006). Natural resorting or bioturbation (i.e., mixing of surface sediment layers through the action of benthic or sediment-dwelling organisms, or through the action of propwash) mixes contaminated and clean sediment layers, resulting over time in a surface layer with chemical concentrations below levels that pose unacceptable risks. ENR can also be applied following sediment removal (e.g., dredging) to manage low levels of residual contamination. As with MNR, an ENR component of an alternative requires long-term monitoring.

As with MNR, the FS will define areas of the LDW that are amenable to ENR based primarily on sediment transport and sediment chemistry data. ENR can be applied to all areas where natural recovery processes are occurring.

4.2.4 Containment

The CTM (RETEC 2005b) evaluated and retained *in situ* capping as a containment remedial technology that is both effective and implementable in the LDW. Capping is a well-developed and documented cleanup technology that isolates contaminants from the overlying water column and prevents direct contact with aquatic biota. Depending on the contaminants and sediment conditions present, a cap is generally designed to reduce risks through the following primary mechanisms: (1) physical isolation of the contaminated sediment sufficient to reduce exposure through direct contact, and to reduce the ability of burrowing organisms to move contaminants to the cap surface, (2) stabilization of contaminated sediment and erosion protection of sediment and cap sufficient to reduce resuspension and transport of contaminants into the water column, and (3) chemical isolation of contaminated sediment sufficient to reduce exposure from dissolved contaminants that may be transported into the water column (OSWER 2006).

Capping is considered both implementable and effective for areas containing contaminated sediments in portions of the LDW where navigation or other public uses would not be physically impeded. If capping is part of the selected remedy for the LDW, bathymetric, hydrodynamic, slope stability, and biological conditions, as well as commercial/public land use, would all be considered during the remedial design phase. At that time, detailed cap design would include material types, gradation, thickness, armoring requirements, design elevation ranges, placement technique, and other design parameters. For example, the cap design for deep depositional waters would be different from designs for intertidal and shallow subtidal areas of high habitat importance and potential episodic erosion events.

For the purposes of developing and evaluating remedial alternatives in this PSA, the sand and armored cap process options are selected to represent the technology as a whole. Sand caps may be applied to net depositional areas and armored caps may be applied to areas within the LDW subject to potential episodic erosion events. Given the existing information on the types and concentrations of contaminants, specialized composite caps or reactive caps are not anticipated to be needed. Additional refinements in cap type and application areas will likely arise in the FS where, at that time, recommendations may be made to evaluate the potential need for reactive or composite cap elements in the design phase.

Any alternative involving capping will include a site-specific erosion analysis during the design phase to determine appropriate armoring requirements, if any. An analysis of the potential for propeller wash, outfall scour, ship wakes, high-flow events, etc., on a localized scale is beyond the scope of this PSA, but will be considered later in the design process for individual SMAs.

Both sand caps and armored caps are effective, implementable, cost-effective, and well-established technologies in the Puget Sound region. The two cap types are commonly used in conjunction, as appropriate, to address different conditions within a given cleanup site. The two cap types have similar overall costs. For the purposes of assembling and evaluating alternatives in this PSA, the distinction between these two cap types is not relevant to the overall analysis. The appropriate mix of these two cap types would be determined during design.

Sediment caps (i.e., caps constructed using sediment from a clean, in-water source) may also be considered as an alternative process option during the design phase. Clean sandy sediment is routinely dredged by USACE from the LDW upper turning basin, as well as from other regional federally-maintained navigation projects (e.g., the Snohomish River). Other regional permitted projects also generate clean sandy material. This clean material has been used at a number of capping projects in the Puget Sound region and can be a cost-effective means of capping or ENR while beneficially using this resource. The FS will include additional analysis of the potential for use of this material in cap or ENR design. Final determinations for this use would occur during the design phase.

4.2.5 Removal

Dredging is the removal of sediment in the presence of overlying water (subtidal and intertidal) using mechanical or hydraulic removal techniques operating from a barge or other floating device. The CTM (RETEC 2005b) provided a detailed discussion of dredging equipment and operational practices. In addition, the CTM reviewed the extensive experience-base of dredging in both the LDW and the greater Puget Sound region.

The CTM (RETEC 2005b) retained both mechanical and hydraulic dredging as effective technologies for removal of contaminated sediment in the LDW. Ultimately, selection of the specific process option for use in removal actions within the LDW will hinge on:

- Implementability considerations
- Performance standards established for removal
- Post-removal handling, dewatering, transport, and disposal
- Costs.

Mechanical dredging and conventional excavation are the representative process options in this PSA. This does not preclude a detailed evaluation of hydraulic dredging in the FS or remedy design. Development of a hydraulic dredging alternative would require the siting, permitting, and development of a processing site for holding and dewatering the dredged sediments, treating process water before discharge, and transferring of dewatered solids to a disposal facility. Development of a processing site would incur costs and pose implementability concerns, particularly in the management and treatment of large volumes of decant water containing PCBs and other COPCs. Land availability for such a processing site may be limited.

Conventional excavation was retained in the CTM (RETEC 2005b) as an effective and implementable removal technology. Excavation would be accomplished with typical earthmoving equipment and would generally occur when the tide is out. Excavation would generally be used on embankments and shallow intertidal areas.

In some cases, the ability to work completely in the dry would be limited by the practical ability to time the available low tides within the construction window. The design may identify certain areas where excavation in the dry is required. In other areas, working in the dry would not be an absolute requirement but would be identified as a preferred method to be implemented as practicable.

While excavation may serve as a component of removal-based remedial alternatives for certain shallow bench areas of the LDW, it is not applicable to deeper areas. For purposes of developing costs in this PSA, mechanical dredging in the wet is used as the representative process option. However, excavation is acknowledged to be a viable alternative to mechanical dredging for site-specific areas.

4.2.6 Treatment Technologies

The CTM (RETEC 2005b) provided a detailed evaluation of individual treatment technologies and their potential applicability to the LDW. The CTM also reviewed the extensive regulatory and industry efforts in

Washington State and elsewhere to determine the viability of treatment in the context of centralized sediment management facilities.

To date, sediment treatment options have been shown to be more costly than available upland disposal alternatives in this region (USACE et al. 1999). Furthermore, treatment is disadvantaged by the lack of demonstrated beneficial uses for the treated sediments. Nevertheless, continued development and improvement of treatment technologies may ultimately advance the cost/benefit value of treatment to a level of acceptability for contaminated sediments.

Table 4-1 summarizes the range of treatment options retained in the CTM (RETEC 2005b) as potentially applicable to the LDW. These include conventional soil washing/particle separation, advanced soil washing, solidification, thermal desorption, and incineration. Conventional soil washing/particle separation was retained as the representative treatment process option because it has been applied at other contaminated sites in the US and Europe and may result in a sand fraction suitable for beneficial use in the LDW.

Soil Washing

Soil washing uses conventional and readily available material handling process elements to separate sediment into fractions according to their particle size or density. The separation is accomplished by screening, gravity settling, floatation, or hydraulic classification, using devices such as hydrocyclones (USACE-DOER 2000). Water treatment would need to be included as part of any washing alternative and would require filtration and treatment with activated charcoal before discharge to either the sanitary sewer (if there is capacity) or directly to the LDW. For the purposes of this PSA, the treated water is presumed to meet the discharge requirements for a National Pollutant Discharge Elimination System (NPDES) permit and to be suitable for discharge directly back into the LDW.

Biogenesis™ is an emerging advanced soil washing process that recently completed a full-scale demonstration in NJ involving approximately 15,000 cubic yards of contaminated sediments from the Passaic River. A report detailing the performance of the process is expected in 2006. The process requires relatively large throughputs and long-term guarantees of sediment volumes to be commercially viable (Stern 2006).

The Biogenesis™ process includes the physical separation aspects of conventional soil washing as well as a proprietary approach that uses high pressure, chemical oxidants, and chelating agents to remove organic compounds and metals adsorbed to the sediment. The process may destroy some portion of the organic compounds, but generates additional wastewater and does not destroy metals.

Sediments in portions of the LDW appear to be sufficiently granular to consider soil washing as a potentially viable treatment. One vendor has indicated that soil washing has the potential to be economical where the sediment contains greater than 30 percent sand (Boskalis-Dolman 2006). When the sediment contains less than 30 percent sand, treatment performance and economics deteriorate. Factors affecting the relative economics for on-site treatment include:

- Percent of sand fraction in dredged material
- Value of treated sand fraction for beneficial use
- Contaminant types and equipment ability to separate chemicals
- Costs associated with locating a treatment facility and other logistics (land availability, transloading access, etc.)
- Treatment and waste disposal costs
- Ability to ensure use of treatment capacity (steady waste stream).

For preliminary cost evaluation purposes in this PSA, the use of soil washing assumes conventional physical separation. This does not preclude the evaluation of Biogenesis™ at later stages in this project. It is assumed that a washed and retained sand fraction could meet the regulatory criteria for in-water placement (e.g., open water disposal criteria or the SQS) and could have a beneficial use in capping, ENR, or habitat creation options in the LDW. The finer fractions (containing the majority of the contaminants) would then be dewatered, transported, and disposed of in a permitted upland landfill. In this way, the treatment would reduce the volume of solid waste, but would not reduce the toxicity or mobility of the contaminants. Also, wastewater from the process would require treatment and disposal.

These factors are initially explored in this PSA and will be further defined in the FS.

Solidification

Solidification is a proven and effective technology for reducing the moisture content of dredged sediments and for reducing the leachability (mobility) of metals. Contaminants are not destroyed by solidification. Solidification is not carried forward for alternative development in this PSA, but may be considered further in the design phase if water reduction methods are needed.

Thermal Treatment

Thermal treatment is potentially effective for destroying a broad range of organic compounds. Thermal destruction and/or desorption and combustion is potentially implementable for sediments, but would require facilities for dewatering and managing sediments, and either transport to out-of-state facilities (incineration) or a constructed off-site facility. Mobile high- and low-temperature thermal desorption units are available, but would require obtaining local use permits. The treated sediment may not meet the requirements for beneficial use (structurally unaltered sediments and COPCs below SMS chemical criteria), and may thus still require landfill disposal. Thermal treatment is not carried forward in this PSA.

4.2.7 Disposal of Contaminated Sediments

The CTM (RETEC 2005b) identified several on-site and off-site disposal options for dredged contaminated sediment. The following disposal options were retained in the CTM for further consideration:

- On-site disposal
  - Contained aquatic disposal (CAD)
  - Confined disposal facility (CDF)
  - New on-site landfill (within LDW Superfund site boundaries)
- Off-site disposal
  - Existing Subtitle C landfill
  - Existing Subtitle D landfill
  - Open-water disposal at a Dredged Material Management Program (DMMP) site.

The first two disposal options are for in-water or near-shore disposal, whereas the three landfill options represent upland disposal. All disposal alternatives have demonstrated effectiveness and implementability in the Puget Sound region and are compared and contrasted in Table 4-2.

On-Site Disposal Process Options

An on-site, in-water, contained aquatic disposal alternative is selected as the representative on-site disposal option for further evaluation in this PSA. Although somewhat limited by space (volume) considerations, CAD cells could be constructed within the LDW navigation channel, provided that the cells are constructed with a final surface below the authorized navigation depth. The federally authorized navigation channel is a legal covenant that requires maintenance of a specified depth; alternatives within the channel cannot decrease the channel depth. Other potential CAD locations outside the navigation channel may be identified in the FS.

Although not evaluated or costed in this PSA, a nearshore CAD or CDF site, or an upland landfill (within the project boundaries) are also potentially viable options for LDW dredged material. These disposal options are considered to be less implementable than an in-water CAD because of land availability and ownership considerations, and the need for mitigation for any lost aquatic habitat. These disposal options may be evaluated in the FS or remedy design phase of the project.

Off-Site Disposal Process Options

For off-site disposal, an existing permitted Subtitle D Landfill was selected as a representative process option for alternatives that involve sediment removal. As documented in the CTM (RETEC 2005b), sediments in the LDW are not expected to exceed concentrations of COPCs that would require disposal in a Subtitle C landfill. Subtitle C disposal will not be developed into a remedial alternative in this PSA, but could be considered if needed during the design phase (e.g., for localized hot spots or other wastes such as treated pilings). Subtitle D landfills have been effectively used for the majority of contaminated sediment projects in the Puget Sound region, including several projects in the LDW.

LDW sediments would likely require treatment to applicable DMMP standards before placement in an open-water disposal site. The clean sand fraction from conventional soil washing may meet these standards. DMMP disposal may be considered in the design phase as a disposal option for treated material or material that meets applicable standards.

4.2.8 Beneficial Use (Following Treatment)

Potential beneficial in-water uses of dredged and treated sediment are as:

- Cap material (for capping or ENR of contaminated sediment)
- Habitat restoration or grade restoration.

Each of these potential in-water applications will have associated material specifications to ensure an appropriate match between material properties and functionality in the aquatic environment. For this PSA, it is assumed that the clean sands resulting from soil washing/separation processes may be suitable for beneficial use in the LDW, provided they meet DMMP and SMS chemical criteria. The clean sands could potentially be used as cap or ENR material, or in habitat restoration. The latter could include creating areas of shallower water, or fill and cover for certain dredge prisms to restore bathymetry to pre-removal contours.

Treated dredged material may also have potential use as upland construction fill. Beneficial upland use may be a viable end-point for treated sediment if an upland fill project is identified that coincides with remediation. Currently, there are no upland beneficial use opportunities identified. Upland beneficial use may therefore be considered in the design phase as an alternative to on-site uses. However, upland beneficial use would require resolution of potential administrative and liability issues.

4.2.9 Summary of Representative Process Options

The representative process options used in developing remedial alternatives and preliminary cost estimates for this PSA are:

- Institutional controls
- MNR
- ENR
- Mechanical dredging (with excavation as appropriate)
- *In situ* capping (sand and armored caps)
- Off-site, upland Subtitle D landfill disposal
- On-site, in-water CAD disposal
- Conventional soil washing/particle separation (Standard waste-water treatment processes [e.g., filtration, carbon adsorption] would also be required as ancillary technologies to the soil washing/separation process option.)
- Beneficial use of sand/gravel fraction from soil washing (return to LDW as capping or habitat enhancement material).

4.3 Conceptual Design Conditions for the LDW

"Conceptual design conditions" refers to the specific physical, chemical, hydrologic, land/water use, and habitat conditions described in Sections 2 and 3 that control the configuration of a remedial alternative. For this PSA, alternatives were assembled primarily on the basis of total PCB distribution, the CSM from the draft *Sediment Transport Analysis Report* (Windward and QEA 2006), bathymetry, and general habitat considerations. After remedy selection in the ROD, the selected remedial alternative will be implemented with detailed site-specific designs.

The following factors were not considered in this PSA, but will be considered in greater detail when developing and evaluating alternatives in the FS: (1) location and handling of debris and pilings; (2) sediment management beneath over-water structures such as docks and piers; (3) location of underwater cables, gas pipes, and sewage/storm water transfer lines; and (4) the explicit consideration of known and important habitat and recreational use areas within the LDW. These factors could significantly increase estimated costs for alternatives involving removal or capping. Other factors, such as site-specific erosion analyses or dredge prism configuration, would be developed in the design phase.

This section defines the design conditions that control the assembly and implementation of specific remedial alternatives. These design conditions are assumed only for this PSA, and may be subject to further refinement in the FS work plan and in the final FS. Assembled alternatives are described in Section 4.4.

4.3.1 Physical Design Conditions

Physical design conditions include bathymetric and grain size considerations. The following assumptions are used for this PSA based on physical design conditions (see Figure 4-1):

- Intertidal and shallow bench areas of the LDW are defined as those areas shallower than -9 ft MLLW. It is assumed that removal and capping would generally be implemented using barge-mounted mechanical dredging or excavation equipment. However, in some locations, land-based equipment could be used for construction in shallow intertidal areas during low tide conditions, where practicable. These areas will be restored to grade after sediment removal.

- It is assumed that capping will not be implemented in shallow bench areas without first removing an equivalent volume/area/depth of contaminated sediments. Application of a 3-ft isolation cap may not be appropriate in areas where changes in the bottom elevation would impinge on current industrial (e.g., navigation) or habitat quality (e.g., for benthic infauna, resident and transient fish). Although not considered in this document, alternative cap designs may be considered in intertidal areas without pre-dredging on a localized scale. In the design phase, dredging and capping designs would be developed on a site-specific basis and would consider net changes to habitat conditions.

- Sediment washing/separation is assumed to be practicable only for sediments with a particle size distribution of at least 30 percent sand. This assumption will be refined in the FS.

- Costs for debris sweeps are assumed to be required for all removal areas.

- Localized presence of piers, piling, bulkheads, overhead utilities, bridges, cable crossings, and other structures are not considered in this PSA, but will be evaluated in design.

- For the purposes of this PSA, volume calculations have been increased by 30 percent for the relatively small AOIs with total PCB concentrations greater than 36 mg/kg OC and increased by 10 percent for the larger areas greater than 24 and 12 mg/kg OC to account for such variations as overdredging, intertidal embankments, side slopes, and dredge area configuration. There was no volume correction factor applied to the interpolated areas with total PCB concentrations greater than 6 mg/kg OC.

4.3.2 Natural Recovery

Natural recovery processes are active in all areas of the LDW, and are expected to remain an active mechanism that reduces COPC concentrations in surface sediments regardless of the remedial alternative that is ultimately selected. The rates of natural recovery are expected to vary significantly by location, as indicated by the varying sedimentation rates and erosion potentials discussed in the draft *Sediment Transport Analysis Report* (Windward and QEA 2006).

The effectiveness of natural recovery processes in reducing surface COPC concentrations, both locally and in the LDW as a whole, will be evaluated in the FS. For the purposes of this PSA, natural recovery is assumed to be a component of all remedial alternatives, but not a stand-alone alternative.

For the purposes of this PSA, ENR is applicable throughout the intertidal and subtidal benches, as well as downstream of RM 2.0 in the navigation channel. ENR is assumed to not be applicable in the navigation channel upstream of RM 2.0, as anticipated future dredging may limit the long-term effectiveness of ENR in these areas. For the purposes of this PSA, ENR is considered to be a component of removal and capping alternatives, but not as a stand-alone alternative.

4.3.3 Use, Habitat, and Water Depth Considerations

The general remedial approaches were also screened by consideration of human uses of the waterway, habitat, and water depth:

- The navigation channel requires maintenance of a specified depth; alternatives within the channel cannot result in a decrease (shallowing) of the federally authorized channel depth.

- For the purposes of this PSA, it is assumed that any dredging in the navigation channel would be designed to expose a clean surface and no capping in the navigation channel is assumed. For simplicity, a constant removal depth of 6 ft. was applied. Once the Phase 2 subsurface data have been analyzed, the depth assumptions will be re-evaluated and will include a “dredge to clean alternative”. This assumption will then be refined in the FS.

- Any CAD alternative in the navigational channel would require a finished surface to be at least 4 ft below the authorized navigation channel. This allows for at least a 2-ft buffer below the USACE’s maximum pay depth for dredging in the navigation channel (2 ft overdredge). This limit would apply to the top of an isolation cap or armor barrier placed above the CAD cell.

- Habitat for benthic infauna and fish species must be considered at locations with depths shallower than -9 ft MLLW (shallow bench). Within this zone, a net change in bed elevation (increase or decrease) may be either beneficial or detrimental to the fish species using the habitat. A site-specific analysis of habitat needs and design configurations may be needed in the detailed remedial designs for individual SMAs. For the purposes of this PSA, cleanup actions in these areas are assumed to be configured to generally result in no net change to the bottom contours. That is, an alternative with a dredging emphasis would require backfilling/ capping in shallow bench areas, and an alternative with a capping emphasis would first require dredging in these areas. For this PSA, it was assumed that there would be a 3-ft removal in the shallow bench areas requiring dredging, followed by restoration to grade with 3 ft of clean sand.

4.4 Assembly of Site-Specific Remedial Alternatives

Site-specific remedial alternatives are assembled for the LDW based upon consideration of the sponsored EAAs, the PPAs, and the AOIs identified in Section 3, with the design considerations listed above. A No Further Action alternative (Alternative A) is included as required by the NCP in this PSA, and assumes No Further Action for the rest of the LDW after completion of the cleanup of the sponsored Early Action Areas.

Five sets of general alternatives (B through F) are assembled around the following elements:

- Completion of the sponsored EAAs (underway)

- Active remediation of the PPAs

- Active remediation of AOIs, with each alternative developed at various multiples of the SQS (and CSL) for total PCBs (65, 36, 24, 12, and 6 mg/kg OC).

Finally, a single combined alternative (Alternative G) that incorporates elements of different assembled alternatives and different total PCB SQS multiples with specific waterway uses is presented for discussion. These remedial alternatives are described below and summarized in Tables 4-3 and 4-4. Section 5 evaluates the implementability, effectiveness, and cost of each of the remedial alternatives.

4.4.1 Common Elements

Each of the following remedial alternatives contain characteristic elements common to all alternatives. Description of these common elements is presented to avoid unnecessary repetition in future sections.

Natural recovery is considered to be an ongoing process in the waterway. This process varies greatly throughout the waterway as a result of differences in bathymetry, depositional processes, potential for episodic erosional events, etc. Natural recovery processes (or "natural attenuation processes") are therefore assumed to carry a site-wide role in the long-term attainment of LDW RAOs. Variations in the natural attenuation processes presently prohibit the evaluation of long-term reductions in SWAC (associated with the MNR component). The development of natural recovery models in the FS will address this issue in greater detail.

In-water work within the LDW is limited to certain time windows. These windows are driven by a multitude of environmental factors (e.g., timing of salmon migrations). For the purposes of this PSA, it is assumed that all in-water work will be performed on a seasonal basis from approximately October 1 to February 14. Furthermore, Native American tribal fishing rights from October to December must be accommodated by any remedial activities.

For the purposes of this PSA, all contaminated material to be disposed of in an off-site upland disposal facility is assumed to go through a transloading facility located on or near the LDW. Currently, no commercial facilities are located on the waterway. The former transloading facility located at Terminal 25 is no longer operational. The design for any alternative will include identification of transloading facilities. Transloading costs are estimated based on previous costs experienced at Terminal 25.

Long-term monitoring is assumed to occur in all remedial alternatives presented in this PSA, for attainment of long-term cleanup objectives for the LDW as a whole. Details will vary somewhat by alternative and reach but are assumed to be similar. For this reason, site-wide long-term monitoring costs are not established in this PSA.

In contrast, certain incremental monitoring costs are associated with containment capping and ENR; these incremental costs are evaluated because they vary according to alternative and hypothetical total PCB RAL. These incremental monitoring costs are based on acreage of the areas with ENR or capping.

Institutional controls are assumed to be an essential component of all remedial alternatives discussed in this PSA. These may include, but are not limited to, fish consumption advisories, water use restrictions, or deed restrictions. In addition to institutional controls, there will be periodic reviews to determine the ongoing effectiveness of any remedial actions. These reviews will help determine the ongoing course of action and any additional remedial actions necessary to achieve long-term RAOs. These costs are not included in this PSA and are assumed to be constant between all of the alternatives.

The alternatives described below are summarized in Table 4-4.

4.4.2 Alternative A: No Further Action

The No Action approach is defined for the FS as completion of the sponsored EAAs already underway, with no further remedial action undertaken. The No Action Alternative is required by the NCP for comparison purposes and will be carried forward into the FS.

4.4.3 Alternative B: Dredge with Upland Disposal

Alternative B emphasizes removal and off-site disposal, with minimal use of capping or natural recovery processes to attain the RAOs. This alternative includes the following elements:

- Completion of the sponsored EAAs.
- For all PPAs, dredging of shallow bench areas (<-9 ft MLLW) to a depth of 3 ft followed by capping to restore original grades (assume 3 ft for containment of subsurface material left in-place), and dredging to a depth of 6 ft in the remaining deeper bench areas; the dredged material from all PPAs is assumed to go to upland disposal. The assumptions related to the depth of dredging have been kept constant among all alternatives for comparative purposes. Once the Phase 2 subsurface data have been analyzed, the depth assumptions will be re-evaluated and will include a "dredge to clean alternative".
- Removal with upland disposal for the AOIs for five scenarios

where the total PCB concentration exceeds 65 mg/kg OC (Alternative B1), 36 mg/kg OC (Alternative B2), 24 mg/kg OC (Alternative B3), 12 mg/kg OC (Alternative B4), or 6 mg/kg OC (Alternative B5).

- For each AOI, dredging of shallow bench areas (<-9 ft MLLW) to a depth of 3 ft followed by capping to restore original grades, and dredging to a depth of 6 ft in the remaining deeper bench areas and the navigation channel.

- For all capping, a nominal 3-ft thickness is assumed and armoring requirements would be determined on a site-specific basis in the design phase.

- Long-term compliance monitoring, including MNR, institutional controls, and periodic reviews (although costs are not included).

Upland disposal of dredged sediments has been demonstrated to be effective and implementable in other remedial projects in the Puget Sound region, and provides a basis of comparison for other treatment and disposal options. Alternative B includes mechanical dredging, barge transport to an offloading/transfer facility within or near the LDW, and transport of wet sediments by railcars to one of the two Subtitle D landfills in eastern Washington or Oregon. Detailed assumptions of this alternative are provided in Appendix C.

For the AOIs, Alternative B is developed for each of the five multiples of the total PCB SQS (and the CSL): 65 mg/kg OC (B1), 36 mg/kg OC (B2), 24 mg/kg OC (B3), 12 mg/kg OC (B4), and 6 mg/kg OC (B5). For each alternative, the areal extent of total PCBs exceeding the SQS multiple is calculated from the PCB distribution maps. Additional assumptions built into the removal component of this alternative include the following (Figure 4-1):

- Shallow bench area (less than -9 ft MLLW) would be managed by dredging or excavation. Because of the value of shallow water habitat to fish, such as juvenile salmonids and crustaceans, approximate restoration to the original grade is assumed. Removal of 3 ft of contaminated sediment, followed by placement of 3 ft of clean cap material (e.g., sand, gravel, rock) serves to both remove and cap contaminated sediments and restore the habitat to original grade.

- Subtidal bench areas between -9 ft MLLW and the navigation channel are not considered to have habitat value that would require grade restoration. As presented in Section 2.3.2, the depth of dredging is assumed to be 6 ft below current grade, and residual management is assumed by placement of a 6-in sand layer over the dredge prism post-removal.

- The navigation channel is dredged to a presumed depth of 6 ft below current grade to remove contaminated sediments. Residual management is assumed by placement of a 6-in sand layer over the dredge prism post-removal.

- The vertical extent of contaminated sediments will be further addressed in appropriate site-specific detail in the FS when subsurface core data are available.

It is noted that removal of contaminated sediment from the LDW without backfilling may not be acceptable to the Native American tribes who are concerned that depressions remaining in the waterway bottom after remedy completion may adversely affect salmon movement upstream. This issue would be further addressed during design.

Sediments would be transported by barge (dredged sediments) or truck (excavated sediments) to a shore-side sediment transloading facility for dewatering, as needed, and loaded onto rail cars for transport to an upland Subtitle D landfill (e.g., Regional Disposal Company in Roosevelt, Washington). Water recovered from dredged sediments would be treated, and it is assumed that the treated water would be sufficiently clean to be discharged under an NPDES permit at the transloading facility. For costing purposes, the onshore water treatment system consists of several Baker tanks for primary sedimentation of solids, coagulant-aided secondary flocculent settling of remaining suspended solids, and filtration/adsorption (i.e., sand, mixed media, activated carbon) to meet water quality requirements.

As an optional upland disposal process option, parties performing cleanups could elect to identify and design an on-site upland disposal facility during remedy design for local disposal of dredged material. Evaluation of such a disposal option would be considered in the design phase and would require agency approval.

Grade restoration via cap placement would likely be accomplished using a clamshell bucket from a barge. For costing purposes, the capping material is assumed to be purchased off-site and barged to the LDW. A 3-ft cap is assumed to be adequate for chemical isolation. Alternatively, thicker caps may be designed to higher elevation grades during remedy design in areas designated for habitat enhancement. All cap design specifics would be determined in the design phase.

After completion of the removal actions, this alternative is considered complete. ENR is not included in this alternative for areas that are not dredged, although natural recovery processes would continue to occur and would be expected to decrease surface sediment concentrations of COPCs over time.

Institutional controls (e.g., fish consumption advisories) are assumed to remain in-place. A 30-year monitoring program that includes sediment and fish tissue sampling after completion of the active remedy, and thereafter every 5 years is assumed for this alternative, but the costs are not included in this PSA analysis because the administrative and monitoring costs would be similar for all the alternatives.

4.4.4 Alternative C: Dredge with Upland Disposal, ENR, and MNR

Alternative C is similar to Alternative B for the sponsored EAAs and PPAs, but also includes a combination of removal ENR and MNR as components of the remedy in the AOIs. Under Alternative C, ENR is used in concert with removal and is generally used to manage areas with lower PCB concentrations. ENR is employed in the bench areas and the navigation channel downstream of RM 2.0, as described below. In summary, Alternative C includes:

- Completion of the sponsored EAAs
- For all PPAs, dredging of shallow bench areas (<-9 ft MLLW) to a depth of 3 ft followed by capping to restore original grades, and dredging to a depth of 6 ft in the remaining deeper bench areas; the dredged material from all PPAs is assumed to go to upland disposal.
- Removal with upland disposal combined with ENR for the AOIs for five scenarios where the total PCB concentration exceeds 36 mg/kg OC (Alternative C1), 24 mg/kg OC (Alternative C2), 12 mg/kg OC (Alternative C3), or 6 mg/kg OC (Alternative C4)
- For each AOI, dredging of shallow bench areas (<-9 ft MLLW) to a depth of 3 ft followed by capping to restore original grades, and dredging to a depth of 6 ft in the remaining deeper bench areas and the navigation channel
- For all capping, a nominal 3-ft thickness is assumed, and armoring requirements would be determined on a site-specific basis in the design phase.
- MNR, ENR, long-term compliance monitoring, institutional controls, and periodic reviews.

All versions of Alternative C include managing the sponsored EAAs and PPAs as described in Alternative B. The specific combinations of dredging and ENR are described below for each of the variants of Alternative C:

1) **Alternative C-1: Active Cleanup for AOIs with total PCB concentrations >36 mg/kg OC.** Alternative C1 uses a combination of dredging and ENR to manage areas that have total PCB concentrations >36 mg/kg OC. Specifically, areas in the navigation channel upstream of RM 2.0 that have total PCB concentrations >36 mg/kg OC are dredged with upland disposal. ENR is applied to all bench areas upstream of RM 2.0 that have total PCB concentrations >36 mg/kg OC. Downstream of RM 2.0, sediments in both the navigation channel and the benches that have total PCB concentrations >65 mg/kg OC are removed with upland disposal. ENR is applied to both the bench areas and navigation channel downstream of RM 2.0 where total PCB concentrations are >36 mg/kg OC.

2) **Alternative C-2: Active Cleanup for AOIs with total PCB concentrations >24 mg/kg OC.** Alternative C2 uses a combination of dredging and ENR to manage areas that have total PCB concentrations >24 mg/kg OC. Alternative C2 includes removal (with upland disposal) of all areas with total PCB concentrations >36 mg/kg OC as described in Alternative B2, and removal (with upland disposal) of the areas in the navigation channel upstream of RM 2.0 with total PCB concentrations >24 mg/kg OC. ENR is applied to all remaining areas in the waterway (in both the navigation channel and the benches) where total PCB concentrations are >24 mg/kg OC.

3) **Alternative C3: Active Cleanup for AOIs with total PCB concentrations >12 mg/kg OC.** Alternative C3 uses a combination of dredging and ENR to manage areas that have total PCB concentrations >12 mg/kg OC. Alternative C3 includes removal (with upland disposal) of all areas with total PCB concentrations >24 mg/kg OC as described in Alternative B3, and removal (with upland disposal) of the areas in the navigation channel upstream of RM 2.0 with total PCB concentrations >12 mg/kg OC. ENR is applied to all remaining areas in the waterway (in both the navigation channel and the benches) where total PCB concentrations are >12 mg/kg OC.

4) **Alternative C4: Active Cleanup for AOIs with total PCB concentrations > 6 mg/kg OC.** Alternative C4 uses a combination of dredging and ENR to manage areas that have total PCB concentrations >6 mg/kg OC. Alternative C4 includes removal

(with upland disposal) of all areas with total PCB concentrations >12 mg/kg OC as described in Alternative B4, and removal (with upland disposal) of the areas in the navigation channel upstream of RM 2.0 with total PCB concentrations >6 mg/kg OC total PCBs. ENR is applied to all remaining areas in the waterway (in both the navigation channel and the benches) where total PCB concentrations are >6 mg/kg OC.

MNR is a component of Alternative C in all areas not actively remediated by dredging, capping, or ENR. MNR will be monitored site-wide for long-term progress toward attaining the LDW RAOs (yet to be determined). MNR is expected to take several years to reduce surface concentrations of COPCs. The expected performance of MNR will be evaluated in the FS. Institutional controls (e.g., fish consumption advisories) are assumed to remain in place. A 30-year monitoring program that may likely include sediment and fish tissue sampling after completion of the active remedy, and thereafter every 5 years, is assumed for this alternative, but the costs are not included because the administrative and monitoring costs are components of all the alternatives.

For this alternative and all alternatives with MNR/ENR components, initial reductions in SWACs as a result of the active cleanup are presented in Section 5 for Time 0, immediately following remedy completion. Longer-term reductions in SWAC (associated with the MNR component) are not evaluated in this PSA but will be estimated in the FS.

4.4.5 Alternative D: Dredge with On-Site CAD Disposal

This alternative includes the remedy elements described for Alternative C as well as:

- Completing the sponsored EAAs
- Constructing one or more in-water disposal cells within the LDW, for CAD of dredged and excavated material; clean material dredged from the CAD excavations would be beneficially used for capping and ENR where practicable.
- Capping shallow bench areas of the PPAs and AOIs following excavation and dredging (For all capping, a nominal 3-ft thickness is assumed, and armoring requirements will be determined on a site-specific basis in the design phase.)
- MNR, ENR, long-term compliance monitoring and institutional controls would be applied as described for Alternative C; areas that are not dredged would be subject to ENR and MNR, as described

in Alternative C.

Removal assumptions are the same as those described for Alternative B. An on-site CAD disposal alternative was included because it has been demonstrated to be effective, implementable and cost-effective in other remediation projects in the Puget Sound region. Detailed assumptions associated with this alternative are provided in Appendix C.

Transportation of dredged material is different from Alternative B. Assumptions built into the removal component of this alternative include those described for Alternative B, but include barge transport of the dredged sediments to the CAD site(s), and offloading of the material from the barge into the CAD cell by bottom-dump placement.

This alternative assumes that up to four similar size CAD cells can be constructed within the upper navigation channel between RM 4.1 and 4.5, and one larger cell in the upper turning basin at RM 4.6 (Figure 4-2). For the purposes of this PSA, the CAD cell design is laid out as multiple individual cells, as opposed to a single larger cell, so that a cell can be constructed, filled with contaminated dredged sediments, and closed within a single dredge window. This approach would also minimize the natural infilling of the CAD cells that would occur if they were left open in this highly depositional area.

Other locations for the CAD cells within the LDW could be explored in the FS or design phase, if this alternative is carried forward for further analysis. For example, a deep water area outside the navigation channel near RM 0.2 may be a suitable location.

For the purposes of this PSA, it is assumed that CAD cells between RM 4.1 and 4.5 would have a surface footprint of 200 ft x 500 ft and would be dredged with a 3:1 side slope to a bottom elevation of -42 ft MLLW, or 27 ft below the authorized depth of the navigation channel (-15 ft MLLW). The dredged material from the CAD cell is assumed to meet the DMMP open-water disposal criteria and the SMS, and would be suitable for beneficial use within the LDW or disposal at the open-water dredged material disposal site in Elliott Bay. During the dredging of each CAD cell, an estimated 9,000 cy of clean dredged material would be stockpiled for use as isolation cap material. Additional clean material may be used for capping and/or ENR within the LDW. Each cell would be constructed to receive an estimated 31,000 cy of contaminated dredged sediments to an elevation no higher than -22 ft MLLW, or 7 ft below the authorized navigation channel depth. Each cell would then be capped with 3 ft of isolation cap (clean material excavated during construction of the cell) and then covered with 2 ft of appropriately sized rock for armoring (6,500 cy). Under the weight of the capping material, consolidation of the underlying dredged sediment is expected, such that the final surface of each CAD cell could be 2.5 – 4 ft below the authorized navigation depth. The final surface of each CAD cell would be expected to be a minimum of 2 ft below the authorized navigation depth. The total volume capacity of these four CAD cells is estimated to be 124,000 cy.

A single larger cell with a surface footprint of 400 ft x 600 ft would be located within the upper turning basin (Figure 4-2). The construction and sequencing would be similar to that described above, with 200,000 cy of clean material from the dredging of the cell being sent to the Elliott Bay disposal site or potentially used as material for capping and ENR, 24,000 cy stockpiled for the isolation cap, and 16,000 cy of armoring material. The larger cell capacity is estimated to be 160,000 cy of contaminated sediments and would only be needed for Alternative D-4, where the volume of sediments > 12 mg/kg OC total PCBs would exceed the CAD capacity. Residual dredge volumes would be disposed of in an upland Subtitle D landfill.

A permanent waterway development and use restriction is assumed for all CAD sites, as well as a long-term maintenance monitoring program. The CAD caps, like all caps, would be maintained as needed in perpetuity, and costs are included for this maintenance monitoring. However, no active maintenance of the CAD caps is expected to be needed.

MNR and ENR are components of this alternative, as described for Alternative C. All MNR/ENR, long-term monitoring, and institutional control assumptions are the same as those applied to Alternative C, with the exception of additional cap monitoring costs associated with the CAD caps.

4.4.6 Alternative E: Dredge and Sediment Washing/Separation with Beneficial Use

This alternative is the same as Alternative C, except that suitable material dredged from the PPAs and AOIs is treated using soil washing in order to recover clean sand. The alternative includes:

- Completion of the sponsored EAAs
- Removal with upland disposal for the PPAs and AOIs where the grain size distribution shows < 30 percent sand
- Removal to a shore-side soil-washing treatment facility for the dredged sediments with ≥ 30 percent sand
- Capping of intertidal and subtidal areas of the AOIs following the excavation and dredging; for all capping, a nominal 3-ft thickness is assumed and armoring requirements would be determined on a site-specific basis in the design phase.

- Beneficial use of clean sand recovered in the treatment process for ENR, capping, or post-dredging grade restoration
- Upland disposal to a Subtitle D landfill of post-treatment residuals (silts and clays)
- MNR, ENR, long-term compliance monitoring and institutional controls would be applied as described for Alternative C; areas that are not dredged would be subject to ENR and MNR, as described in Alternative C.

For the AOIs, remedial alternatives are developed for each multiple of the total PCB SQS: 65-36 mg/kg OC (E1), 24 mg/kg OC (E2), 12 mg/kg OC (E3), and 6 mg/kg OC (E4). For each alternative, the areal extent of total PCBs exceeding multiples of the SQS is calculated from the PCB distribution maps. Removal assumptions are the same as those described for Alternative B.

For the purposes of this PSA, a commercially available soil-washing treatment unit would be located in a facility constructed adjacent to the LDW. The facility would require:

- Berthing access directly on the LDW, with suitable structural features for heavy offloading equipment
- A bermed stockpile and containment area with storage capacity based on one full dredging season (estimated as 165,000 cy) and designed for leachate and precipitation collection and storage
- Water treatment facilities and discharge permits (or meet substantive requirements)
- Suitable utility services
- Offloading derrick and containment apron with front-end loaders, or other heavy equipment for stockpile management
- Rail service for loading contaminated fine sediment fractions into rail cars; alternatively, trucks could haul the fine fractions to a nearby transfer station for rail loading, provided the transfer station has suitable facilities.

Sediments would be transported by barge (dredged) or truck (excavated) to a shore-side sediment handling facility for stockpiling. Material would then be screened to remove oversized material and debris before transfer to holding tanks. The sediment slurry stream would be pumped: (1) initially through a rotating sieve drum to separate and wash the coarse fraction (> 20 mm), (2) through a vibrating shaker screen for separation of the medium to coarse fraction (3–20 mm), (3) then to hydrocyclones and a counter-current washer for the sand fraction, (4) into a pre-thickener/clarifier module to separate the silt/clay from the process water, and (5) to belt presses for mechanical dewatering of the silt/clay fraction.

Soil washing or separation has not been demonstrated in the Puget Sound region, but has been included for potential use and cost comparison. Detailed assumptions associated with this alternative are provided in Appendix C. However, it is worth noting that a key assumption for this alternative is that the percent sands reflected in the surface sediments are representative of the subsurface sediments over the depth of the removal profile. This is a very gross assumption that will not be resolved until after the subsurface cores are analyzed. At this point, it is assumed that 60 percent of dredged or excavated material would have sufficient sand content to potentially be treated.

Another key assumption is that the 30 percent sand cut-off would be applicable to the LDW. This number is representative of the minimum sand fraction required for soil washing at other sites. A more conservative estimate would be 30 to 50 percent sands. However, for the purpose of alternative development, 30 percent is applied here. The sand fraction is assumed to be clean below the DMMP or the SMS chemical and biological criteria, and thus available for beneficial use in capping, ENR, or habitat grade-restoration. The retained filter cake is assumed to contain the contaminant faction, and would be transported off-site for disposal at an upland Subtitle D landfill.

MNR/ENR, long-term monitoring, and institutional controls would be applied, as described in Alternative C.

4.4.7 Alternative F: Cap to the Maximum Extent Practicable

This alternative is the same as Alternative C, except that deep benches (>-9 ft MLLW) are capped rather than dredged. The alternative includes the following elements:

- Completion of the sponsored EAAs
- For the PPAs, shallow bench area removal and capping, subtidal mechanical dredging, and upland disposal
- Mechanical dredging with upland disposal for the AOIs from the navigation channel for four scenarios where the total PCB concentrations exceed 36, 24, 12, and 6 mg/kg OC

- Removal of 3 ft of contaminated sediment in the shallow bench areas (above -9 ft MLLW) in the AOIs, followed by placement of 3 ft of clean capping material to restore the habitat to original grade

- Capping with no removal in areas between -9 ft MLLW and the navigation channel in the AOIs

- For all containment capping, a nominal 3-ft thickness is assumed and armoring requirements would be determined on a site-specific basis in the design phase.

- MNR/ENR, long-term monitoring, and institutional controls would be applied, as described in Alternative C.

4.4.8 Alternative G: Hypothetical Combined Alternative

Alternative G is one example of a combined approach for managing sediments at different RALs, based on river use, habitat, and sediment transport characteristics. Alternative G is presented in this PSA to illustrate an alternative way of focusing appropriate actions on specific areas. It is anticipated that the FS may present other variants of this approach. Alternative G is not intended to illustrate any specific proposed RAL.

This alternative includes the elements described below and shown on Figure 4-3:

- Completion of the sponsored EAAs

- For all PPAs, dredging of shallow bench areas (<-9 ft MLLW) to a depth of 3 ft followed by capping to restore original grades, and dredging to a depth of 6 ft in the remaining deeper bench areas; the dredged material from all PPAs is assumed to go to upland disposal.

- In the AOIs upstream of RM 2.0, dredge navigation channel areas with total PCB concentrations >12 mg/kg OC, followed by upland disposal.

- In the AOIs downstream of RM 2.0, dredge the navigation channel and deep bench areas with total PCB concentrations >65 mg/kg OC, followed by upland disposal.

- ENR applied to all of the shallow bench areas downstream of RM 2.0 with total PCB concentrations >12 mg/kg OC

- Dredge remaining areas upstream of RM 2.0 with total PCB concentrations >24 mg/kg OC, followed by upland disposal; shallow bench areas would be capped to restore the original grade.

The combined alternative uses the same elements as described for Alternative C—dredging with natural recovery with varying RALs and spatial areas. The main distinction between this alternative and those previously described is that this alternative applies a more aggressive sediment management level (24 mg/kg OC total PCBs) upstream of RM 2.0, where navigation dredging is more frequent, and at areas of high public use and valued habitat, and a less aggressive sediment management level in other areas. MNR/ENR, long-term compliance monitoring, and institutional controls would generally be applied, as described in Alternative C.

Table 4-1 Summary of Technologies Retained in the CTM as Potentially Applicable to the LDW

General Response Action	Remedial Technology Type	Process Option
No Action	None	Not Applicable
Institutional Controls	Physical, Engineering or Legislative Restrictions	Fish or Shellfish Consumption Advisories Waterway Use Restrictions Access/Deed Restrictions
Monitored Natural Recovery	Physical Transport	Desorption, Diffusion, Dilution, Volatilization, Resuspension, and Transport
	Chemical and Biological Degradation	Dechlorination or degradation (aerobic and anaerobic)
	Physical Burial Processes	Sedimentation
Enhanced Natural Recovery	Enhanced Physical Burial	Thin-layer sand/sediment placement to augment natural sedimentation rate
Containment	Capping	Conventional Sand Cap Sediment Cap Armored Cap Composite Cap Reactive Cap
Removal	Dredging	Hydraulic Dredging Mechanical Dredging
	Dry Excavation	Excavator (for specific conditions)
Ex Situ Treatment	Chemical/Physical	Conventional soil washing/particle separation Advanced Soil Washing
	Physical	Solidification
	Thermal	Incineration High-Temperature Thermal Desorption Low-Temperature Thermal Desorption
Disposal	On-Site	Contained Aquatic Disposal Confined Disposal Facility On-Site Upland Confined Fill In-Water Beneficial Use
	Off-Site	Existing Subtitle D Upland Landfills Existing Subtitle C or TSCA Landfill Upland Confined Fill (MTCA commercial/industrial) Upland Beneficial Use DMMP Open-Water Disposal

Table 4-2 Selection of Representative Process Options for Development of Remedial Alternatives

General Response Action	Remedial Technology	Process Option	Effectiveness	Implementability	Representative Process Option for GRA and Programmatic PSA Alternative	Comments
No Action	None	Not Applicable	Not expected to meet Remedial Action Objectives	Not expected to comply with Applicable or Relevant and Appropriate Requirements, and thus would not be administratively implementable	• No Further Action	A No Action Alternative (after completion of the EAAs) will be developed in the Feasibility Study in Compliance with CERCLA FS guidance.
Institutional Controls (ICs)	Physical, Engineering or Administrative Restrictions	• Fish or Shellfish Consumption Advisories • Waterway Use Restrictions • Access/Deed Restrictions	ICs reduce risks to humans from exposure to contaminated sediments and fish. In the absence of treatment, containment, or removal, ICs do not reduce ecological risks.	ICs are implementable and require the cooperation and consent of tribal, municipal, state, and federal agencies, as well as the general public.	• Consumption advisories • Waterway use restrictions • Deed/development restrictions	Institutional controls will likely be a component of all LDW alternatives presented in the FS. ICs are not pivotal to the development and evaluation of programmatic remedial alternatives, but are discussed in this PSA.
Monitored Natural Recovery (MNR)1	Physical Transport	Desorption, Diffusion, Dilution, Volatilization, Resuspension, and Transport	MNR may be an effective component of a cleanup remedy for reducing concentrations of contaminants in surface sediments over time. Its effectiveness is expected to vary by location. Sediment transport investigations indicate that sedimentation processes are active throughout the LDW. Bed erosion is an episodic process that may be most pronounced during the 100-year, spring tide, high-flow event. Episodic bed scour is minimal downstream of RM 2.0, and potentially increases upstream of RM 3.0. The effectiveness of MNR will be further evaluated in the FS.	There are no physical intervention elements to MNR that preclude implementation. Monitoring is implementable. Requires ICs to ensure that conditions supporting MNR are preserved and to reduce risks of human exposure during sediment recovery period. MNR has been implemented as part of sediment remedial actions nation-wide, and in the Puget Sound region.	• MNR	MNR is qualitatively discussed and carried forward in this PSA. Physical burial processes are applicable to all COPCs. As discussed in the CTM, chemical and biological processes are not anticipated to contribute significantly to natural recovery for PCBs, but may be significant for certain other organic COPCs (e.g., phthalates). The FS will include further evaluations of the effectiveness of MNR.
	Chemical and Biological Degradation	Dechlorination or degradation				
	Physical Burial Processes	Sedimentation				
Enhanced Natural Recovery	Enhanced Physical Burial	Thin layer (6 to 12") of sand or sediment	Applicable to areas with moderate concentrations of COPCs. Effective in all areas where MNR mechanisms are active but too slow to achieve sediment COPC reduction in a reasonable timeframe.	ENR is considered to be implementable for the bench areas and downstream portions of the LDW, but may not be implementable in certain portions of the navigation channel. ENR has been implemented as a component of sediment remedial alternatives in the Puget Sound region. The equipment and process knowledge is available locally.	• ENR	ENR is qualitatively discussed and carried forward in this PSA. ENR may be used throughout the LDW, but will be considered primarily for use in bench areas with low to intermediate sedimentation rates. ENR is also used to manage dredge residuals. The FS will include further evaluations of the effectiveness of ENR.
Containment	Capping	• Sand Cap • Sediment Cap • Armored Cap • Composite Cap • Reactive Cap	Capping is a demonstrated and effective technology for reducing human and ecological risks of exposure to sediment contaminants. Capping physically isolates the contaminated sediments from receptors, stabilizes contaminated sediments so they are not transported, and chemically/ isolates the contaminants beneath the cap.	Capping uses conventional and readily available equipment and has been successfully implemented at a number of sites in the Puget Sound region. Selection/application criteria will be developed and presented in the FS to aid in delineating areas suitable for capping. ICs may be required to protect the cap from disturbance and damage.	• Sand/Sediment Caps • Armored Caps	This PSA develops and evaluates capping alternatives using conventional sand capping and armored capping options. While other variations (e.g., composite, reactive) may be applicable and considered in the FS or design phase, they are not specifically evaluated in this programmatic PSA. For this PSA, capping is also used for habitat restoration in shallow bench areas and for grade restoration.
Removal	Dredging	Hydraulic Dredging	It is a proven effective sediment removal technology. Has been demonstrated to be effective on multiple sediment remediation projects nationally. Diver-operated hydraulic dredging under docks and piers has been used for small removals within the Puget Sound region; but its effectiveness is limited, and this method increases short-term risks to workers.	The primary implementability concern with hydraulic dredging is the infrastructure and space needed to manage the large volumes of water generated. Presence of debris and underwater infrastructure (cables, pipes) may complicate operations and limit effectiveness. Diver-assisted methods are potentially suitable for areas with in-water (and over-water) infrastructure. Not suitable for intertidal areas. Hydraulic dredges and the necessary supporting infrastructure (i.e., dewatering equipment and facilities) have limited local availability.	• Mechanical Dredging • Land-based Excavators	All removal technologies are effective and potentially implementable for the LDW and may be evaluated during the Remedial Design. However, this PSA evaluates mechanical dredging for in-water removal alternatives and mechanical excavation equipment for intertidal excavations as the representative process options primarily because of availability of local equipment and experience.
		Mechanical Dredging	It is proven effective sediment removal technology. Has been demonstrated to be effective on multiple sediment remediation projects nation-wide, as well as in the Puget Sound region and in the LDW.	Implementable. Suitable where debris is present. Underwater infrastructure (cables, pipes) may complicate operations. Potentially suitable for intertidal areas. Not suitable for under-pier areas. Equipment, infrastructure, and considerable application knowledge is available locally.		
	Dry Excavation	Excavator	Effective conventional shore-based technology for removing sediments in intertidal areas that cannot easily be accessed with barge-mounted dredges. Has been demonstrated to be effective on multiple sediment remediation projects nation-wide, as well as in the Puget Sound region and in the LDW.	Shore-based excavation is an implementable technology that can be used in certain embankment and intertidal areas where barge-mounted dredges are impractical.		
***Ex Situ* Treatment**	Physical/ Chemical	Soil Washing/Separation • Conventional Soil Washing/ Particle Separation • Advanced Soil Washing (e.g., Biogenesis ®)	Conventional soil washing and physical separation have demonstrated effectiveness for reducing the volume of contaminated sediments by separating coarser materials from contaminant-containing fine fractions. This treatment reduces the volume of contaminated sediment requiring disposal, but generates additional wastewater and does not destroy contaminants. Biogenesis^{SM} is an emerging soil washing process that is currently in a demonstration phase. The process may destroy some portion of the organic contaminants, but generates additional wastewater and does not destroy metals.	Soil washing/separation equipment is not available locally, but mobile units are available and have been applied at other contaminated sediment projects nation-wide. Soil washing systems have the potential to be cost effective where there is a significant coarse fraction. There are no institutional barriers for application of soil washing/separation. However, whether the retained sand fraction is sufficiently clean for beneficial uses remains to be determined in conjunction with the DMMP/SMS agencies.	• Conventional Soil Washing/Particle Separation	Conventional soil washing/particle separation is potentially effective and implementable, and may result in a portion of the material (sand) being suitable for beneficial use in the LDW. The fine fractions containing the majority of the contaminants would require landfill disposal. Conventional soil washing is carried forward as the representative treatment process option in this PSA. Advanced soil washing may be re-considered in the design phase.

Table 4-2 Selection of Representative Process Options for Development of Remedial Alternatives

General Response Action	Remedial Technology	Process Option	Effectiveness	Implementability	Representative Process Option for GRA and Programmatic PSA Alternative	Comments
Ex Situ* Treatment *(continued)	Physical	Solidification	Solidification is a proven and effective technology for reducing the moisture content of dredged sediments and for reducing the leachability (mobility) of metals. Contaminants are not destroyed by solidification. Solidification does not provide any additional risk reduction if sediments are ultimately placed in a properly designed landfill or other confinement facility.	Solidification is a conventional remediation technology that utilizes readily available and standard equipment, and thus is readily implemented. Solidification does not result in a material that would meet the requirements for beneficial use, so would still require landfill disposal for the treated materials.	• Conventional Soil Washing/Particle Separation	Solidification is not carried forward for alternative development in this PSA, but may be considered further in the design phase if water reduction methods are needed.
	Thermal	• Incineration • Low-temperature Thermal Desorption (LTTD) • High-temperature Thermal Desorption (HTTD)	LTTD is potentially effective for SVOCs but is less effective for complete destruction of PCBs and pesticides. HTTD is potentially effective for SVOCs, PAHs, PCBs, and pesticides. Metals are not destroyed or altered by thermal processes. Locally-operated LTTD facilities have demonstrated effectiveness at reducing SVOC concentrations to below MTCA Method A criteria, but to date have no experience in meeting SMS criteria.	Thermal destruction and/or desorption and combustion is potentially implementable for sediments, but would require facilities for dewatering and managing sediments, and either transport to out-of-state facilities (incineration) or a constructed off-site facility (HTTD and LTTD). Mobile HTTD and LTTD units are available, but would require obtaining local use permits. Thermal treatment would not likely meet the requirements for beneficial use (structurally unaltered sediments and COPCs below SMS), and would thus likely still require landfill disposal.		Thermal treatment options are not carried forward for alternative development in this PSA.
Disposal	On-Site	• Contained Aquatic Disposal • Confined Disposal Facility (Upland) • On-site Confined Fill (Upland) • In-water beneficial re-use (see below)	All on-site disposal options have demonstrated effectiveness nation-wide, in the Puget Sound region, and in the LDW. Disposal does not reduce contaminant volume or toxicity but achieves protection by eliminating direct exposure and transport of COPCs. Disposal facilities would be designed for effective long-term physical and chemical isolation.	On-site disposal is implementable from an engineering and construction standpoint and has been administratively implemented at other CERCLA sites. In the LDW there are limited space and competitive use considerations for CDFs or upland confined fills. Implementability for CDFs is further limited by the need for mitigation for lost aquatic habitat and limited availability of suitable land for such mitigation. One CAD does exist just outside the LDW. For the volumes of dredged sediments anticipated from the LDW, a CAD may need to be located beneath the navigation channel. Administratively this may be feasible, but would require long-term waterway use restrictions.	• On-site in-water CAD	An on-site CAD is retained for remedial development in this PSA. No candidate sites for CDFs or upland fill have been identified that are suitable and not subject to competing industrial uses. This does not preclude adoption of the technology at the remedial design phase as an alternative to upland landfill disposal if property ownership, liability, mitigation, and engineering factors are favorably resolved.
	Off-Site	Subtitle D Landfill	Subtitle D landfills have been demonstrated to be effective for disposal of contaminated sediments from the Puget Sound region, and specifically the LDW. Landfills effectively isolate contaminated materials from the environment and reduce mobility risks. No reduction in contaminant toxicity or volume.	Regional landfills (e.g., Rabanco; Roosevelt, WA) are available and have capacity to accept wet, mechanically dredged or hydraulically dredged sediments and dewatered sediments.	• Off-Site Upland Subtitle D Landfill	Placement of dredged sediment in an existing Subtitle D landfill is retained as the representative disposal process option for alternatives developed in this PSA.
		TSCA or Subtitle C Landfill	Similar to Subtitle D Landfill, but would be used only for highly contaminated sediments.	While implementable (regional Subtitle C facilities exist) the dredged sediments are not expected to be designated as TSCA waste, State Dangerous Waste, or RCRA hazardous waste.		Contaminant concentrations in dredged sediments are not anticipated to exceed TSCA or RCRA threshold concentrations. Therefore landfill disposal would generally not require a Subtitle C facility. This disposal technology will not be developed into a remedial alternative, but could be considered if needed during the design phase (e.g., for localized hot spots or other wastes such as treated pilings).
		DMMP Open-Water Disposal	LDW sediments may require treatment to applicable standards (DMMP) before placement in the PSDDA open-water disposal site. Effectiveness, in terms of risk reduction, is therefore tied to removal and treatment, not disposal.	Implementable only in the context of alternatives where dredged sediments are treated to applicable standards. Clean sand fractions from conventional soil washing may meet these standards. Ability of other treatment technologies to meet standards is unknown. Permitting required.		DMMP disposal may be considered in the design phase as a disposal option for treated or uncontaminated dredge material.
Beneficial Use (following treatment)	In-water	• Capping • ENR • Habitat restoration	In-water beneficial reuse assumes that sediments are treated to applicable standards (DMMP/SMS) before reuse. Effectiveness, in terms of risk reduction, is therefore tied to removal and treatment, not the reuse itself.	Placement of treated sediments in the aquatic environment (e.g., capping, habitat restoration) is technically feasible as long as the material meets cleanup and other applicable criteria (e.g., suitability as habitat substrate, capping material). The physical acceptability of treated sediment as capping or habitat restoration material needs to be confirmed.	• On-site capping and habitat enhancement	Beneficial in-water use (within the LDW Superfund Site) may be determined to be a viable end-point for sediments in conjunction with alternatives involving treatment. This PSA assumes beneficial use of the sand/gravel fraction from soil washing treatment as cap/habitat enhancement media. Beneficial use may reduce purchased material costs for cap and habitat enhancement actions.
	Upland	• Construction fill	Upland beneficial use assumes that sediments are treated to applicable standards (e.g., MTCA) before reuse. Effectiveness, in terms of risk reduction, is therefore tied more to removal and treatment and less to the reuse itself.	Placement of treated sediments in the uplands (e.g., as construction fill) is technically and administratively feasible if the material meets cleanup and other applicable criteria (e.g., structural standards). An upland project would need to be identified to receive the material, coincident with remediation. Achieving MTCA cleanup levels may be difficult. Administrative issues would need to be resolved regarding potential liability associated with residual contaminant concentrations in an uncontrolled upland use.		Beneficial upland use may be a viable end-point for treated sediment if an upland fill project is identified that coincides with remediation. Currently, there are no upland beneficial reuse opportunities identified. Upland beneficial reuse may therefore be considered in design as an alternative to on-site uses. However, the potential for generating positive cash flow by selling material as commodity is low, and administrative and liability issues would need resolution.

Table 4-3 Proposed Action Strategies for Remedial Alternatives for AOIs in the LDW

<table>
<tr><th rowspan="3">Hypothetical RAL for Total PCBs [2] (mg/kg OC)</th><th colspan="5">REMEDIAL ALTERNATIVE [1]</th></tr>
<tr><th>B</th><th>C</th><th>D, E</th><th>F</th><th>G</th></tr>
<tr><th>Dredge / Dispose</th><th>Dredge / Disposal and ENR</th><th>CAD / Treatment</th><th>Capping</th><th>Hypothetical / Combined</th></tr>
<tr><td>> 65</td><td>B1:
Removal above 65 mg/kg OC
*</td><td></td><td></td><td></td><td rowspan="5">Downstream RM 2.0:
Dredge with upland disposal of the navigation channel and deep bench above 65 mg/kg OC and ENR the shallow bench above 12 mg/kg OC.

Upstream RM 2.0:
Dredge with upland disposal of the navigation channel above 12 mg/kg: Dredge with upland disposal above 24 mg/kg OC. Restore shallow bench areas to grade (restoration cap).</td></tr>
<tr><td>> 36</td><td>B2:
Removal above 36 mg/kg OC
*</td><td>C1:
Removal above 65 mg/kg OC
ENR above 36 mg/kg OC
*</td><td>D1/E1:
Removal above 65 mg/kg OC
ENR above 36 mg/kg OC
*</td><td>F1:
Removal/Capping above 65 mg/kg OC
ENR above 36 mg/kg OC
*</td></tr>
<tr><td>> 24</td><td>B3:
Removal above 24 mg/kg OC
*</td><td>C2:
Removal above 36 mg/kg OC
ENR above 24 mg/kg OC
*</td><td>D2/E2:
Removal above 36 mg/kg OC
ENR above 24 mg/kg OC
*</td><td>F2:
Removal/Capping above 36 mg/kg OC
ENR above 24 mg/kg OC
*</td></tr>
<tr><td>> 12</td><td>B4:
Removal above 12 mg/kg OC
*</td><td>C3:
Removal above 24 mg/kg OC
ENR above 12 mg/kg OC
*</td><td>D3/E3:
Removal above 24 mg/kg OC
ENR above 12 mg/kg OC
*</td><td>F3:
Removal/Capping above 24 mg/kg OC
ENR above 12 mg/kg OC
*</td></tr>
<tr><td>> 6</td><td>B5
Removal above 6 mg/kg OC
*</td><td>C4:
Removal above 12 mg/kg OC
ENR above 6 mg/kg OC
*</td><td>D4/E4:
Removal above 12 mg/kg OC
ENR above 6 mg/kg OC
*</td><td>F4:
Removal/Capping above 12 mg/kg OC
ENR above 6 mg/kg OC
*</td></tr>
</table>

[1] All shallow bench areas where removal occurs will be reshored to grade with habitat restoration cap.

[2] Hypothetical RALs are mulitples of the SQS and the CSL for total PCBs.

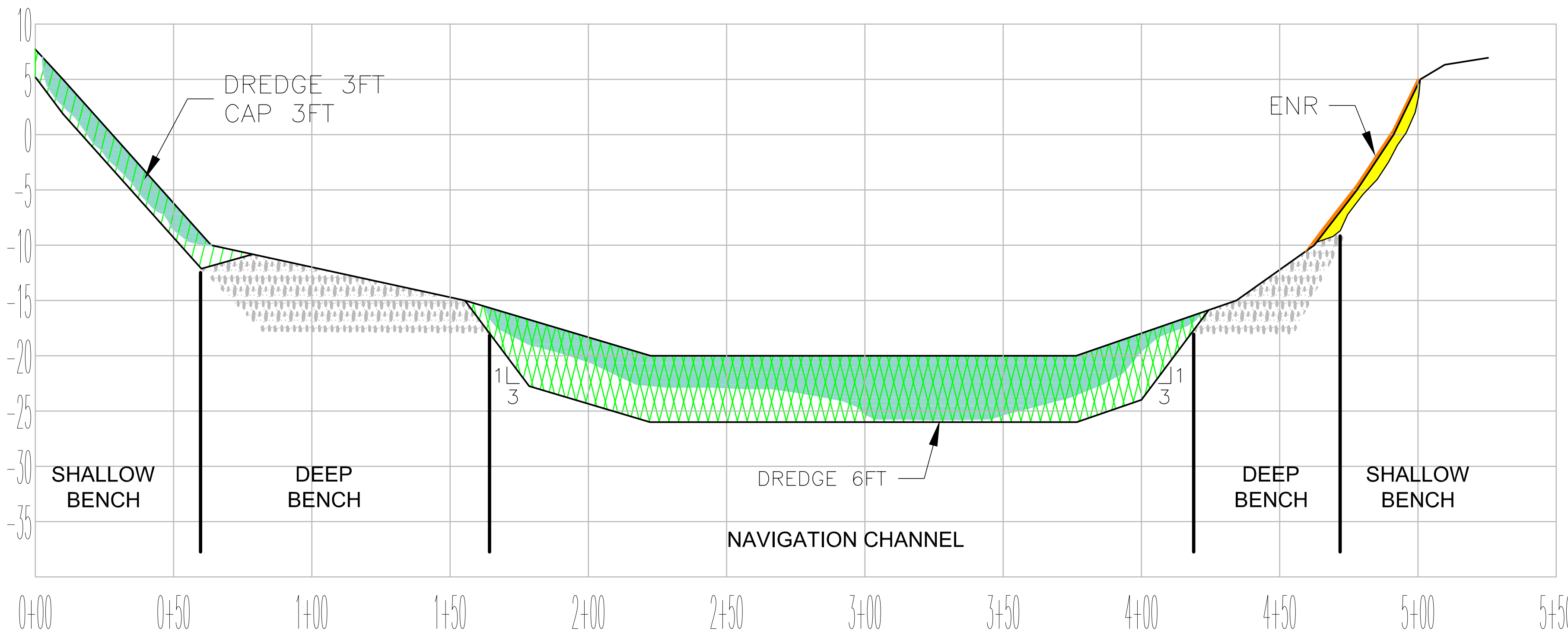
* = MNR implied as a viable recovery process for the rest of waterway without stating a value. MNR rates will vary depending upon locations in the LDW.

Table 4-4 Assembled Remedial Alternatives for the LDW by Reaches

Remedial Areas		Remedial Alternatives and Actions						
		A: No Further Action	B: Dredge with Upland Off-site Disposal	C: Dredge with Upland Off-site Disposal and ENR Remaining Areas	D: Dredge with Upland Off-site Disposal and Onsite In-water Disposal	E: Dredge with Treatment, Disposal and Beneficial Reuse	F: Cap to the Maximum Extent Possible	G: Hypothetical Combined Alternative
Sponsored EAAs		Dredge/Cap	Dredge/Cap	Dredge/Cap	Dredge/Cap	Dredge/Cap	Dredge/Cap	Dredge/Cap
PPAs		Dredge/Cap	Dredge/Cap	Dredge/Cap	Dredge/Cap	Dredge/Cap	Dredge/Cap	Dredge/Cap
AOIs[1]								
Reach	**Bathymetric Zone**							
Downstream RM 2.0	Navigation Channel		Dredge	Dredge / ENR	Dredge / ENR	Dredge / ENR	Dredge / ENR	Dredge > 65 mg/kg OC
	Bench Areas							
	Shallow Bench Depth < -9 ft MLLW		Dredge / Cap	Dredge / Cap / ENR	Dredge / Cap / ENR	Dredge / Cap / ENR	Dredge / Cap / ENR	ENR > 12 mg/kg OC
	Deep Bench Depth ≥ -9 ft MLLW		Dredge	Dredge / ENR	Dredge / ENR	Dredge / ENR	Cap, ENR	Dredge > 65 mg/kg OC
RM 2.0 to 3.0	Navigation Channel		Dredge	Dredge	Dredge	Dredge	Dredge	Dredge > 12 mg/kg OC
	Bench Areas							
	Shallow Bench Depth < -9 ft MLLW		Dredge / Cap	Dredge / Cap / ENR	Dredge / Cap / ENR	Dredge / Cap / ENR	Dredge / Cap / ENR	Dredge / Cap > 24 mg/kg OC
	Deep Bench Depth ≥ -9 ft MLLW		Dredge	Dredge / ENR	Dredge / ENR	Dredge / ENR	Cap	Dredge > 24 mg/kg OC
Upstream RM 3.0	Navigation Channel		Dredge	Dredge	Dredge	Dredge	Dredge	Dredge > 12 mg/kg OC
	Bench Areas							
	Shallow Bench Depth < -9 ft MLLW		Dredge / Cap	Dredge / Cap / ENR	Dredge / Cap / ENR	Dredge / Cap / ENR	Dredge / Cap / ENR	Dredge / Cap > 24 mg/kg OC
	Deep Bench Depth ≥ -9 ft MLLW		Dredge	Dredge / ENR	Dredge / ENR	Dredge / ENR	Cap	Dredge > 24 mg/kg OC

Notes:
MNR implied as a viable recovery process for the rest of waterway without stating a value. MNR rates will vary depending upon locations in the LDW.
Sponsored EAAs assumed to be Dredge with Upland Disposal under all remedial alternatives.
PPAs assumed to be remediated over entire area subject to Alternatives B through E. In Alternative F, the PPAs are assumed to be dredged with upland off-site disposal.
[1] Expressed as reaches and bathymetric zones from the Conceptual Site Model

Alternative Assumptions	Complete sponsored EEAs and PPAs.	Complete the sponsored EAAs and PPAs. Dredge with upland disposal the AOIs > multiples of the SQS for total PCBs. MNR remaining areas.	Complete the sponsored EEAs and PPAs. Dredge with upland disposal the AOIs > multiples of the SQS for total PCBs, ENR to next action level. MNR remaining areas.	Complete the sponsored EEAs and PPAs. Dredge with on-site, in-water disposal of AOIs > multiples of the SQS for total PCBs. ENR to next action level. MNR remaining areas.	Complete the sponsored EAAs and PPAs. Dredge with treatment, upland disposal and beneficially use the AOIs > multiples of the SQS for total PCBs, ENR to next action level. MNR remaining areas.	Complete the sponsored EAAs and PPAs. Dredge the navigation channel and cap the bench areas of the AOIs > multiples of the SQS for total PCBs, ENR to next action level. MNR remaining areas.	*Downstream RM 2.0:* Dredge with upland disposal navigation channel and deep bench areas above 65 mg/kg OC (extending dredge area to areas > 12 mg/kg OC) and ENR shallow bench above 12 mg/kg OC. *Upstream RM 2.0:* Dredge with upland disposal navigation channel above 12 mg/kg, dredge with upland disposal and cap shallow bench areas above 24 mg/kg OC (extending dredge area to areas > 12 mg/kg OC). Dredge with upland disposal deep bench areas above 24 mg/kg OC. MNR remaining areas.



LEGEND

POTENTIAL REMEDIAL ACTIONS

- ENR
- DREDGE 3FT AND CAP 3FT
- DREDGE 6FT
- MNR REMAINING AREAS

TOTAL PCB CONCENTRATIONS (mg/kg OC)

- >24
- >12 – ≤24
- ≤12

30 0 60

HORIZONTAL SCALE IN FEET
VERTICAL EXAGGERATION= 4:1

NOTES:

1. ALTERNATIVE C-3 SELECTED FOR THIS REPRESENTATIVE DEPICTION.
2. MUDLINE ELEVATION FROM ACTUAL BATHYMETRY (RM 2.7)
3. PCB CONCENTRATIONS ILLUSTRATED ARE HYPOTHETICAL AND FOR ILLUSTRATIVE PURPOSES. THEY DO NOT REPRESENT ACTUAL PCB CONCENTRATIONS FROM A CROSS-SECTION AT RM 2.7.

DRAFT

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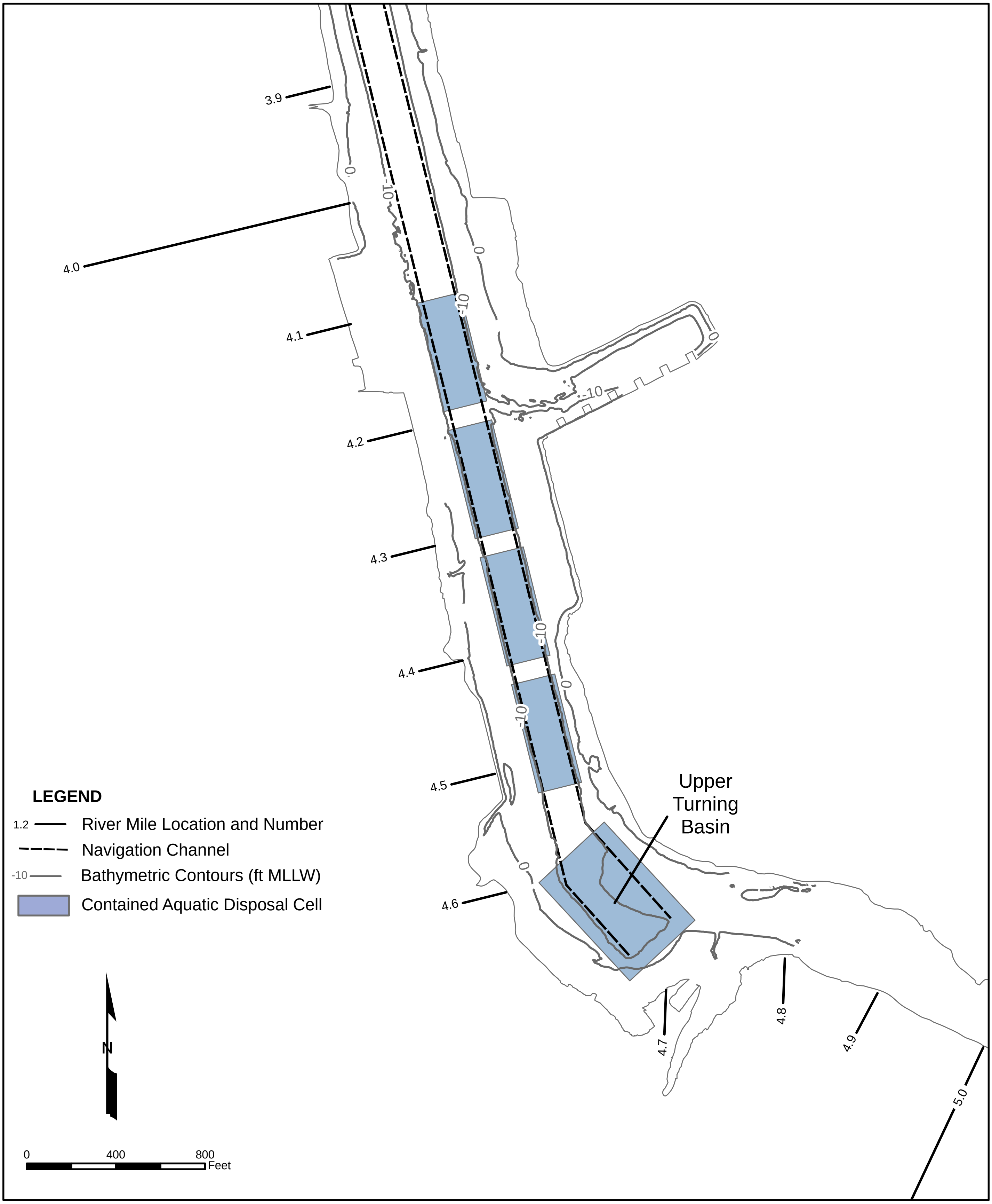
LDW DRAFT
PRELIMINARY SCREENING OF ALTERNATIVES
PORS5-18220-603

DATE: 05/09/06 | DRWN: A.S./SEA

CONCEPTUAL CROSS-SECTION ILLUSTRATING POTENTIAL REMEDIAL ACTIONS FOR USE IN LDW

FIGURE 4-1



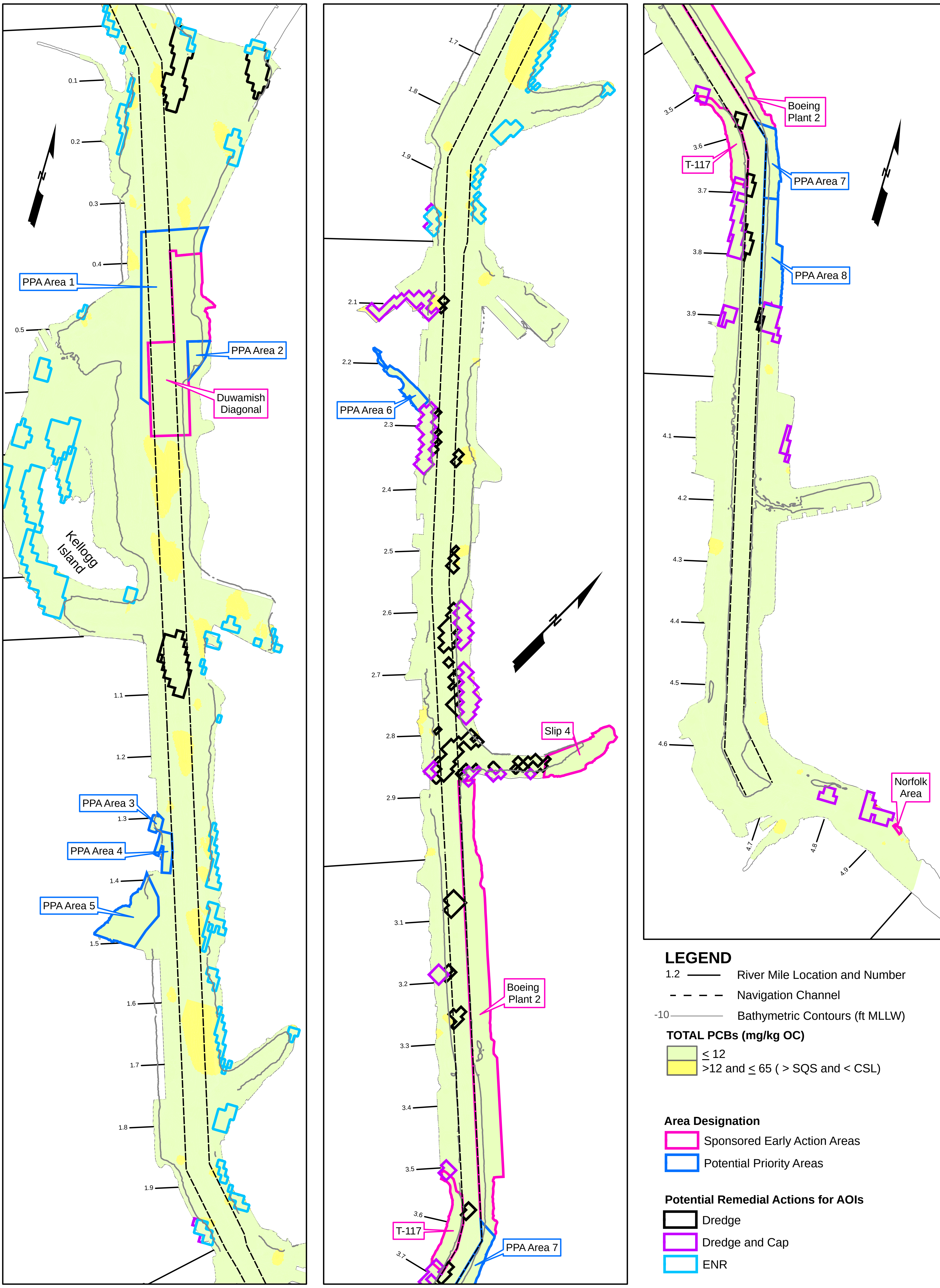
FILE: T:/LDWG_Duwamish/Projects/PSA_Oct06/CADs2.MXD

RETEC **DRAFT**

Lower Duwamish Waterway Group

Port of Seattle / City of Seattle / King County / The Boeing Company

LDW DRAFT PRELIMINARY SCREENING OF ALTERNATIVES (PORS5-18220-603)	CONCEPTUALIZED LOCATIONS FOR CAD SITES IN THE LDW
DATE: 9/12/06 KBL/ftc	**FIGURE 4-2**



1. Mapping uses the 12-23-05 dataset provided by Windward Environmental LLC.
2. Total PCB isopleth was set at the SQS (12 mg/kg OC) for total PCBs.
3. The interpolated total PCB distribution after sediment removals at the sponsored EAAs and PPAs (see Figure 3-3) was used as the basis for distinguishing between areas above (yellow) and below (green) the SQS for total PCBs (12 mg/kg OC).
4. The potential remedial actions shown for AOIs were defined by the rules described in Section 4.4.8 of the text.

0 400 800 Feet

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DRAFT PRELIMINARY SCREENING OF ALTERNATIVES
(PORS5-18220-603)

REMEDIAL AREAS ASSOCIATED WITH HYPOTHETICAL ALTERNATIVE G

DATE: 9/26/06 DWN. BY: KBL/ftc

FIGURE4-3

FILE: T:/LDWG_Duwamish/Projects/PSA_Oct06/RemAltg.MXD

5 Screening of Preliminary Alternatives

This section screens the preliminary remedial alternatives identified in Section 4 following the guidelines established in EPA (1988) guidance and Washington State's MTCA rule (WAC 173-340) for conducting an FS. The set of retained process options were first evaluated in the CTM (RETEC 2005b) and were generally considered to be implementable and effective for conditions in the LDW. Guidance requires that the initial screening of remedial alternatives be based on implementability, effectiveness, and cost. The retained list of representative remedial alternatives will be subject to a detailed analysis later in the FS using the nine CERCLA evaluation criteria listed below, which include consideration of public concern and acceptance of an alternative. The nine CERCLA (and MTCA) evaluation criteria include:

- Long-term effectiveness and performance
- Implementability
- Cost
- Overall protection of human health and the environment
- Compliance with Applicable or Relevant and Appropriate Requirements (ARARs)
- Reduction of toxicity, mobility, and volume through treatment
- Short-term effectiveness
- State acceptance
- Community acceptance.

CERCLA guidance (EPA 1988) provides that remedial alternatives are screened first against the short- and long-term aspects of three broad criteria: implementability, effectiveness, and cost. Considerations for application of these criteria in this PSA are described below.

5.1 Evaluation Criteria

5.1.1 Implementability Evaluation

Implementability is evaluated based on the technical feasibility (i.e., availability of equipment, constructability, reliability, and previous applications in the Puget Sound region) as well as the administrative and institutional barriers to implementation of an alternative (i.e., agency approval). For the purposes of this PSA, remedial alternatives are evaluated on a waterway-wide basis.

Actual design and cleanup of individual areas will likely be accomplished by a number of separate performing parties and will consider detailed site-specific conditions. The implementation of the selected remedy by multiple parties has significant implementability and cost implications for remedial alternatives incorporating on-site disposal or treatment. This consideration is beyond the scope of this PSA, but will be addressed in the FS.

5.1.2 Effectiveness Evaluation

CERCLA RI/FS guidance requires that the effectiveness evaluation focus on: (1) the potential effectiveness of alternatives in handling the estimated areas or volumes of media and meeting the remedial action goals identified in the RAOs, (2) the potential impacts to human health and the environment during construction and implementation phases, and (3) how proven and reliable the process is with respect to the contaminants and conditions at the site (EPA 1988). Remedial action goals and RAOs will not be identified until after completion of the Phase 2 RI and the risk assessments. However, the effectiveness of process options in handling the estimated areas or volumes of contaminated media (criterion 1) was addressed in the CTM (RETEC 2005b). The evaluation of criteria 2 and 3 in this PSA focuses on short-term effectiveness and long-term effectiveness of the alternatives.

The FS will evaluate the effectiveness of each remedial alternative relative to MTCA, the RAOs, and ARARs. This PSA has been prepared earlier in the RI/FS process than it normally would be, in order to allow for early input by the agencies and stakeholders on the development of the FS Work Plan and potential remedial alternatives. Because it is being prepared before the RAOs and ARARs analysis is available, there will be additional effectiveness considerations addressed in the FS, than those presented in this PSA.

Short-Term Effectiveness

In this PSA, short-term effectiveness includes an evaluation of the effects of the remedial alternatives during the construction and implementation phase of the project. Because RAOs have not yet been established for this project, this PSA provides a qualitative evaluation of these considerations. These include:

- Protection of the community and workers during the remedial action
- Environmental impacts of implementing the remedial action

- The expected length of time to implement the remedial alternative. The time frames are qualitatively contrasted to Alternative A (No Action).

Long-Term Effectiveness

Long-term effectiveness refers to the magnitude of residual risks remaining at the conclusion of the remedial activities, and the need for and reliability of additional containment measures and/or institutional controls. Post-remedy effectiveness is evaluated in this subsection by risk reduction in terms of the magnitude of reductions in chemical concentrations and the associated reduction in sediment toxicity. Chemical effectiveness is evaluated based on the reduction in sediment contaminant concentrations in terms of a post-remedy SWAC of total PCBs and in the reduction in the number of stations exceeding the SQS and CSL. (Although not addressed in this document, further reductions in chemical concentrations are expected to occur as source control efforts and natural recovery processes continue, and will be evaluated in the FS.)

SWAC Reduction

The estimated reductions in the SWAC of total PCBs presented in this PSA are a function of the hypothetical RALs. Relative risk reduction is therefore discussed as a range for each of the major alternatives. Figure 5-1 presents a summary of the estimated SWAC reductions as a function of the hypothetical RALs and associated actionable areas. Estimates of total PCB SWAC reductions are used as a semi-quantitative measure of risk reduction. Reductions in the surface sediment total PCB concentrations are estimated in two ways:

1) For the sponsored EAAs and PPAs, the total PCB bed maps were re-interpolated following remedy completion. The new interpolations were used to calculate post-remedy SWACs by substituting an assumed post-remedial total PCB concentration of 5 mg/kg OC within the boundaries established for each action.

2) For the AOIs, the total PCB bedmaps following remedy completion of the sponsored EAAs and PPAs were used (interpolations were not re-run after every multiple of the SQS). Post-remedy SWACs were calculated for each multiple of the SQS by substituting the same post-remedy concentration described above within the boundaries or isopleths established for each hypothetical total PCB RAL (represented as multiples of the SQS).

Interpolation methods are described in more detail in Appendix B. As noted in Section 1.3, development of this PSA was occurring concurrently with further exploration of IDW interpolation methods, and it is recognized that there may be differences between the results of interpolations presented in this PSA and those recently reported in the *Technical Memorandum: GIS Interpolation of Total PCBs in the LDW Surface Sediment* (Windward 2006c). However, such differences are largely irrelevant because the interpolations used in this PSA are for illustrative purposes only. It is recognized that further investigations and evaluations are likely to result in different interpolations (and different SWACs) than those used as the basis for this PSA. Nevertheless, the fundamental principles demonstrated by consideration of the interpolated PCB distributions and the calculated SWACs as presented herein are sufficient for the purposes of this PSA.

Point Reduction

The effectiveness in reducing chemical concentrations and toxicity relative to the SMS is evaluated based on the anticipated reduction in the numbers of stations where the concentrations of sediment COPCs other than PCBs exceeded their respective SQS or CSL chemical criteria or where toxicity test results exceeded the SQS or CSL biological effects criteria. The total numbers of stations where either the SQS or CSL was exceeded in the baseline condition were tabulated, and for each remedial alternative, the remediation would be expected to also remove or control the COPCs or toxicity. Table 5-1 presents the number of stations with detected SQS and CSL chemical exceedances for contaminated areas under baseline conditions. Tabulating the incremental reductions in COPCs or toxicity then becomes a surrogate for risk reduction. This evaluation explicitly assumes that all alternatives are equally protective and differ solely in the way contaminants are controlled (removal, containment, or attenuation) and in the time it takes to achieve that control. Capping, dredging, excavation, and ENR were all assigned the same post-remedial concentrations for the purposes of this analysis.

Permanence

Permanence is evaluated relative to previous experience in other sediment management projects, as well as a qualitative discussion of what additional controls may be needed post-remedy. All alternatives assume that institutional controls and some level of residual capping are a component of the remedy. Natural recovery processes are active in all areas of the LDW, and are expected to remain an active mechanism that reduces COPC concentrations in surface sediments regardless of the remedial alternative that is ultimately selected. The rates of natural recovery are expected to vary significantly by location. The FS will include a more detailed analysis of natural recovery processes, including a predictive tool, to formulate alternatives that explicitly include natural recovery as a component. The FS will also provide estimates of post-cleanup SWAC reductions that will be expected to occur over time throughout the LDW as a result of the ongoing natural recovery processes. These site-wide SWAC reductions over time may be an important part of attaining the long-term RAOs for the LDW.

5.1.3 Cost Evaluation

The cost evaluation in this PSA presents the capital and operating costs for each remedial alternative. Costs were evaluated on a net present worth basis. Capital cost estimates include both direct and indirect costs, costs associated with engineering and administration, and a 30 percent contingency factor to account for construction conditions not currently identified. Operation, maintenance, and other foreseeable costs associated with cap monitoring are included. However, long-term compliance monitoring costs for the LDW as a whole are not included.

A detailed summary of the cost assumptions for each remedial alternative is presented in Appendix C. Long-term monitoring of the LDW is assumed to be a component of all alternatives and maintenance is not included as a specific line item. The incremental costs of site-specific monitoring for areas that involve capping or ENR are included.

5.2 Alternatives Screening

In this section, each of the preliminary remedial alternatives (identified as Alternatives A through G in Section 4) is screened using the criteria of implementability, effectiveness, and cost.

5.2.1 Alternative A: No Further Action

Implementability

This alternative is implementable, because no further remedial action, permit requirements, or landowner approvals would be required after completing sediment removals at the sponsored EAAs. Some contaminated sediments may remain in place at depth in the navigation channel and on the benches, which would require long-term institutional controls and/or limitations on maintenance dredging operations.

Effectiveness

Alternative A would not result in any short-term adverse impacts to on-site workers or the community after completion of the sponsored EAAs, because no additional remedial action would take place. Completing the removals at the sponsored EAAs does result in a relatively large decrease in the waterway-wide total PCB SWAC (Figure 5-1). The baseline total PCB SWAC of 13 mg/kg OC would be reduced to 7.9 mg/kg OC; an approximately 39 percent reduction in total PCBs. Completion of the sponsored EAAs also results in a reduction of SQS and CSL chemical exceedances (Table 5-1). Baseline SQS and CSL chemical exceedances are 309 and 252, respectively. Post-EAA residual contamination would remain in the waterway: total PCB SWAC of 7.9 mg/kg OC; 210 SQS and 79 CSL chemical exceedances. Natural recovery processes would further reduce the chemical concentrations over time under this alternative. However, MNR is not an explicit component of this alternative.

Cost

Costs for completing the sponsored EAAs are estimated to total $44.5M for the approximately 31.2 acres of those EAAs (Table 5-2). These costs were based on estimates provided by the LDWG parties at the time of initial drafting of this document, but are subject to change as sponsored parties develop their remedial designs. Additional costs that would be incurred in this alternative would include long-term monitoring, and maintenance of institutional controls such as fish consumption advisories. These costs are likely to be common to all alternatives for the LDW, and will be developed further in the FS.

5.2.2 Alternative B: Dredge with Upland Disposal

Implementability

Technical Implementability

Mechanical dredging with upland disposal is a technically feasible and implementable alternative in the LDW. The equipment and infrastructure for removal with transport to a Subtitle D facility are readily available Similar projects have been recently implemented in the East Waterway, Todd Shipyards, the former Lockheed site, and at the Duwamish/Diagonal EAA.

Construction considerations for Alternative B that could affect the schedule, costs, and the effectiveness of this alternative include: locating and working around underwater cables, gas pipes, and sewage/stormwater transfer; scheduling in and around the active industrial activities in the LDW (e.g., vessel and barge traffic); and dredging or excavation around dolphins, pilings, and over-water structures such as docks and piers. The logistics of staging around these facilities may significantly decrease production rates assumed in this PSA, and the ability to achieve a given RAL within a specific area, Construction considerations will be further addressed in the FS, once SMAs have been identified.

This alternative assumes that dredged or excavated materials would be either loaded onto trucks on-site or loaded onto conventional barges and moved off-site. The material from barges would be offloaded to either rail cars or trucks at a commercial transloading facility in the project vicinity.

Administrative Implementability

There are no administrative barriers anticipated for implementing removal with upland disposal. The substantive requirements for the hydraulic permit required under the Clean Water Act, as well as the operation requirements imposed by the Endangered Species Act for salmonids, will need to be considered and met during implementation. Removal, followed by grade restoration in intertidal and shallow subtidal areas, should be adequate to address concerns about changes to habitat for important benthic, crustacean, and fish species. Implementation will require timing of construction during the allowed fish window time frame, consultation with the Muckleshoot Tribe to ensure that activities would not interfere with tribal fishing, and would also require coordination with industries that use the LDW.

Alternative B would also require the application of institutional controls, including fish consumption advisories, until such time as fish tissue concentrations of PCBs were lowered to levels that are protective of human health. In addition, a necessary component of this alternative is the long-term monitoring program. The appropriate institutional controls and long-term monitoring are implementable and effective in this context.

Effectiveness

Short-Term Effectiveness

Dredging and disposal activities would have low to moderate potential for health impacts to the community and workers from contaminant release during dredging operations (OSWER 2006). Operationally, human health exposures and safety issues are managed by engineering controls, best management practices, and the requirement for rigorous health and safety programs with the dredging and disposal contractors. Community concerns may include increased truck or rail traffic for staging and/or transport of dredged materials, night time operations that impact quality of life, and potentially fishing restrictions in the areas of operations during dredging. These may be managed by locating transport/staging facilities away from communities or community corridors, restricting operations near neighborhoods to daylight hours, and temporary fishing closures in areas of operation. Input from the local community and the Muckleshoot Tribe will be needed to effectively manage these issues.

In-water activities include excavation and dredging. Excavation may have some short-term, localized impacts associated with moving equipment in and out of the intertidal areas. Dredging may temporarily resuspend contaminated sediments in the water column. Resuspension rates may be controlled through best management practices (BMPs) (such as modifying the dredge or placement process) and/or engineering controls (such as installing silt curtains around the remediation areas). Short-term risks associated with these alternatives are related to the areas or volumes requiring management, and the duration of implementation. Longer durations typically decrease short-term effectiveness. Management of residuals can also be challenging because dredging typically loses 1 to 5 percent of the dredged material volume during implementation. Therefore, residual management by application of clean materials over the exposed sediment surface is built into all cost assumptions.

Additional challenges to short-term effectiveness include: pre-debris identification and removal, access to under-pier or behind-pier areas, and coordination with vessel traffic, all of which may produce increased short-term risks by lack of adequate site controls that can be placed around limited access areas.

Time to complete the action varies with the selected total PCB RAL and the acres involved. Table 5-2 arrays the dredging alternative by RAL. Completing the sponsored EAAs, PPAs, and AOIs in areas with total PCB concentrations above 65 mg/kg OC would require remediation over a total of 52.6 acres, and require 21 on-water days to complete the AOI portion only. Completing the same actions in areas with total PCB concentrations above 6 mg/kg OC would involve 200.1 acres, and an estimated 1,043 on-water days to complete the AOI portion only.

The estimated time to achieve the RAOs will be evaluated in the FS.

Long-Term Effectiveness

Dredging and upland disposal provide a high degree of long-term effectiveness and permanence of the remedy. The COPCs are permanently removed from the LDW and disposed in a controlled landfill. Sediment residuals that are at or above cleanup levels post-dredging could be expected. For the purposes of this PSA, a thin-layer placement of clean sands or sediments post-dredging is assumed for all dredging prisms.

The relative magnitude of reductions in surface sediment total PCB concentrations, and the numbers of stations exceeding the chemical and toxicological SQS/CSL levels are reflected in Table 5-1. As discussed previously, a relatively large decrease in the waterway-wide total PCB SWAC is achieved by completing the sponsored EAAs and implementing removal actions at the PPAs. After completing the sponsored EAA and PPA actions, implementing alternatives in the AOIs by the different multiples of the SQS results in incrementally smaller reductions in the SWAC (Table 5-1). Alternative B, implementing remedial actions in the AOIs for sediments with total PCB concentrations above 65 mg/kg OC, results in an additional SWAC reduction from approximately 7.0 to 6.1 mg/kg OC. While this SWAC is a total reduction of 53 percent from baseline, it is only an incremental reduction of 7 percent. Implementing remedial actions for sediments with total PCB concentrations above 12 mg/kg OC would reduce the SWAC to approximately 4.8 mg/kg OC, while implementing alternatives to 6 mg/kg OC would reduce the SWAC to approximately 4.0 mg/kg OC.

These analyses suggest that there might be a waterway-wide lower limit of what is technically achievable in terms of a post-remedial SWAC, and that limit may be on the order of a total PCB SWAC of 4 mg/kg OC. To achieve this lower limit in the short term would require actively remediating a total of nearly 200.1 acres in the LDW (sponsored EAAs, PPAs, and AOIs to 6 mg/kg OC). The lower limit of total PCB reduction, or residual concentrations in equilibrium with surrounding sediments and new bedloads, is not known at this time, and may need to be further evaluated in the FS. Some combination of short-term active reductions and longer-term natural recovery may also be effective in achieving a similar SWAC reduction over a longer restoration timeframe.

Remediation of the sponsored EAAs and PPAs results in a relatively large decrease in the waterway-wide number of stations with exceedances of either the SQS or CSL chemical criteria for any COPC, including PCBs (Table 5-1). The baseline numbers of stations with SQS and CSL chemical exceedances are reduced from 309 and 252, respectively, to 210 with SQS and 79 with CSL chemical exceedances after completion of the sponsored EAAs. Remediating the PPAs results in a further decrease to 145 stations with SQS exceedances and 38 stations with CSL exceedances (Table 5-1).

In addition to total PCBs, there are stations with other chemicals (notably phthalates, PAHs, and metals) that exceed the SQS/CSL in the AOIs. Table 5-1 shows how those numbers decrease with increased removal at the lower multiples of the total PCB SQS in Alternative B. For example, removal undertaken to 12 mg/kg OC would leave 41 stations with chemical concentrations exceeding the SQS and 22 stations exceeding the CSL, while actions to 6 mg/kg OC would leave only 26 stations with SQS exceedances and 14 with CSL exceedances.

Of the 48 sediment toxicity stations evaluated in the LDW, 30 stations exceeded either the SQS or CSL biological effects criteria (Table 5-1). Completion of the sponsored EAAs and PPAs reduces the number exceeding the effects criteria to 22 stations. Implementing Alternative B in areas with total PCB concentrations above 65 mg/kg OC affects only two additional stations (20 remaining hits), while remediating to the SQS of 12 mg/kg OC reduces the number of remaining toxicity exceedances to 9.

Cost

Costs for completing the sponsored EAAs are estimated to total $44.5M, while the additional cost for completing the aggregate 19.3 acres of PPAs by dredging with upland disposal is $28.2M (Table 5-2). Incremental costs for each of the evaluated dredging alternatives in B are presented in Table 5-2. The total estimated LDW project cost for Alternative B ranges from approximately $76.2M for remediation of areas with total PCB concentrations above 65 mg/kg OC, to as much as approximately $258M for remediation of areas with total PCB concentrations above 6 mg/kg OC.

5.2.3 Alternative C: Dredge with Upland Disposal, ENR and MNR

Implementability

Technical Implementability

Alternative C is similar to Alternative B, but includes ENR as an integral component of the active remedy, as well as long-term MNR. As noted for Alternative B, mechanical dredging (with or without intertidal excavation) with upland disposal is a demonstrated and implementable alternative for application in the LDW.

The ENR component is also implementable. Administratively, ENR has been implemented in projects in the Puget Sound region, including the Thea Foss Waterway, Wyckoff/West Eagle Harbor, and the Puget Sound Naval Shipyard sites (Ecology 2005b; EPA 1995; EPA 2000). Like Alternative B, this alternative will require the application of institutional controls, including fish consumption advisories, until such time as fish tissue concentrations of PCBs are lowered to levels that are protective of human health. Long-term monitoring and institutional controls are both implementable and effective.

One area of technical uncertainty regarding the implementability of Alternative C would be slope stability during placement of ENR sediments. This will be evaluated further in the FS, and engineered during the design phase for successful implementation.

Administrative Implementability

The administrative issues for Alternative C are essentially the same as those in Alternative B. One issue that will require consideration is the administrative requirements for placement of ENR material in the navigation channel. This will be explored with the USACE and discussed in the FS.

Effectiveness

Short-Term Effectiveness

The dredging and disposal activities in Alternative C are the same as those described for Alternative B. Like dredging, ENR would have low potential to cause adverse health impacts to the community and workers from contaminant release during placement operations. There are no additional health or quality of life impacts to the community different than those described for dredging and disposal that would result from enacting the ENR portion of the remedy.

Time to complete the action varies with the selected total PCB RAL and the acres involved. Table 5-3 arrays the dredging and ENR alternatives by total PCB RAL. Completing the sponsored EAAs, PPAs, and AOIs with dredging of areas with total PCB concentrations above 65 mg/kg OC and ENR in areas with total PCB concentrations above 36 mg/kg OC would require remediation over approximately 56 acres, and require 25 on-water days to complete the AOI portion only. Completing the same actions in areas with total PCB concentrations above 6 mg/kg OC would involve 200.1 acres, and 516 on-water days to complete the AOI portion only. By contrast, the similar action for Alternative B required over 1,043 on-water days.

The estimated time to achieve the RAOs will be evaluated in the FS.

Long-Term Effectiveness

The dredging with upland disposal portion of the remedy provides a high degree of long-term effectiveness and permanence. The COPCs are permanently removed from the waterway and disposed in a controlled landfill. Sediment residuals that are at or above cleanup levels post-dredging are managed by thin-layer placement of clean sands or sediments over the dredging prisms. The relative magnitude of reductions in surface sediment total PCB concentrations, and the numbers of stations exceeding the chemical and toxicological SQS/CSL levels are the same as those described for Alternative B and are reflected in Table 5-1.

For the purposes of this PSA, placement of a thin-layer of sand or sediment for ENR over contaminated sediments is assumed to result in an immediate, but perhaps temporary, reduction in sediment COPC concentrations to an equilibrium value similar to that of capping (e.g., 5 mg/kg OC total PCBs). The relative long-term effectiveness of ENR will depend upon various factors, including the amount of material placed (e.g., 6 inches vs. 1 ft), stability on a slope, erosion potential, the starting COPC concentrations, and, in particular, the amount of re-working by the resident benthic organisms. Over time, it could be expected that reworking by benthic organisms or propwash would result in some elevated concentrations of COPCs, but it is currently not possible to predict to what degree that would occur. While ENR is an implementable and effective component of this alternative, the long-term effectiveness will need to be evaluated further in the FS.

Cost

Costs in Alternative C for completing the sponsored EAAs and the aggregate PPAs are the same as those represented in Alternative B: $44.5 million (M) and $28.2M, respectively. Incremental costs for each of the evaluated alternatives in C are presented in Table 5-3. The total estimated LDW project cost for Alternative C ranges from approximately $77.2M for active remediation of areas with total PCB concentrations above 36 mg/kg OC (dredging above 65 mg/kg OC, and ENR above 36 mg/kg OC), to approximately $165.2M for active remediation of areas with total PCB concentrations above 6 mg/kg OC (dredging above 12 mg/kg OC, and ENR above 6 mg/kg OC). While comparable in cost to dredging with upland disposal under Alternative B at the higher total PCB RALs (65 to 24 mg/kg OC), at the lower RALs the costs for managing to the same RAL are roughly 30 to 50 percent lower than those for Alternative B (for active remediation of areas with total PCB concentrations above 12 and 6 mg/kg OC, respectively).

5.2.4 Alternative D: Dredge with On-Site CAD Disposal and ENR

Implementability

Technical Implementability

Alternative D is similar to Alternative C, but includes mechanical dredging with disposal in an on-site, in-water CAD cell. Dredging is an implementable remedial alternative, as discussed for Alternative B. The equipment and infrastructure for sediment removal, transport, construction, and closure of a CAD cell are available for the LDW. This alternative has been demonstrated to be implementable in the LDW, in the Puget Sound region, and nation-wide. For example, a single CAD already exists within the West Waterway near the mouth of the Duwamish waterway. A CAD project has also recently been successfully completed at the Puget Sound Naval Shipyard. Construction of that CAD occurred off-site from the shipyard, not within the limits of a federally-maintained navigation channel.

Geotechnical explorations (or a review of geotechnical data from nearby locations) would be needed to assess implementability of the CAD cell excavations.

This alternative also includes ENR as a component. The same factors affecting implementation of ENR cited for Alternative C are relevant to Alternative D.

Additional technical implementability issues relate to the ability to construct, fill, and close CAD cells seasonally during times of low sedimentation rates from the upper Duwamish River system. As noted in Section 2, the upstream portion of the LDW where the CAD cells would be constructed is functionally a sediment “trap,” and is highly depositional.

Administrative Implementability

Challenges to implementation of this alternative would be associated with: (1) construction within the limits of the existing navigation channel, (2) construction of the CAD cell during the fish window (October to February) during a period when river flow and sediment transport into the LDW is at its highest, (3) potentially insufficient space (volume) to handle all of the LDW-wide dredged sediments at lower RALs, (4) institutional challenges associated with obtaining a restricted development covenant for the federally authorized navigation channel, and (5) administrative challenges related to agency approval.

A further institutional challenge to implementation of this alternative is the coordination that would be required (logistically and contractually) for use of the CAD among the (potentially) several performing parties that may be implementing the cleanups in the various portions of the LDW. Such challenges have been overcome for other similar on-site disposal projects (e.g., the Blair Slip 1 CDF in Commencement Bay), but there is limited ability at present to evaluate this factor in the LDW.

Effectiveness

Short-Term Effectiveness

Short-term impacts that would be associated with Alternative D for the dredging, upland disposal, and ENR components are the same as those described for Alternative B. Construction, use, and closure of the on-site CAD cell would have low potential to cause adverse health impacts to the community and workers. There are no additional health or quality of life impacts to the community different than those described for dredging and disposal that would result from enacting the CAD portion of the remedy, and less upland handling and transportation would be required compared with the upland disposal alternatives. Slightly greater short-term environmental impacts (e.g., turbidity generation, longer in-water work duration) would be associated with excavating and filling the CAD cells; these would be managed through monitoring and BMPs similar to the dredging process.

Time to complete the action varies with the selected total PCB RAL and the acres involved. Table 5-4 arrays the alternatives by total PCB RAL. Completing the sponsored EAAs, PPAs, and AOIs with dredging of areas with total PCB concentrations above 65 mg/kg OC and ENR in areas with total PCB concentrations above 36 mg/kg OC would require remediation over approximately 56 acres, and require 35 on-water days to complete the AOI portion only. Completing the same actions in areas with total PCB concentrations above 6 mg/kg OC involves 200.1 acres, and 634 on-water days to complete the AOI portion only.

The estimated time to achieve the RAOs will be evaluated in the FS.

Long-Term Effectiveness

Alternative D provides the same high degree of long-term effectiveness and permanence as Alternative C. While use of an on-site CAD cell means that some COPCs remain within the LDW, the chemicals are permanently and effectively contained and all exposure pathways are removed. Sediment volumes exceeding the CAD capacity would be taken to a Subtitle D landfill. Sediment residuals that are at or above cleanup levels post-dredging are managed by thin-layer placement of clean sands or sediments over the dredging prisms. The relative magnitude of reductions in surface sediment total PCB concentrations, and the numbers of stations exceeding the chemical and toxicological SQS/CSL levels are the same as those described for Alternative C, and are reflected in Table 5-1.

Cost

Costs in Alternative D for completing the sponsored EAAs and the aggregate PPAs are the same as those represented in Alternative B: $44.5M and $28.2M, respectively. Incremental costs for each of the evaluated alternatives in D are presented in Table 5-4. The total estimated LDW project cost for Alternative D ranges from approximately $76.5M for active remediation of areas with total PCB concentrations above 36 mg/kg OC (dredging above 65 mg/kg OC, and ENR above 36 mg/kg OC), to approximately $157.0M for active remediation of areas with total PCB concentrations above 6 mg/kg OC (dredging above 12 mg/kg OC, and ENR above 6 mg/kg OC). While comparable in cost to dredging with upland disposal under Alternative B at the higher RALs (65 to 24 mg/kg OC), at the lower RALs the costs for managing to the same RAL are similar to Alternative C, and roughly 30 to 50 percent lower than those for Alternative B (for active remediation of areas with total PCB concentrations above 12 and 6 mg/kg OC, respectively).

For the purposes of this PSA, Alternative D costs have assumed that dredged material from the PPAs is not disposed of in the CAD, but rather would go to upland disposal. Additional cost savings could be realized under Alternative D if the PPA material were disposed of in the CAD. This may be further evaluated in the FS.

5.2.5 Alternative E: Dredge with Treatment and Beneficial Use

Implementability

Technical Implementability

Alternative E is similar to Alternative C, but includes treatment by conventional soil washing and separation of dredged material, beneficial use of the retained sand portion, and off-site upland disposal of the contaminated fine-grained fractions of the dredged material. The mechanical dredging, barge transport, and upland disposal components of this alternative have been demonstrated to be implementable for the LDW. The equipment and infrastructure for sediment removal, transport, and off-loading are in place in the waterway or nearby.

A technical concern associated with the sediment/washing/separation component is availability of equipment and expertise. While the process equipment itself is generally available, it not generally available in the Puget Sound region. Hydrocyclones, centrifuges, or mobile soil washing processes have been used at other contaminated dredging projects outside the region; but this equipment would need to be mobilized to the LDW. Recent examples include New Bedford Harbor, Massachusetts; SMU 56/57 on the Lower Fox River, Wisconsin; Manistique Harbor, Michigan; and the Miami River, Florida sediment sites.

A second concern is the need to establish and maintain the required infrastructure for treatment. Implementation would require siting a treatment facility. At present, there are no established soil-washing treatment facilities in the region. Consequently, an upland property would be required to erect and operate a plant to accommodate material storage, pretreatment, and handling processes. If located outside the LDW, the processing site would also require permitting.

Water treatment would be required to meet the conditions of an NPDES permit for discharge to the waterway. Treatment of decant water containing PCBs has been effective at the other sites listed above. Provided the substantive requirements for a permit can be met, water treatment would be a cost consideration, but not an implementation barrier.

Implementability of this alternative would also depend upon quantifying the percent sand component throughout the sediment column profile and identifying whether a 30 percent sand fraction is an appropriate cut-off for LDW sediments. For the purposes of this PSA, a 30 percent sand content is assumed to be the lower cutoff for efficient recovery in this type of treatment process. Phase 1 and 2 data from the LDW indicate that surface sediments in the LDW comprise more than 30 percent sand in up to 60 percent of the waterway, but this assumption will need to be re-evaluated as a result of the Phase 2 sediment coring work. Additionally, sediments with higher TOC require additional treatment and handling procedures and, as such, a more appropriate cut-off under those conditions might be as high as 50 percent sand. More detailed economic analyses and treatability testing would be needed to define this critical criterion.

There are no barriers to disposal of the retained filter cake after treatment. While testing may be required to ensure that it meets the criteria for a Subtitle D landfill, the transport and disposal facilities are in place.

ENR is also a component of this remedy. The same applications and limits described for Alternative C are applicable to Alternative E.

Administrative Implementability

Administrative issues associated with the dredge, disposal, and ENR components of Alternative E are similar to those described for Alternatives B and C. An institutional challenge to implementation of this alternative is the coordination that would be required (logistically and contractually) for use of the treatment facility among the (potentially) several performing parties that may be implementing the cleanups in the various portions of the LDW. This is a greater concern under this alternative (compared to Alternative D) because of the large fixed investments that would be required for treatability testing, mobilizing the technology, and siting the treatment facility. Also, certain performing parties may not elect to use the treatment facility because of liability concerns associated with residual COPC concentrations in wastewater and treated material.

Beneficial use of the separated material requires that: (1) the retained sands have chemical concentrations that are less than the applicable DMMP[5] or SMS criteria, (2) the retained material will be structurally unaltered and acceptable by DMMP standards, and (3) an administrative mechanism can be found to allow the beneficial use of the material. The latter concern would be reduced if the treatment and beneficial use occurred on-site, in which case these activities would not require permitting.

Effectiveness

Short-Term Effectiveness

Short-term effectiveness issues would be similar as those described for Alternatives B and C. Construction, use, and closure of the mobile soil-washing units may have somewhat greater short-term risks to workers, as a result of the increased handling and processing of the sediments. The sediment treatment facility may have greater environmental impacts to nearby

[5] The CTM (RETEC 2005b) documented that the first determination for beneficial use is whether treated dredged material is classified as a solid waste. Under Washington State law, a dredged material is defined as a solid waste if it has been designated as unsuitable for open-water disposal (WAC 173-350-040 of the Solid Waste Handling Standards). For evaluating potential treatment technologies, the DMMP Screening Levels (SL) would be used to define whether the material is a solid waste. Treated material that meets these screening levels may be a candidate for in-water beneficial use, if the material can also be shown to meet the Washington State Sediment Management Standards (WAC 173-204). Treated sediment that exceeds the DMMP SL may qualify for upland use, but would require a more stringent set of permit requirements.

communities (e.g., noise and exhaust from heavy equipment, over longer timeframes) as compared to upland or in-water disposal alternatives.

Time to complete the action (Table 5-5) is similar to that described for Alternative D. Completing the sponsored EAAs, PPAs, and AOIs with dredging of areas with total PCB concentrations above 65 mg/kg OC and ENR in areas with total PCB concentrations above 36 mg/kg OC would require remediation over approximately 56 acres, and require 25 on-water days to complete the AOI portion only. Completing the same actions in areas with total PCB concentrations above 6 mg/kg OC involves 200.1 acres, and 516 on-water days to complete the AOI portion only.

The estimated time to achieve the RAOs will be evaluated in the FS.

Long-Term Effectiveness

Alternative E provides the same high degree of long-term effectiveness and permanence as Alternative C. As noted above, confirmation that the washed and retained material will need to be at or below the DMMP criteria, and/or the selected RAL in the ROD, before it may be beneficially used in the waterway. The relative magnitude of reductions in surface sediment total PCB concentrations, and the numbers of stations exceeding the chemical and toxicological SQS/CSL levels are the same as those described for Alternative C, and are reflected in Table 5-1.

Cost

Costs in Alternative E for completing the sponsored EAAs and the aggregate PPAs are the same as those represented under all alternatives: $44.5M and $28.2M, respectively. Incremental costs for each of the evaluated alternatives in E are presented in Table 5-5. The total estimated LDW project cost for Alternative E ranges from approximately $80.5M for active remediation of areas with total PCB concentrations above 36 mg/kg OC (dredging above 65 mg/kg OC, and ENR above 36 mg/kg OC), to approximately $176.1M for active remediation of areas with total PCB concentrations above 6 mg/kg OC (dredging above 12 mg/kg OC, and ENR above 6 mg/kg OC).

For the purposes of this PSA, Alternative E costs have assumed that dredged material from the PPAs is not treated, but rather would go to upland disposal. Higher costs would be associated with Alternative E if the PPA material were treated. This could be further evaluated in the FS if that document develops a treatment alternative. Finally, the unit costs developed for Alternative E ($138 - $ 329/cy) may have a higher degree of uncertainty than the unit costs associated with the other alternatives because of uncertainties in the effectiveness of the treatment facility siting and beneficial use scenarios. The FS will further evaluate whether the 30% sand criterion is both applicable and practical for the LDW, the costs associated with facility siting and mobilization, as well as the potential for beneficial reuse of treated sand.

5.2.6 Alternative F: Cap to the Maximum Extent Practicable

Implementability

Technical Implementability

Capping is a well-demonstrated and implementable remedial alternative for contaminated sediments in the Puget Sound region. The equipment, infrastructure, and technical know-how for implementing this alternative are present in the LDW. The CTM (RETEC 2005b) documented 15 capping projects that have been successfully implemented within the Puget Sound region. These have included sand, conventional sediment, armored, and composite caps. Reactive caps have also been implemented in the Puget Sound region and are currently being considered for several other locations within Washington State.

Caps are technically implementable provided the basic engineering constraints can be accommodated (e.g., bottom depth requirements in navigation areas). Additional technical considerations that would be considered in the remedial design phase include site-specific design for erosion, earthquakes, identifying the appropriate long-term institutional controls over the capped site, and assessing site-specific impacts to habitat quality. For composite or reactive caps, the expected tidal ranges in the LDW may require additional planning and engineering considerations.

MNR and ENR are also components of this remedy. The same applications and limits described for Alternative C are applicable to Alternative F.

Administrative Implementability

The primary substantive institutional or administrative barriers to capping in the LDW relate to land ownership and requirements for long-term site use and cap monitoring. Any cap constructed on privately-owned land would require concurrence by the landowner, a legal mechanism to implement the required long-term commitment to monitoring and maintenance, and institutional controls, including deed or use restrictions for activities that could disturb a cap. The Port of Seattle controls a large portion of the LDW property originally belonging to the King County Commercial Waterway District No. 1. There are a number of private owners that own small portions of the in-water portions of the LDW or the side slips, as well as platted streets that are controlled by the City of Seattle and King County, out to the Port property. Site ownership issues will be evaluated further in the FS.

Changes to critical habitat that might be associated with elevation changes would be addressed in the design for specific SMAs. This PSA assumes approximate restoration of existing intertidal grades in capped areas. During the FS or design phase, caps that result in expansion of shallow subtidal or intertidal habitat might also be considered. Institutional controls would be required with any capping alternative, including restrictive covenants, potential waterway use restrictions, and a commitment to a long-term operation and maintenance plan.

Effectiveness

Short-Term Effectiveness

Short-term effectiveness issues would be generally the same as those described for Alternatives B and C. However, short-term water quality impacts may be somewhat lesser under Alternative F because less contaminated sediment would be disturbed and resuspended as a result of the dredging process. Cap construction would have low to moderate potential to cause adverse health impacts to the community and workers.

Time to complete the action is similar to that described for Alternative C (Table 5-6). Completing the sponsored EAAs, PPAs, and AOIs with capping of areas with total PCB concentrations above 65 mg/kg OC and ENR in areas with total PCB concentrations above 36 mg/kg OC would require remediation over approximately 56 acres, and require 17 on-water days to complete the AOI portion only. Completing the same actions in areas with total PCB concentrations above to 6 mg/kg OC involves 200.1 acres, and 383 on-water days to complete the AOI portion only.

The estimated time to achieve the RAOs will be evaluated in the FS.

Long-Term Effectiveness

Alternative F provides a similar degree of long-term effectiveness and permanence as Alternative B. Use of in-water containment caps results in a permanent and effective containment of the chemicals left in place, and removal of all exposure pathways. The relative magnitude of reductions in surface sediment total PCB concentrations, and the numbers of stations exceeding the chemical and toxicological SQS/CSL levels are the same as those described for Alternative C, and are reflected in Table 5-1.

Cost

Costs in Alternative F for completing the sponsored EAAs and the aggregate PPAs are the same as those represented under all alternatives: $44.5M and $28.2M, respectively. Incremental costs for each of the evaluated alternatives in F are presented in Table 5-6. The total estimated LDW project cost for Alternative F ranges from approximately $76.6M for active remediation of areas with total PCB concentrations above 36 mg/kg OC (dredging above 65 mg/kg OC, and ENR above 36 mg/kg OC), to approximately $156.8M for active remediation of areas with total PCB concentrations above 6 mg/kg OC (dredging above 12 mg/kg OC, and ENR above 6 mg/kg OC).

5.2.7 Alternative G: Hypothetical Combined Alternative

Implementability

Technical Implementability

The combined alternative uses the same remedial elements as described for Alternatives C and F and is thus considered to be implementable for the LDW. The main distinction between this alternative and those previously described is that this alternative applies different sediment RALs to different reaches and segments of the waterway.

Administrative Implementability

Issues associated with administrative implementability are the same as those described for Alternatives C and F.

Effectiveness

Short-term and long-term effectiveness are similar to those described for Alternatives C and F. The estimated post-cleanup total PCB SWAC for this alternative is 5.6 mg/kg OC.

Cost

The aggregate cost for completing the sponsored EAAs, PPAs and the actions under Alternative G is approximately $86.6M (Table 5-7). In this hypothetical combined alternative, the cost falls approximately mid-way between alternatives 2 and 3 for the other evaluated Alternatives (B through F).

5.3 Preliminary Comparison of Alternatives

This section compares, contrasts, and screens the alternatives based upon the implementability, effectiveness, and cost information presented in the previous section. Comparative costs for all of the alternatives are provided in Table 5-8. A relative ranking of implementability and effectiveness for all of the alternatives is provided in Table 5-9.

5.3.1 Implementability Comparison

All remedial alternatives described in this PSA are generally technically and administratively implementable in the LDW. Dredging, upland disposal, capping, and ENR have all been implemented to varying degrees in the LDW, in the Puget Sound region, and in EPA Region 10, and are considered to have a moderate to high degree of ability to be technically implemented (Table 5-9). Alternatives D (CAD disposal) and E (treatment with beneficial use) are technically implementable, but have administrative barriers associated with implementing the alternatives. While the CADs have a successful history of application in the Puget Sound region and nation-wide, the main administrative challenges to implementation include obtaining a restricted development covenant for the federally authorized navigation channel, gaining agency approval for the alternative, and coordination that would be required (logistically and contractually) for use of the CAD among the (potentially) several performing parties that may be implementing the cleanups in the various portions of the LDW. Alternative D is thus ranked as having a low to moderate degree of administrative implementability (Table 5-10).

Alternative E is technically implementable, using demonstrated and proven soil washing and separation equipment to separate the sediment into (presumably) clean sand that is available for beneficial use, and landfilling the residual contaminated silts/clays. While not having a demonstrated record in the Puget Sound region or EPA Region 10, separation has been successfully demonstrated on several large-scale PCB projects nationally. Beneficial use of the separated material requires that: (1) the retained sands have chemical concentrations that are less than the applicable DMMP or SMS criteria, (2) the retained material will be structurally unaltered and acceptable by DMMP standards, and (3) an administrative mechanism can be found to allow the beneficial use of the material on-site. Alternative E is thus ranked as having a low to moderate ability to be administratively implemented.

5.3.2 Effectiveness Comparison

Short-Term Effectiveness

All of the remedial alternatives evaluated are considered to have short-term effectiveness. The degree to which there may be short-term impacts to human health and the environment during remedial construction primarily depends upon the level of cleanup required; a higher degree (or area) required for cleanup will require a longer time-frame to implement, and would thus be considered to have increased opportunity to adversely impact the in-water receptors, as well as impact the community, tribal, and industrial uses of the waterway. For example, the most aggressive action of dredging (with upland disposal) areas with total PCB concentrations above 6 mg/kg OC (Alternative B5) would require 1,043 on-water days to implement (Table 5-9). To achieve a similar level of management using a capping emphasis (Alternative F4) would require only 383 on-water days. This comparison illustrates the fact that there are ways of achieving the same long-term protection, while minimizing short-term impacts on the environment and the community.

Long-Term Effectiveness

This PSA assumes that all of the remedial alternatives confer the same degree of risk reduction when implemented at similar hypothetical total PCB RALs. Figure 5-1 shows graphically that the greatest reduction in the total PCB SWAC occurs with completion of the sponsored EAAs and PPAs, and then incrementally smaller reductions are achieved for each progressive multiple of the SQS in the AOIs. Remediating the 14.3 acres in the AOIs with total PCB concentrations above 24 mg/kg OC would result in a total PCB SWAC of approximately 5.6 mg/kg OC. Remediating all sediments in the AOIs with total PCB concentrations above 12 mg/kg OC would require removal or containment of 46.7 acres and would yield an additional decrease in the total PCB SWAC of less than approximately 0.8 mg/kg OC. Remediating all sediments in the AOIs with total PCB concentrations above 6 mg/kg OC would involve a total of 150 acres, while yielding an additional total PCB SWAC reduction of only approximately 1.6 mg/kg OC relative to remediating all sediments with total PCB concentrations above 24 mg/kg OC.

These analyses suggest that there might be a waterway-wide lower limit of what is technically achievable in terms of a post-remedial total PCB SWAC, and that limit may be on the order of a total PCB SWAC of 4 mg/kg OC. To achieve this lower limit in the short term would require actively remediating a total of approximately 200 acres in the LDW (sponsored EAAs, PPAs, and AOIs to 6 mg/kg OC). The lower limit of total PCB reduction, or residual concentrations in equilibrium with surrounding sediments and new sediment deposition, is not known at this time, and may need to be further evaluated in the FS. Some combination of short-term active reductions and longer-term natural recovery may also be effective in achieving a similar total PCB SWAC reduction over a longer restoration timeframe.

The anticipated effectiveness of the various remedial alternatives in reducing the numbers of stations with chemical and/or toxicity test SQS/CSL exceedances are shown in Table 5-1. Table 5-1 shows that with increasingly aggressive cleanups, there is a concomitant reduction in stations exceeding the SQS/CSL. Figure 5-3 shows the location of stations with chemical exceedances of the SQS/CSL after completion of the sponsored EAAs and PPAs, while Figure 5-4 shows the same for toxicity tests. What is evident from these data is that even with the most aggressive cleanup (of all areas with total PCB concentrations above 6 mg/kg OC), there will still be residual chemical and toxicity test exceedances within the LDW.

The remedial alternatives do vary in their degree of permanence and in their long-term reliance on institutional controls (Table 5-9). Dredging, soil washing, capping, and upland or CAD placement of contaminated sediments have a high degree of permanence and long-term effectiveness. Alternatives C through G incorporate ENR as an active remedy component. The degree to which ENR confers permanence or long-term effectiveness will need to be investigated further in the FS. All remedies likewise assume that MNR will be a component of the remedy; MNR will also require further investigation in the FS.

Cost

As set forth in CERCLA and MTCA (Chapter 173-340-360[5]), a cleanup action is not considered practicable if the incremental cost of a cleanup action is substantial and disproportionate to the incremental degree of protection it would provide over a lower and less protective cleanup action. When selecting from among two or more remedial alternatives that provide sufficient and equal levels of protection, the alternative with the lower cost may be given preference; subject to public concerns, stakeholder preference, and technical uncertainty.

Total project costs estimated in this PSA range from $44.5M for Alternative A (no action, other than completion of the sponsored EAAs), to $258M for dredging with upland disposal of sediments with total PCB concentrations above 6 mg/kg OC (Table 5-9). Figure 5-5 shows the incremental aggregate cost for each of the remedial alternatives relative to the changes in the total PCB SWAC. These analyses suggest the following:

1) The sponsored EAA and the PPA actions are estimated to cost, on aggregate $72.7M, and cumulatively to reduce the total PCB SWAC by 46 percent (Table 5-9). The incremental increases in SWAC reduction by implementing additional actions in the AOIs are low by comparison (Figure 5-1), and require increasingly large expenditures.

2) Alternative B, dredging with upland disposal, is the most aggressive and costly remedial alternative.

3) Alternatives C through F are relatively similar in cost for total PCB RALs between 65 and 12 mg/kg OC, but differentiate more clearly with increasingly lower RALs (i.e., 6 mg/kg OC) (Figure 5-5).

4) A combined alternative (Alternative G is presented as one possible example) may provide the greatest cost-benefit balancing.

5.4 Screening Summary

Based upon the comparative analysis, the remedial alternatives are screened as follows:

- **Alternative A.** No Further Action (other than completion of the sponsored EAAs) is a required remedial alternative under the NCP and is retained for further evaluation in the FS. Alternative A also provides a baseline against which all other actions in the LDW can be compared in terms of cost and overall risk reduction.

- **Alternative B.** Dredge with Upland Disposal is retained for further evaluation in the FS. This alternative is commonly employed in the LDW, the Puget Sound region, and EPA Region 10, and the equipment and facilities necessary for implementing this alternative are readily available. Removal with upland Subtitle D landfill disposal is implementable; effective for managing the COPC and biological effects in the LDW; and, while the most expensive of the alternatives evaluated, it is considered to be cost-effective.

- **Alternative C.** Dredge with Upland Disposal and ENR is retained for further evaluation in the FS. This alternative is similar to Alternative B, but includes ENR as a component of achieving a given hypothetical total PCB RAL. The ability of ENR to achieve long-term effectiveness and permanence will be further evaluated in the FS.

- **Alternative D.** Dredge with Disposal to an On-Site CAD is not retained for further evaluation in the FS as a stand-alone remedy on a site-wide basis. While technically implementable and effective for the COPCs in the LDW, this alternative is screened out as a site-wide alternative based principally on the administrative and institutional challenges associated with permanently locating a CAD cell within the federally authorized navigation channel and coordinating the construction and use of the CAD among various performing parties. CAD as a process option is retained, and may become a component of other alternatives evaluated during the FS or during the design phase.

- **Alternative E.** Dredge with Treatment, Beneficial Use, and Upland Disposal. Treatment is retained for further evaluation in the FS on a site-wide basis. While technically implementable, technical issues would need to be resolved to demonstrate that retained material would be acceptable by DMMP and SMS standards. Administrative concerns include siting and (potential) permitting of a treatment facility, and coordinating the construction and use of the treatment facility among various performing parties. Finally, the increased cost of Alternative E does not afford additional protectiveness compared to the other alternatives. Soil washing as a treatment process is retained, and may become a component of other alternatives evaluated during the FS.

- **Alternative F.** Cap to the Maximum Extent Practicable is retained for further consideration in the FS. Capping has been demonstrated within the Puget Sound region to be implementable, effective for managing the COPCs and biological effects in the LDW, and cost-effective.

- **Alternative G.** The hypothetical Combined Alternative is retained for further consideration in the FS. Alternative G is implementable, effective for managing the COPCs and biological effects in the LDW, and is cost-effective. While a specific example of a combined alternative was developed in this PSA, other similar combined alternatives may be further explored in the FS.

Table 5-1 Effectiveness of Potential Remedial Alternatives in Reducing Chemical Concentrations and Toxicity [1]

Remedial Areas	Acres per Area [3]	Cumulative Total Acres [4]	SWAC Reduction: Post-Remedial Total PCB SWAC [5] (mg/kg OC)	SWAC Reduction: % Reduction [6] in Total PCB SWAC (mg/kg OC)	Point Reduction: # of Detected SQS/CSL Chemical Exceedances Remaining Post-Remedy (All Chemicals): > SQS, ≤ CSL	Point Reduction: # of Detected SQS/CSL Chemical Exceedances Remaining Post-Remedy (All Chemicals): >CSL	Point Reduction: # of SQS/CSL Toxicity Exceedances Remaining Post-Remedy [7]
Baseline Conditions	200.1	—	13.0	0%	309	252	30
EAAs [2]	31.2	31.2	7.9	39%	210	79	30
PPAs	19.3	50.5	7.0	46%	145	38	22
AOIs							
> 65 (CSL)	2.1	52.6	6.1	53%	143	28	20
≤ 65 and >36	3.4	56.0	6.1	53%	133	26	17
≤ 36 and >24	8.8	64.8	5.6	57%	113	25	14
≤ 24 and >12 (SQS)	32.4	97.2	4.8	63%	41	22	9
≤ 12 and > 6	102.9	200.1	4.0	69%	26	14	4
TOTAL	**200.1**						

Notes:

1 Preliminary estimates subject to change. Estimates do not account for long-term reduction in concentrations associated with MNR.

2 Four surface samples (CH0014, SD-DUW60, WES238, SD-DUW87) on boundary of Boeing Plant 2 EAA included within the EAA removal areas.

3 Total acres in this evaluation include sponsored EAAs, PPAs, and the AOIs where surface sediments are > 6 total PCB mg/kg OC.

4 Cumulative total acres includes the sponsored EAAs, PPAs, and the interval in the AOIs that exceeds the specified total PCB concentration.

5 SWAC calculated by replacing all remedial areas with 5 mg/kg OC. Any value <6 mg/kg OC is retained in the SWAC calculation.

6 From baseline.

7 Stations where there is an SQS or CSL exceedance for any toxicity hit; summarized by location.

Table 5-2 Summary of Costs for Alternative B: Dredge with Upland Off-site Disposal [1,2]

Sponsored EAAs and PPAs	Quantity	Units	Cost	Post-Remedy SWAC	% Reduction from Baseline
Sponsored Early Action Areas [3]	**31.2**	**Acres**	**$44,500,000**	7.9	39%
Potential Priority Areas [3]	**19.3**	**Acres**	**$28,200,000**	7	46%

			B1		**B2**		**B3**		**B4**		**B5**	
			Dredge above 65 mg/kg OC		**Dredge above 36 mg/kg OC**		**Dredge above 24 mg/kg OC**		**Dredge above 12 mg/kg OC**		**Dredge above 6 mg/kg OC**	
Areas of Interest	**Unit**	**Unit Cost**	**Quantity**	**Cost**	**Quantity**	**Cost**	**17**	**Cost**	**Quantity**	**Cost**	**Quantity**	**Cost**
Dredging [4]	CYS	$30	23,407	$702,203	56,187	$1,685,596	120,215	$3,606,464	385,510	$11,565,312	1,189,429	$35,682,876
Disposal of Dredged Material [5]	CYS	$91	23,407	$2,139,837	56,187	$5,136,549	120,215	$10,990,051	385,510	$35,243,207	1,189,429	$108,737,142
Treatment and Disposal of Filter Cake (Alternative E only) [10]	CYS	$138 - $329	0	$0	0	$0	0	$0	0	$0	0	$0
Confined Aquatic Disposal [13]	CYS	$63	0	$0	0	$0	0	$0	0	$0	0	$0
Containment Capping [6]	Acres	$388,582	0	$0	0	$0	0	$0	0	$0	0	$0
Residual Capping [7]	Acres	$84,858	2.40	$203,659	5.00	$424,290	6.50	$551,577	26.60	$2,257,224	96.10	$8,154,858
Habitat Restoration Capping [8]	Acres	$270,604	0.40	$108,242	2.10	$568,269	6.00	$1,623,625	20.80	$5,628,568	53.60	$14,504,387
Enhanced Natural Recovery (ENR) [9]	Acres	$75,549	0.00	$0	0.00	$0	0.00	$0	0.00	$0	0.00	$0
Construction QA/QC [11]	Acres	$121,397	2.80	$339,911	7.10	$861,917	12.50	$1,517,459	47.40	$5,754,205	149.70	$18,173,089
Long-Term Cap O&M Monitoring [12]	Acres	$128,099	0	$0	0	$0	0	$0	0	$0	0	$0
Monitored Natural Recovery Compliance Monitoring Administrative Costs Institutional Costs			*Monitored natural recovery, compliance monitoring, institutional controls, and administrative costs are assumed to be independent of active remedial action levels and therefore not included for analysis under the PSA.*									
Total Estimated AOI Cost				**$3,493,851**		**$8,676,621**		**$18,289,177**		**$60,448,515**		**$185,252,352**
Estimated Days to Complete In-Water Activities, Disposal, and/or Soil Washing				**21**		**49**		**104**		**337**		**1043**
Post-Remedial Spatially-Weighted Average Concentration (SWAC) of total PCBs (mg/kg OC)				**6.1**		**6.1**		**5.6**		**4.8**		**4.0**
Percent Reduction in SWAC from Baseline				**53%**		**53%**		**57%**		**63%**		**69%**
TOTAL REMEDY COST				**$76,200,000**		**$81,400,000**		**$91,000,000**		**$133,200,000**		**$258,000,000**

Note: Costs associated with engineering, procurement, management, overhead, contingency, and sales tax are calculated within each unit cost

[1] These estimates do not include RI/FS costs of approximately $30 million for the LDW.
[2] Long-term compliance monitoring costs are not included in these costs.
[3] Assumes 6 ft removal of Navigation Channel and Deep Bench Areas and 3 ft removal and 3 ft capping of Shallow Bench Areas for PPAs. Remedial costs associated with sponsored EAAs were provided by LDWG.
[4] Dredging assumptions used for unit costs are presented in Table C-6
[5] Disposal and handling assumptions used for unit costs are presented in Table C-7
[6] Capping assumptions used for unit costs are presented in Table C-10
[7] Residual assumptions used for unit costs are presented in Table C-11
[8] Habitat restoration assumptions used for unit costs are presented in Table C-12
[9] ENR assumptions used for unit costs are presented in Table C-13
[10] Treatment assumptions used for unit costs are presented in Table C-8
[11] Construction QA/QC assumptions used for unit costs are presented in Table C-14
[12] Long-term cap O&M assumptions used for unit costs are presented in Table C-15
[13] Confined Aquatic Disposal assumptions used for unit costs are presented in Table C-9

Table 5-3 Summary of Costs for Alternative C: Dredge with Upland Off-Site Disposal and ENR [1,2]

Sponsored EAAs and PPAs	Quantity	Units	Cost	Post-Remedy SWAC	% Reduction from Baseline
Sponsored Early Action Areas[3]	**31.2**	**Acres**	**$44,500,000**	7.9	39%
Potential Priority Areas[3]	**19.3**	**Acres**	**$28,200,000**	7	46%

			C1		C2		C3		C4	
			Dredge above 65 mg/kg OC ENR above 36 mg/kg OC total PCBs		Dredge above 36 mg/kg OC ENR above 24 mg/kg OC total PCBs		Dredge above 24 mg/kg OC ENR above 12 mg/kg OC total PCBs		Dredge above 12 mg/kg OC ENR above 6 mg/kg OC total PCBs	
Areas of Interest	**Unit**	**Unit Cost**	**Quantity**	**Cost**	**Quantity**	**Cost**	**Quantity**	**Cost**	**Quantity**	**Cost**
Dredging[4]	CYS	$30	23,407	$702,203	56,187	$1,685,596	120,215	$3,606,464	385,510	$11,565,312
Disposal of Dredged Material[5]	CYS	$91	23,407	$2,139,837	56,187	$5,136,549	120,215	$10,990,051	385,510	$35,243,207
Treatment and Disposal of Filter Cake (Alternative E only)[10]	CYS	$138 - $329	0	$0	0	$0	0	$0	0	$0
Confined Aquatic Disposal[13]	CYS	$63	0	$0	0	$0	0	$0	0	$0
Containment Capping[6]	Acres	$388,582	0	$0	0	$0	0	$0	0	$0
Residual Capping[7]	Acres	$84,858	1.70	$144,259	3.60	$305,489	9.80	$831,609	36.80	$3,122,776
Habitat Restoration Capping[8]	Acres	$270,604	0.40	$108,242	2.10	$568,269	6.00	$1,623,625	20.80	$5,628,568
Enhanced Natural Recovery (ENR)[9]	Acres	$75,549	3.40	$256,867	8.60	$649,722	30.80	$2,326,910	92.10	$6,958,065
Construction QA/QC[11]	Acres	$121,397	5.50	$667,682	14.30	$1,735,973	46.60	$5,657,087	149.70	$18,173,089
Long-Term Cap O&M Monitoring[12]	Acres	$128,099	3.40	$435,537	8.60	$1,101,653	30.80	$3,945,453	92.10	$11,797,930
Monitored Natural Recovery Compliance Monitoring Administrative Costs Institutional Controls			*Monitored natural recovery, compliance monitoring, institutional controls, and administrative costs are assumed to be independent of active remedial action levels and therefore not included for analysis under the PSA.*							
Total Estimated AOI Cost				$4,454,626		$11,183,250		$28,981,200		$92,488,948
Estimated Days to Complete In-Water Activities, Disposal, and/or Soil Washing				23		56		131		418
Post-Remedial Spatially-Weighted Average Concentration (SWAC) of total PCBs (mg/kg OC)				6.1		6.1		5.6		4.8
Percent Reduction in SWAC from Baseline				53%		53%		57%		63%
TOTAL REMEDY COST				**$77,200,000**		**$83,900,000**		**$101,700,000**		**$165,200,000**

Note: Costs associated with engineering, procurement, management, overhead, contingency, and sales tax are calculated within each unit cost

1 These estimates do not include RI/FS costs of approximately $30 million for the LDW.

2 Long-term compliance monitoring costs are not included in these costs.

3 Assumes 6 ft removal of Navigation Channel and Deep Bench Areas and 3 ft removal and 3 ft capping of Shallow Bench Areas for PPAs. Remedial costs associated with sponsored EAAs were provided by LDWG.

4 Dredging assumptions used for unit costs are presented in Table C-6

5 Disposal and handling assumptions used for unit costs are presented in Table C-7

6 Capping assumptions used for unit costs are presented in Table C-10

7 Residual assumptions used for unit costs are presented in Table C-11

8 Habitat restoration assumptions used for unit costs are presented in Table C-12

9 ENR assumptions used for unit costs are presented in Table C-13

10 Treatment assumptions used for unit costs are presented in Table C-8

11 Construction QA/QC assumptions used for unit costs are presented in Table C-14

12 Long-term cap O&M assumptions used for unit costs are presented in Table C-15

13 Confined Aquatic Disposal assumptions used for unit costs are presented in Table C-9

Table 5-4 Summary of Costs for Alternative D: Dredge with Upland Off-Site Disposal and On-Site In-Water CAD Disposal [1,2]

Sponsored EAAs and PPAs	Quantity	Units	Cost	Post-Remedy SWAC	% Reduction from Baseline
Sponsored Early Action Areas [3]	**31.2**	**Acres**	**$44,500,000**	7.9	39%
Potential Priority Areas [3]	**19.3**	**Acres**	**$28,200,000**	7	46%

			D1		D2		D3		D4	
			Dredge above 65 mg/kg OC ENR above 36 mg/kg OC total PCBs		Dredge above 36 mg/kg OC ENR above 24 mg/kg OC total PCBs		Dredge above 24 mg/kg OC ENR above 12 mg/kg OC total PCBs		Dredge above 12 mg/kg OC ENR above 6 mg/kg OC total PCBs	
Areas of Interest	**Unit**	**Unit Cost**	**Quantity**	**Cost**	**Quantity**	**Cost**	**Quantity**	**Cost**	**Quantity**	**Cost**
Dredging [4]	CYS	$30	23,407	$702,203	56,187	$1,685,596	120,215	$3,606,464	385,510	$11,565,312
Disposal of Dredged Material [5]	CYS	$91	0	$0	0	$0	0	$0	101,510	$9,280,040
Treatment and Disposal of Filter Cake (Alternative E only) [10]	CYS	$138 - $329	0	$0	0	$0	0	$0	0	$0
Confined Aquatic Disposal [13]	CYS	$63	23,407	$1,463,098	56,187	$3,512,078	120,215	$7,514,367	284,000	$17,752,124
Containment Capping [6]	Acres	$388,582	0	$0	0	$0	0	$0	0	$0
Residual Capping [7]	Acres	$84,858	1.70	$144,259	3.60	$305,489	9.80	$831,609	36.80	$3,122,776
Habitat Restoration Capping [8]	Acres	$270,604	0.40	$108,242	2.10	$568,269	6.00	$1,623,625	20.80	$5,628,568
Enhanced Natural Recovery (ENR) [9]	Acres	$75,549	3.40	$256,867	8.60	$649,722	30.80	$2,326,910	92.10	$6,958,065
Construction QA/QC [11]	Acres	$121,397	5.50	$667,682	14.30	$1,735,973	46.60	$5,657,087	149.70	$18,173,089
Long-Term Cap O&M Monitoring [12]	Acres	$128,099	3.40	$435,537	8.60	$1,101,653	30.80	$3,945,453	92.10	$11,797,930
Monitored Natural Recovery			*Monitored natural recovery, compliance monitoring, institutional controls, and administrative costs are assumed to be independent of active remedial action levels and therefore not included for analysis under the PSA.*							
Compliance Monitoring										
Administrative Costs										
Institutional Controls										
Total Estimated AOI Cost				$3,777,886		$9,558,779		$25,505,516		$84,277,905
Estimated Days to Complete In-Water Activities, Disposal, and/or Soil Washing				33		79		181		536
Post-Remedial Spatially-Weighted Average Concentration (SWAC) of total PCBs (mg/kg OC)				6.1		6.1		5.6		4.8
Percent Reduction in SWAC from Baseline				53%		53%		57%		63%
TOTAL REMEDY COST				**$76,500,000**		**$82,300,000**		**$98,300,000**		**$157,000,000**

Note: Costs associated with engineering, procurement, management, overhead, contingency, and sales tax are calculated within each unit cost

[1] These estimates do not include RI/FS costs of approximately $30 million for the LDW.

[2] Long-term compliance monitoring costs are not included in these costs.

[3] Assumes 6 ft removal of Navigation Channel and Deep Bench Areas and 3 ft removal and 3 ft capping of Shallow Bench Areas for PPAs. Remedial costs associated with sponsored EAAs were provided by LDWG.

[4] Dredging assumptions used for unit costs are presented in Table C-6

[5] Disposal and handling assumptions used for unit costs are presented in Table C-7

[6] Capping assumptions used for unit costs are presented in Table C-10

[7] Residual assumptions used for unit costs are presented in Table C-11

[8] Habitat restoration assumptions used for unit costs are presented in Table C-12

[9] ENR assumptions used for unit costs are presented in Table C-13

[10] Treatment assumptions used for unit costs are presented in Table C-8

[11] Construction QA/QC assumptions used for unit costs are presented in Table C-14

[12] Long-term cap O&M assumptions used for unit costs are presented in Table C-15

[13] Confined Aquatic Disposal assumptions used for unit costs are presented in Table C-9

Table 5-5 Summary of Costs for Alternative E: Dredge with Treatment, Disposal, and Beneficial Use [1,2]

Sponsored EAAs and PPAs	Quantity	Units	Cost	Post-Remedy SWAC	% Reduction from Baseline
Sponsored Early Action Areas[3]	**31.2**	**Acres**	**$44,500,000**	7.9	39%
Potential Priority Areas[3]	**19.3**	**Acres**	**$28,200,000**	7	46%

			E1		E2		E3		E4	
			Dredge above 65 mg/kg OC ENR above 36 mg/kg OC total PCBs		**Dredge above 36 mg/kg OC ENR above 24 mg/kg OC total PCBs**		**Dredge above 24 mg/kg OC ENR above 12 mg/kg OC total PCBs**		**Dredge above 12 mg/kg OC ENR above 6 mg/kg OC total PCBs**	
Areas of Interest	**Unit**	**Unit Cost**	**Quantity**	**Cost**	**Quantity**	**Cost**	**Quantity**	**Cost**	**Quantity**	**Cost**
Dredging[4]	CYS	$30	23,407	$702,203	56,187	$1,685,596	120,215	$3,606,464	385,510	$11,565,312
Disposal of Dredged Material[5]	CYS	$91	9,363	$855,935	22,475	$2,054,620	48,086	$4,396,020	154,204	$14,097,283
Treatment and Disposal of Filter Cake (Alternative E only)[10]	CYS	$138 - $329	14,044	$4,618,544	33,712	$7,097,902	72,129	$11,938,355	231,306	$32,015,117
Confined Aquatic Disposal[13]	CYS	$63	0	$0	0	$0	0	$0	0	$0
Containment Capping[6]	Acres	$388,582	0	$0	0	$0	0	$0	0	$0
Residual Capping[7]	Acres	$84,858	1.70	$144,259	3.60	$305,489	9.80	$831,609	36.80	$3,122,776
Habitat Restoration Capping[8]	Acres	$270,604	0.40	$108,242	2.10	$568,269	6.00	$1,623,625	20.80	$5,628,568
Enhanced Natural Recovery (ENR)[9]	Acres	$75,549	3.40	$256,867	8.60	$649,722	30.80	$2,326,910	92.10	$6,958,065
Construction QA/QC[11]	Acres	$121,397	5.50	$667,682	14.30	$1,735,973	46.60	$5,657,087	149.70	$18,173,089
Long-Term Cap O&M Monitoring[12]	Acres	$128,099	3.40	$435,537	8.60	$1,101,653	30.80	$3,945,453	92.10	$11,797,930
Monitored Natural Recovery Compliance Monitoring Administrative Costs Institutional Controls			*Monitored natural recovery, compliance monitoring, institutional controls, and administrative costs are assumed to be independent of active remedial action levels and therefore not included for analysis under the PSA.*							
Total Estimated AOI Cost				$7,789,267		$15,199,223		$34,325,525		$103,358,141
Estimated Days to Complete In-Water Activities, Disposal, and/or Soil Washing				23		56		131		418
Post-Remedial Spatially-Weighted Average Concentration (SWAC) of total PCBs (mg/kg OC)				6.1		6.1		5.6		4.8
Percent Reduction in SWAC from Baseline				53%		53%		57%		63%
TOTAL REMEDY COST				**$80,500,000**		**$87,900,000**		**$107,100,000**		**$176,100,000**

Note: Costs associated with engineering, procurement, management, overhead, contingency, and sales tax are calculated within each unit cost

1 These estimates do not include RI/FS costs of approximately $30 million for the LDW.

2 Long-term compliance monitoring costs are not included in these costs.

3 Assumes 6 ft removal of Navigation Channel and Deep Bench Areas and 3 ft removal and 3 ft capping of Shallow Bench Areas for PPAs. Remedial costs associated with sponsored EAAs were provided by LDWG.

4 Dredging assumptions used for unit costs are presented in Table C-6

5 Disposal and handling assumptions used for unit costs are presented in Table C-7

6 Capping assumptions used for unit costs are presented in Table C-10

7 Residual assumptions used for unit costs are presented in Table C-11

8 Habitat restoration assumptions used for unit costs are presented in Table C-12

9 ENR assumptions used for unit costs are presented in Table C-13

10 Treatment assumptions used for unit costs are presented in Table C-8

11 Construction QA/QC assumptions used for unit costs are presented in Table C-14

12 Long-term cap O&M assumptions used for unit costs are presented in Table C-15

13 Confined Aquatic Disposal assumptions used for unit costs are presented in Table C-9

Table 5-6 Summary of Costs for Alternative F: Cap to the Maximum Extent Possible [1,2]

Sponsored EAAs and PPAs	Quantity	Units	Cost	Post-Remedy SWAC	% Reduction from Baseline
Sponsored Early Action Areas [3]	**31.2**	**Acres**	**$44,500,000**	7.9	39%
Potential Priority Areas [3]	**19.3**	**Acres**	**$28,200,000**	7	46%

			F1		F2		F3		F4	
			Cap/Dredge above 65 mg/kg OC ENR above 36 mg/kg OC total PCBs		Cap/Dredge above 36 mg/kg OC ENR above 24 mg/kg OC total PCBs		Cap/Dredge above 24 mg/kg OC ENR above 12 mg/kg OC total PCBs		Cap/Dredge above 12 mg/kg OC ENR above 6 mg/kg OC total PCBs	
Areas of Interest	**Unit**	**Unit Cost**	**Quantity**	**Cost**	**Quantity**	**Cost**	**Quantity**	**Cost**	**Quantity**	**Cost**
Dredging [4]	CYS	$30	16,000	$480,000	31,019	$930,556	74,429	$2,232,872	264,549	$7,936,474
Disposal of Dredged Material [5]	CYS	$91	16,000	$1,462,714	31,019	$2,835,701	74,429	$6,804,277	264,549	$24,184,975
Treatment and Disposal of Filter Cake (Alternative E only) [10]	CYS	$138 - $329	0	$0	0	$0	0	$0	0	$0
Confined Aquatic Disposal [13]	CYS	$63	0	$0	0	$0	0	$0	0	$0
Containment Capping [6]	Acres	$388,582	0.70	$272,008	1.40	$544,015	4.00	$1,554,329	14.40	$5,595,585
Residual Capping [7]	Acres	$84,858	1.00	$84,858	2.20	$186,688	5.80	$492,177	22.40	$1,900,820
Habitat Restoration Capping [8]	Acres	$270,604	0.40	$108,242	2.10	$568,269	6.00	$1,623,625	20.80	$5,628,568
Enhanced Natural Recovery (ENR) [9]	Acres	$75,549	3.40	$256,867	8.60	$649,722	30.80	$2,326,910	92.10	$6,958,065
Construction QA/QC [11]	Acres	$121,397	5.50	$667,682	14.30	$1,735,973	46.60	$5,657,087	149.70	$18,173,089
Long-Term Cap O&M Monitoring [12]	Acres	$128,099	4.10	$525,206	10.00	$1,280,991	34.80	$4,457,850	106.50	$13,642,558
Monitored Natural Recovery Compliance Monitoring Administrative Costs Institutional Controls			*Monitored natural recovery, compliance monitoring, institutional controls, and administrative costs are assumed to be independent of active remedial action levels and therefore not included for analysis under the PSA.*							
Total Estimated AOI Cost				$3,857,576		$8,731,914		$25,149,127		$84,020,134
Estimated Days to Complete In-Water Activities, Disposal, and/or Soil Washing				17		35		92		312
Post-Remedial Spatially-Weighted Average Concentration (SWAC) of total PCBs (mg/kg OC)				6.1		5.6		4.8		4.0
Percent Reduction in SWAC from Baseline				53%		57%		63%		69%
TOTAL REMEDY COST				**$76,600,000**		**$81,500,000**		**$97,900,000**		**$156,800,000**

Note: Costs associated with engineering, procurement, management, overhead, contingency, and sales tax are calculated within each unit cost

1 These estimates do not include RI/FS costs of approximately $30 million for the LDW.
2 Long-term compliance monitoring costs are not included in these costs.
3 Assumes 6 ft removal of Navigation Channel and Deep Bench Areas and 3 ft removal and 3 ft capping of Shallow Bench Areas for PPAs. Remedial costs associated with sponsored EAAs were provided by LDWG.
4 Dredging assumptions used for unit costs are presented in Table C-6
5 Disposal and handling assumptions used for unit costs are presented in Table C-7
6 Capping assumptions used for unit costs are presented in Table C-10
7 Residual assumptions used for unit costs are presented in Table C-11
8 Habitat restoration assumptions used for unit costs are presented in Table C-12
9 ENR assumptions used for unit costs are presented in Table C-13
10 Treatment assumptions used for unit costs are presented in Table C-8
11 Construction QA/QC assumptions used for unit costs are presented in Table C-14
12 Long-term cap O&M assumptions used for unit costs are presented in Table C-15
13 Confined Aquatic Disposal assumptions used for unit costs are presented in Table C-9

Table 5-7 Summary of Costs for Alternative G: Hypothetical Combined Alternative [1, 2]

Sponsored EAAs and PPAs	Quantity	Units	Cost
Sponsored Early Action Areas [3]	**31.2**	**Acres**	**$44,500,000**
Potential Priority Areas [3]	**19.3**	**Acres**	**$28,200,000**

Areas of Interest	Quantity	Unit	Unit Cost	Cost
Dredging [4]	**41,344**	**CYS**	**$30**	**$1,240,320**
Mobilization/Demobilization and Removal of contaminated sediment to total PCB active remediation level				
Pre-removal of debris, logs etc. before dredging				
Disposal of Dredged Material [5]	**41,344**	**CYS**	**$91**	**$3,779,652**
Disposal of contaminated sediment at off-site subtitle D landfill.				
Cost includes transportation of sediment by barge/truck to transloading facility.				
Cost includes dewatering of supernatant				
Containment Capping [6]	**3.00**	**Acres**	**$388,582**	**$1,165,747**
Mobilization/demobilization costs and placement of 2 feet of capping material to contain contaminated sediment in-place				
Residual Capping [7]	**14.70**	**Acres**	**$84,858**	**$1,247,413**
Placement of thin layer of capping material to address dredge residuals				
Habitat Restoration Capping [8]	**0.00**	**Acres**	**$270,604**	**$0**
Placement of 3 feet of capping material for enhancement of nearshore habitat after removal of contaminated sediment.				
Armoring included as needed for erosion control				
Enhanced Natural Recovery (ENR) [9]	**11.90**	**Acres**	**$75,549**	**$899,033**
Placement of thin 6-inch thick layer of material for Enhanced Natural Recovery				
Construction QA/QC [10]	**29.60**	**Acres**	**$121,397**	**$3,593,343**
Monitoring active remediation processes - dredging, excavation, cap placement	.			
Post-verification surface sediment monitoring to verify remedy (may include water/sediment quality - chemical analysis, bathymetry, turbidity)				
Long-Term Cap O&M Monitoring [11]	**14.90**	**Acres**	**$128,099**	**$1,908,677**
Costs associated with long-term monitoring of containment caps and ENR. Performed at years 1, 2, 5, 10 and every 5 years until year 30 (may include sediment coring, chemical analysis, bathymetry).				
Cost is present worth of annual cost assuming 7% interest rate.				
Monitored Natural Recovery				
Costs associated with monitoring natural recovery. Cost is present worth of annual cost assuming 30-year duration and 7% interest rate.		*Monitored natural recovery, compliance monitoring, institutional controls, and administrative costs are assumed to be independent of active remedial action levels and therefore not included for analysis under the PSA.*		
Compliance Monitoring				
Costs associated with long-term monitoring of project site to ensure project site remains protective of human/environmental health.				
Administrative Costs and Institutional Controls				
Costs associated with establishment and public education of site-specific restrictions including periodic reviews, and long-term administration of established restrictions.				
TOTAL ESTIMATED COST [1,2]				**$86,600,000**
Estimated Days to Complete In-Water Activities, Disposal, and/or Soil Washing				**51**
Post-Remedial Spatially-Weighted Average Concentration (SWAC) of total PCBs (mg/kg OC)				**5.4**
Percent Reduction in SWAC from Baseline				**58%**

Note: Costs associated with engineering, procurement, management, overhead, contingency, and sales tax are calculated within each unit cost

1 These estimates do not include RI/FS costs of approximately $30 million for the LDW.

2 Long-term compliance monitoring costs are not included in these costs.

3 Assumes 6 ft removal of Navigation Channel and Deep Bench Areas and 3 ft removal and 3 ft capping of Shallow Bench Areas for PPAs. Remedial costs associated with sponsored EAAs were provided by LDWG.

4 Dredging assumptions used for unit costs are presented in Table C-6

5 Disposal and handling assumptions used for unit costs are presented in Table C-7

6 Capping assumptions used for unit costs are presented in Table C-10

7 Residual assumptions used for unit costs are presented in Table C-11

8 Habitat restoration assumptions used for unit costs are presented in Table C-12

9 ENR assumptions used for unit costs are presented in Table C-13

10 Construction QA/QC assumptions used for unit costs are presented in Table C-14

11 Long-term cap O&M assumptions used for unit costs are presented in Table C-15

Table 5-8 Cost Comparison for Preliminary Site-Specific Remedial Alternatives for the LDW

		Alternative Descriptions and Estimated Costs (in $USD) [3,4]												
Remedial Areas	Total Acres	A: No Further Action	B: Dredge with Upland Off-site Disposal					C: Dredge with Upland Off-site Disposal and ENR to Next Appropriate Action Level				D: Dredge with Upland Off-site Disposal and On-site CAD			
			B1	B2	B3	B4	B5	C1	C2	C3	C4	D1	D2	D3	D4
Sponsored EAAs [1]	31.2	44,500,000	$44,500,000	$44,500,000	$44,500,000	$44,500,000	$44,500,000	$44,500,000	$44,500,000	$44,500,000	$44,500,000	$44,500,000	$44,500,000	$44,500,000	$44,500,000
PPAs	19.3	—	$28,200,000	$28,200,000	$28,200,000	$28,200,000	$28,200,000	$28,200,000	$28,200,000	$28,200,000	$28,200,000	$28,200,000	$28,200,000	$28,200,000	$28,200,000
AOIs [2]															
>65 (CSL)	2.1		$3,500,000	—	—	—	—	—	—	—	—	—	—	—	—
>36	5.7		—	$8,700,000	—	—	—	$4,500,000	—	—	—	$3,800,000	—	—	—
>24	14.3		—	—	$18,300,000	—	—	—	$11,200,000	—	—	—	$9,600,000	—	—
>12 (SQS)	46.7		—	—	—	$60,500,000	—	—	—	$29,000,000	—	—	—	$25,600,000	—
> 6	149.6		—	—	—	—	$185,300,000	—	—	—	$92,500,000	—	—	—	$84,300,000
Total		44,500,000	$76,200,000	$81,400,000	$91,000,000	$133,200,017	$258,000,000	$77,200,000	$83,900,000	$101,700,000	$165,200,000	$76,500,000	$82,300,000	$98,300,000	$157,000,000

		Alternative Descriptions and Estimated Costs (in $USD) [3,4]										
Remedial Areas	Total Acres		E: Dredge with Treatment, Disposal and Beneficial Reuse					F: Cap To Maximum Extent Possible				G: Hypothetical Combined Alternative
			E1	E2	E3	E4		F1	F2	F3	F4	G
Sponsored EAAs [1]	31.2		$44,500,000	$44,500,000	$44,500,000	$44,500,000		$44,500,000	$44,500,000	$44,500,000	$44,500,000	$44,500,000
PPAs	19.3		$28,200,000	$28,200,000	$28,200,000	$28,200,000		$28,200,000	$28,200,000	$28,200,000	$28,200,000	$28,200,000
AOIs [2]												
>65 (CSL)	2.1		—	—	—	—		—	—	—	—	—
>36	5.7		$7,800,000	—	—	—		$3,900,000	—	—	—	—
>24	14.3		—	$15,200,000	—	—		—	$8,800,000	—	—	$13,900,000
>12 (SQS)	46.7		—	—	$34,400,000	—		—	—	$25,200,000	—	—
> 6	149.6		—	—	—	$103,400,000		—	—	—	$84,100,000	—
Total			$80,500,000	$87,900,000	$107,100,000	$176,100,000		$76,600,000	$81,500,000	$97,900,000	$156,800,000	$86,600,000

Notes:

1 Remedial cost estimates for sponsored EAAs were provided by LDWG.

2 AOI areas expressed as multiples of the SQS and the CSL for total PCBs in mg/kg OC.

3 These estimates do not include RI/FS costs of approximately $30 million for the LDW.

4 Long-term compliance monitoring costs are not included in these costs.

"—" = option is not implementable or not carried forward as an alternative; or not applicable for the table.

Note: Costs associated with engineering, procurement, management, overhead, contingency, and sales tax are calculated within each unit cost

Table 5-9 Summary of Implementability, Effectiveness, and Cost Screening for Site-Specific Remedial Alternatives for the LDW

CERCLA and MTCA SCREENING CRITERIA[2] Used in this PSA		A: No Further Action	B: Dredge with Upland Off-Site Disposal	C: Dredge with Upland Off-Site Disposal and ENR Remaining Areas	D: Dredge with Upland Off-Site Disposal and On-Site CAD	E: Dredge with Treatment, Disposal and Beneficial Reuse	F: Cap to the Maximum Extent Possible	G: Hypothetical Combined Alternative
		Alternative Descriptions						
Implementability								
	Technical Implementability	—	High	High	High	Medium	High	High
	Administrative Implementability	Low	High	Moderate	Low to Moderate	Low to Moderate	Moderate	Moderate
Effectiveness								
Short-Term	a) Environmental impacts during dredging	—	Moderate to High	Moderate	Moderate	Moderate	Moderate	Moderate
Short-Term	b) Human health risks	Low	Low to Moderate	Low to Moderate	Low to Moderate	Low to Moderate	Low to Moderate	Low to Moderate
Short-Term	c) Time until completion of active remedial actions[1]	Long	Short to Long 21 to 1,043 days	Short to Moderate 25 to 516 days	Short to Long 35 to 634 days	Short to Long 25 to 516 days	Short to Moderate 17 to 383 days	Short 51
Long-Term	a1) Magnitude of incremental SWAC risk reduction after remediation of EAAs	40%	0 to 17%	0 to 17%	0 to 17%	0 to 17%	0 to 17%	0 to 17%
Long-Term	a2) Magnitude of cumulative SWAC reduction after remediation of EAAs	—	46 to 69%	46 to 69%	46 to 69%	46 to 69%	46 to 69%	46 to 69%
Long-Term	b) Magnitude of incremental point SQS/CSL risk reduction after remediation of EAAs	—	7 to 54%	7 to 54%	7 to 54%	7 to 54%	7 to 54%	7 to 54%
Long-Term	c) Degree of reliance on institutional controls and long-term monitoring (permanence)	High	Low to Moderate	Moderate to High	Moderate to High	Moderate to High	Low to Moderate	Moderate
Cost								
	Cost Relative to Alternative A	—	High[1]	Moderate	Moderate	High	Moderate	Low
	Range of Costs[3]	$44.5 M	$76 - $258 M	$77 - $165 M	$76 - $157M	$80 - $176 M	$77 - $157 M	$87 M

Notes:

[1] Relative ranking is dependent upon the hypothetical remedial action level selected, and is based on number of days to complete AOI and PPA components of the individual remedy.

[2] When evaluating alternatives relative to Alternative A, assume the same hypothetical remedial action level is applied across all alternatives during comparison.

[3] These estimates do not include RI/FS costs of approximately $30 million for the LDW, nor long-term compliance monitoring costs, and costs associated engineering, procurement, management, overhead, contingency, and sales tax.

[4] For example, an incremental change in SWAC (Table 5-1) from 4.8 to 4.0 equals 0.8, which is then divided by 4.8 which equals 17% (magnitude of incremental SWAC reduction)

HIGH = higher risk, longer time, higher cost, higher effort to implement; LOW - lower risk, less time, lower cost, less effort to implement

Each alternative's implementability, effectiveness, and cost are summarized as relative categories of high, medium, and low relative to Alternative A.

Figure 5-1 Changes to the SWAC Associated with Increasing Areas of Remediation for the Entire LDW

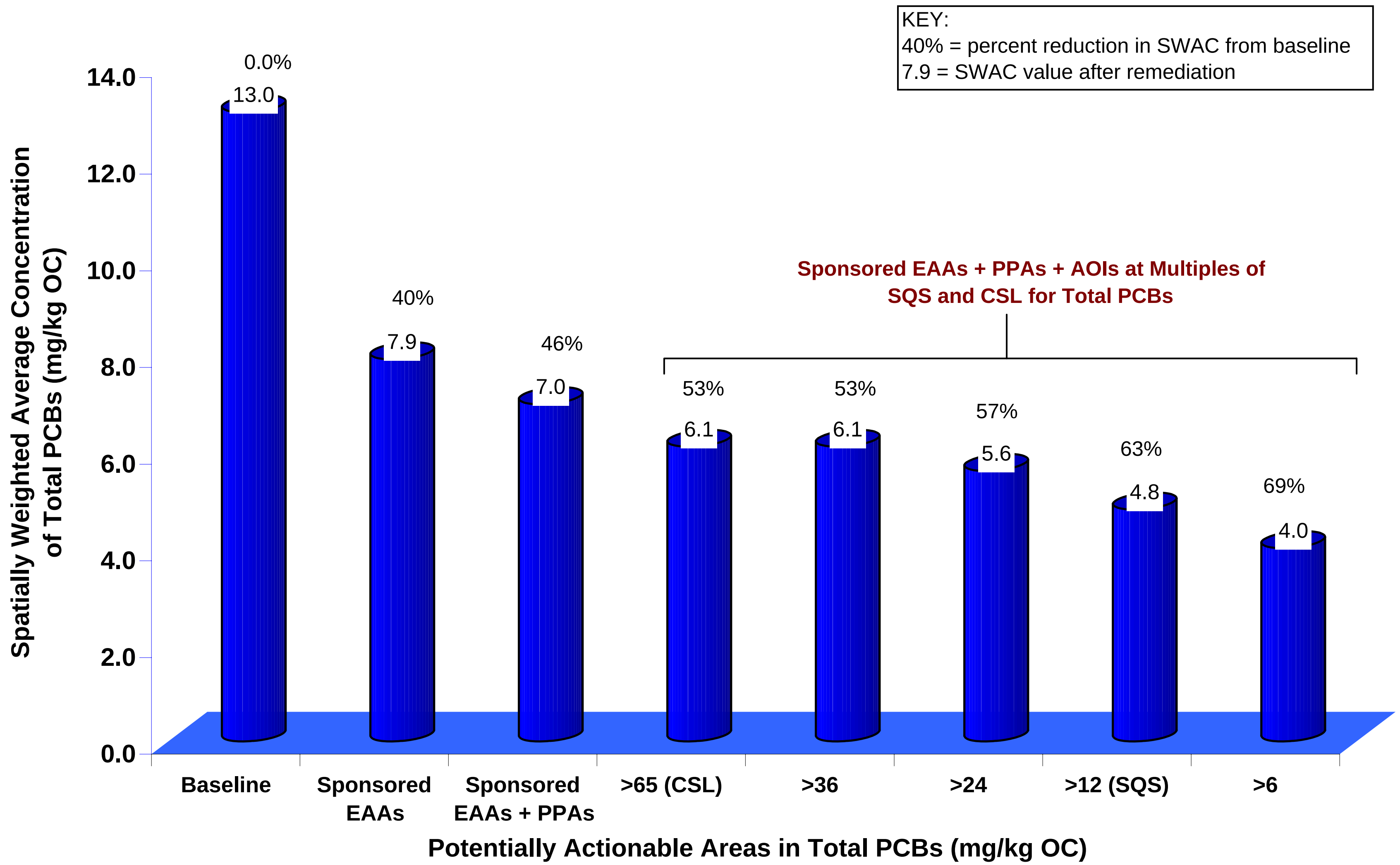
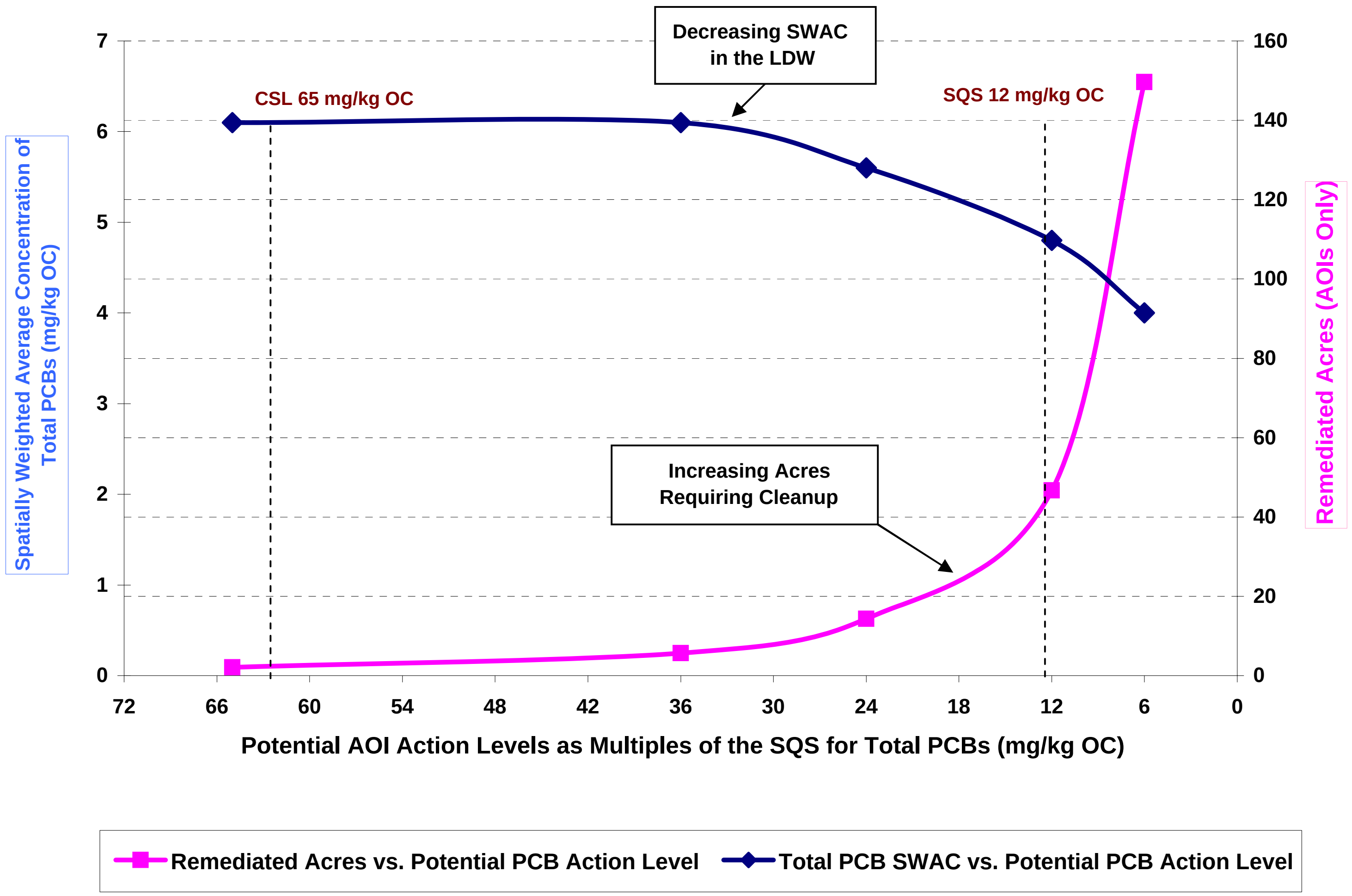


Figure 5-2 Relationship between Incremental SWAC Reduction and Acreages Affected for Cleanup at Different Multiples of the SQS



Note: SWAC values and analysis assume that sediment removals at the sponsored EAAs and PPAs have already occurred.

LEGEND

1.2 —— River Mile Location and Number

- - - - Navigation Channel

Remaining Detections For Any SMS Chemical - All Waterway	> SQS and ≤ CSL	> CSL
Station where PCB Exceedance is Highest of all SMS Chemicals Analyzed[4]	△ (yellow)	▲ (red)
Station where Chemical (other than PCBs) Exceedance is Highest of all SMS Chemicals Analyzed	● (yellow)	● (red)

Station where Detected Chemicals Do Not Exceed SMS Criteria

Area Designation

Sponsored Early Action Areas

Potential Priority Areas

Interpolated Total PCBs (mg/kg OC)

- ≤ 6
- >6 and ≤ 12
- >12 and ≤ 24
- >24 and ≤ 36
- >36 and ≤ 65
- > 65

1. Mapping uses the 12-23-05 dataset provided by Windward Environmental LLC.
2. Total PCB isopleths were set at multiples of the SQS (12 mg/kg OC) and the CSL (65 mg/kg OC) for total PCBs.
3. For surface sediments within remediated areas, the post-remedial surface sediment total PCB concentration was set at 5 mg/kg OC.
4. Includes stations where PCBs were the only chemicals analyzed.

0 400 800 Feet

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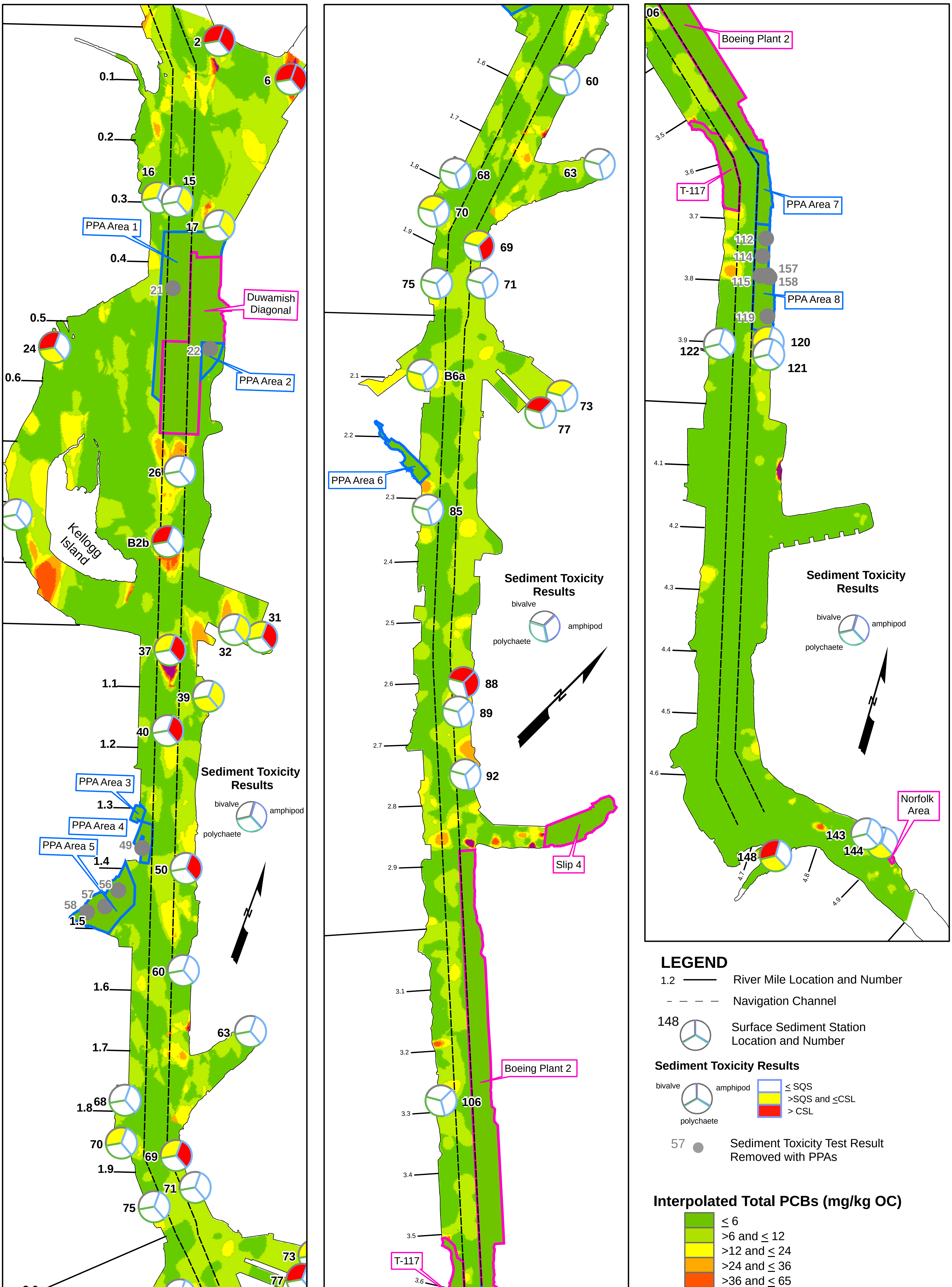
LDW DRAFT PRELIMINARY SCREENING OF ALTERNATIVES (PORS5-18220-603)	DISTRIBUTION OF SURFACE SEDIMENT CHEMICAL SQS/CSL EXCEEDANCES REMAINING IN THE LDW AFTER SEDIMENT REMOVALS AT THE SPONSORED EAAs AND PPAs
DATE: 9/12/06 DWN. BY: KBL/ftc	**FIGURE 5-3**

FILE: T:/LDWG_Duwamish/Projects/PSA_Oct06/Tier3Rcsl_sqs.MXD



LEGEND

1.2 River Mile Location and Number

Navigation Channel

148 Surface Sediment Station Location and Number

Sediment Toxicity Results

bivalve, amphipod, polychaete

≤ SQS

>SQS and ≤CSL

> CSL

57 Sediment Toxicity Test Result Removed with PPAs

Interpolated Total PCBs (mg/kg OC)

≤ 6

>6 and ≤ 12

>12 and ≤ 24

>24 and ≤ 36

>36 and ≤ 65

> 65

Area Designation

Sponsored Early Action Areas

Potential Priority Areas

1. Mapping uses the 12-23-05 chemical dataset and the toxicity test result files from 9-14-05 provided by Windward Environmental LLC.
2. Total PCB isopleths were set at multiples of the SQS (12 mg/kg OC) and the CSL (65 mg/kg OC) for total PCBs.
3. For surface sediments within remediated areas, the post-remedial surface sediment total PCB concentration was set at 5 mg/kg OC.

0 400 800 Feet

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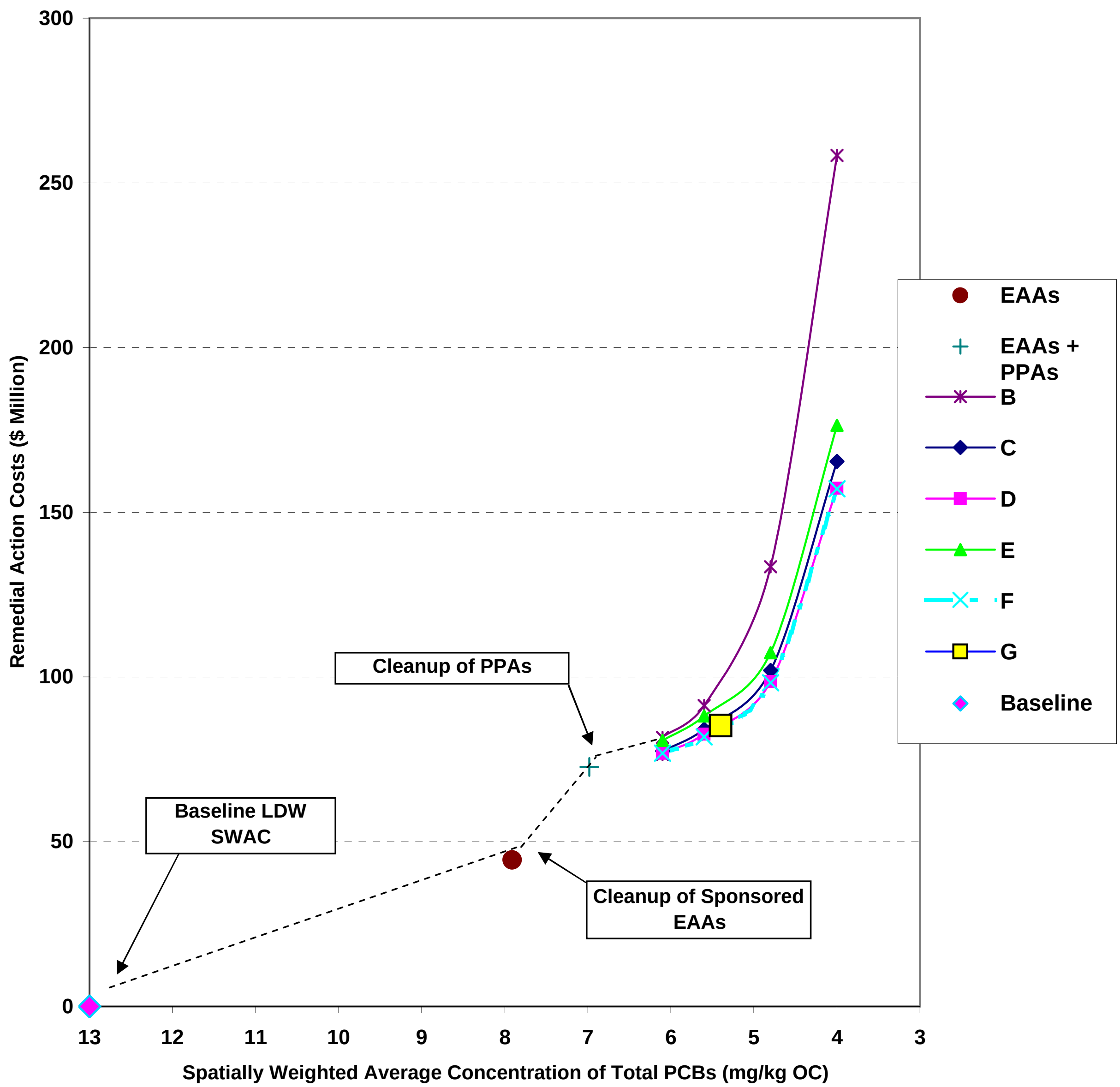
LDW
DRAFT PRELIMINARY SCREENING OF ALTERNATIVES
(PORS5-18220-603)

DISTRIBUTION OF SURFACE SEDIMENT TOXICITY TEST RESULTS REMAINING IN THE LDW AFTER THE SEDIMENT REMOVALS AT SPONSORED EAAs AND PPAs

DATE: 9/12/06 | DWN. BY: KBL/ftc | FIGURE 5-4

FILE: T:/LDWG_Duwamish/Projects/PSA_Oct06/Tier3Rcsl_sqs2wBio.MXD

Figure 5-5 Remedial Action Costs vs. Total PCB SWAC for Sponsored EAAs, PPAs, and Remedial Alternatives B through G (including baseline conditions)



Note: Total PCB concentrations are hypothetical values corresponding to time zero immediately after active remediation.

Costs do not include long-term compliance monitoring costs to ensure long-term remedy success. Monitoring will be implemented regardless of remedy. Further reductions in the SWAC can be expected to occur as a result of natural recovery processes, but such long-term changes have not been quantified and hence have not been included.

6 Summary and Conclusions

The objective of this PSA is to examine the suite of remedial process options presented in the CTM (RETEC 2005b) and assemble the process options into implementable and effective remedial alternatives that should be carried forward for consideration in the FS. This PSA has been prepared earlier in the RI/FS process than it normally would be, in order to allow for early input by the agencies and stakeholders on the development of potential remedial alternatives. Because it is being prepared before all of the RI/FS sampling data are available, there will likely be changes to the FS remedial alternatives based on stakeholder and agency input and new information. This document satisfies the AOC requirement for a Preliminary Screening of Alternatives technical memorandum. Comments received from the EPA and Ecology on this draft will be addressed in the screening of alternatives section of the FS.

The analyses in this PSA will also be used to inform the FS work plan, which will identify data needed to complete the FS. Consistent with the RI/FS process under CERCLA (USEPA 1988) and MTCA (Ecology 2001), this technical memorandum satisfies several steps in the alternatives development process:

- A range of areas and volumes of contaminated sediment are estimated using multiples of the SQS for total PCBs. The estimated quantities are used in this document to represent the range of conditions potentially addressed by site-wide remedial alternatives in the waterway-wide FS. These estimates will be refined once the Phase 2 risk assessment and RI reports are available.

- Groups of potentially actionable areas used for comparing remedial alternatives and costs are identified.

- Appropriate technologies and process options that represent the range of potential General Response Actions are summarized from information presented in the CTM (RETEC 2005b) and are assembled into a comprehensive set of site-wide remedial alternatives.

- Assembled alternatives are evaluated against three broad categories of screening criteria: implementability, effectiveness, and cost. Because the purpose of this screening is to identify a representative range of remedial alternatives that will undergo a more thorough and extensive analysis, alternatives are evaluated more generally (USEPA 1988). In the detailed screening of remedial alternatives (which will occur in the FS), the alternatives will be evaluated using the specific CERCLA and MTCA criteria and their individual factors.

The FS may also evaluate other remedial alternatives or variants on these alternatives, considering the new subsurface sediment information, the results of the Phase 2 human health and ecological risk assessments, and the RAOs and preliminary remediation goals. This section presents a summary of this PSA evaluation process and steps, and the major findings of each step. Feasibility considerations not fully developed in this PSA are also addressed in this section.

6.1 Relevant Conclusions from Each Step

Relevant conclusions for each major step of this PSA process (Figure 1-3) are summarized below.

6.1.1 Characteristics of the LDW

Important characteristics of the LDW that affect the development of remedial alternatives in this PSA include:

- Distribution of the COPCs in the LDW
- Physical conditions (bathymetry, grain size)
- Results of the draft *Sediment Transport Analysis Report* (Windward and QEA 2006)
- Human and ecological uses of the waterway.

Total PCBs are the predominant COPC in the LDW, with the greatest spatial extent of contaminated areas. Therefore, total PCBs were selected as the primary indicator chemical for defining contaminated areas. The distribution of total PCBs was mapped as multiples of the SQS. Other detected chemical exceedances were evaluated, but, in general, the areas with total PCB concentrations above the SQS also included other detected chemicals that exceeded the SQS. The FS will contain a more complete analysis of the need to cleanup other COPCs outside of the PCB footprint. The draft *Sediment Transport Analysis Report* (Windward and QEA 2006) designated three distinct reaches (RM 0 to 2, RM 2 to 3, and RM 3 to 5) within the LDW with differing sedimentation and erosion characteristics. These reaches were further subdivided into segments based on bathymetric zones and the functional uses of the area (shallow bench, deep bench, and navigation channel). These site features form the basis of a physical CSM used to develop LDW-wide remedial alternatives and assumptions.

6.1.2 Identification of Potentially Actionable Areas

Areas with contaminated sediment were overlaid with the CSM to define potentially actionable areas within the LDW. These areas, which may potentially require action within the LDW, were identified in order to provide a consistent basis for comparing relative costs among remedial alternatives. The areas include:

- Sponsored EAAs at which cleanup actions are already planned or completed (Windward 2003b)
- PPAs that include both previously identified (but non-sponsored) EAAs (Windward 2003b) and other areas that meet the criteria used to define EAAs after the Phase 2 RI sampling
- Other AOIs in the LDW where surface sediments exceed various multiples of the SQS for total PCBs.

These areas were identified for development of remedial alternatives in this document. These areas may be refined, and other areas may be included in the FS analyses.

6.1.3 Development and Screening of Representative Remedial Alternatives

Remedial alternatives for the LDW that include each of the General Response Actions were assembled using representative process options from the CTM (RETEC 2005b). Each alternative was constructed considering two defining sets of constraints: 1) the range of physical design conditions found in the LDW, based on the CSM; and 2) a hypothetical range of total PCB RALs to estimate the potential extent of the AOIs. In addition, a hypothetical combined alternative was developed for illustrative purposes. The combined alternative (Alternative G) involves the concept of applying different RALs across different portions of the LDW. All of the active remedial alternatives (Alternatives B through G) assume that: (1) actions already underway at the sponsored EAAs will be completed, and (2) the PPAs will also be remediated.

All of the active remedial alternatives are considered technically implementable and potentially effective.

The seven remedial alternatives evaluated in this PSA are summarized as follows:

- **Alternative A – No Further Action (other than the completion of the sponsored EAAs).** Alternative A is a required alternative under the NCP and is retained for further evaluation in the FS.

- **Alternative B – Dredge with Upland Disposal.** This alternative involves dredging and off-site upland disposal of sediments that exceed the hypothetical total PCB RAL used in this analysis. This alternative is technically implementable and the equipment and facilities necessary for implementing this alternative are readily available. Alternative B is retained for further evaluation in the FS. The remaining alternatives include elements of this alternative.

- **Alternative C – Dredge with Upland Disposal, ENR, and MNR.** This alternative is similar to Alternative B, but includes ENR as a component of achieving a given hypothetical total PCB RAL. MNR is a presumed component of all alternatives for applicable areas. Alternative C is retained for further evaluation in the FS.

- **Alternative D – Dredge with Disposal to an On-Site CAD Disposal, ENR, and MNR.** This alternative involves dredging the areas described in Alternative B, followed by disposal of the contaminated sediments in one or more on-site, in-water CAD cells. Alternative D is screened out as a site-wide alternative based principally on the administrative and institutional challenges associated with permanently locating a CAD cell within the federally authorized navigation channel and coordinating the construction and use of the CAD among various performing parties. CAD as a process option is retained, and may become a component of other alternatives evaluated during the FS.

- **Alternative E – Dredge with Treatment, Beneficial Use and Upland Treatment, ENR, and MNR.** This alternative is similar to Alternative C, except that soil washing would be used to separate coarse material from the dredged sediments. Separated sands and gravels are assumed to be suitable for beneficial use as capping material. The finer fractions would be disposed at an off-site upland landfill. While technically implementable, technical issues would need to be resolved to demonstrate that retained material would be acceptable by DMMP and SMS standards. Administrative concerns include siting and (potential) permitting of a treatment facility, and coordinating the construction and use of the treatment facility among various performing parties. A treatment alternative is retained as a waterway-wide, stand-alone technology for further evaluation in the FS.

- **Alternative F – Cap to the Maximum Extent Practicable, ENR, and MNR.** This alternative is similar to Alternative C, except that capping of the shallow and deep bench areas is used rather than dredging these areas as described in Alternative C. Areas within the navigation channel would be dredged as described under Alternative C. Capping has been demonstrated within the Puget Sound region to be implementable, effective for managing the COPCs and biological effects in the LDW, and cost-effective. Alternative F is retained for further consideration in the FS.

- **Alternative G – Hypothetical Combined Alternative.** Alternative G is one example of a combined approach for managing sediments at different RALs, based on the type of action and considerations such as the river use, habitat, and sediment transport characteristics. After remedy completion of the sponsored EAAs and PPAs, a combination of sediment removal, grade restoration capping, and ENR and MNR would occur throughout various reaches of the LDW. Alternative G is considered effective, implementable, and cost-effective. Alternative G is retained for further consideration in the FS, and other variants of such a combined alternative will likely be developed in the FS.

All remedial alternatives that were evaluated include remediation of the sponsored EAAs and PPAs. It is assumed that dredged material from the sponsored EAAs and PPAs will be disposed at an off-site, upland disposal facility.

Figure 6-1 brackets the range of costs and SWAC reductions achieved by representative Alternatives B through G. The cost of achieving an incremental reduction in the total PCB SWAC (at Time 0, immediately following active remedial measures) increases substantially following completion of the sponsored EAAs and PPAs. Alternative G is shown as a single point rather than a continuum; however, other variants of Alternative G may be considered in the FS in order to bracket the range of costs for combined approaches.

The remedial alternatives are considered effective and technically implementable. Alternative D, which includes CAD disposal, is technically feasible, but has significant administrative implementation challenges on a site-wide basis. These issues include construction within the existing navigation channel, managing construction when river flow and sediment transport is at its highest, potentially insufficient space (volume) to handle all of the LDW-wide dredged sediments at lower RALs, institutional challenges associated with obtaining a restricted development covenant for the federally authorized navigation channel, and administrative challenges related to agency approval. A further institutional challenge to implementation of this alternative is the coordination that would be required (logistically and contractually) for use of the CAD among the (potentially) several performing parties that may be implementing the cleanups in the various portions of the LDW. CAD as a process option is retained, however, for potential inclusion in

FS remedial alternatives. Further analysis will be required in the FS to determine the administrative implementability of a CAD cell, if this process option is developed into a component of an alternative.

Alternative E (which includes treatment by conventional soil washing/separation) is technically implementable, but technical issues would need to be resolved to demonstrate its effectiveness in meeting DMMP and SMS standards. Administrative implementability concerns include siting and (potential) permitting of a treatment facility, and coordinating the construction and use of the treatment facility among various performing parties. Finally, the increased cost of Alternative E may not afford additional protectiveness compared to the other alternatives. In summary, Alternatives A, B, C, E, F, and G will be carried forward as site-wide remedial alternatives in the FS. Elements of Alternative D may be considered in the FS on a localized scale or in combination with other alternatives.

The alternatives carried forward in this PSA enable the development of a broad range of remedial alternatives representing all response actions and implementation scenarios typical of sediment remediation projects elsewhere in the Pacific Northwest and the nation as a whole. The assembly of representative process options into specific remedial alternatives in this document does not preclude the consideration and potential use of other technology options that may, during remedial design, be determined to yield comparable or even improved cost/benefit value (e.g., as a result of technology advances).

6.2 Limitations of this PSA

While this PSA lays out a process for evaluating remedial alternatives and actionable areas, this exercise was undertaken solely for the purposes of providing and communicating a preliminary screening of remedial alternatives. It is explicitly acknowledged that final cleanup areas or RALs can only be selected after completion of the Phase 2 RI, the human health and ecological risk assessments, and careful development of the RAOs for the LDW. Analyses used in this document present the results of baseline and post-remedial interpolations for total PCBs in surface sediments only for use in this PSA. It is expected that these analyses will be repeated once all surface and subsurface data for the Phase 2 RI are compiled and evaluated.

The retained remedial alternatives will be further evaluated in the FS using all nine CERCLA criteria in conjunction with the MTCA evaluation criteria.

Specific feasibility considerations not fully developed in this PSA include the following:

- **Habitat Enhancement**. This PSA assumes that remedial actions within intertidal or shallow subtidal areas will generally be required to restore existing mudline grades after dredging or excavation. However, on a local scale, alternative mudline elevations (higher or lower) may be considered in the FS to expand intertidal or shallow subtidal habitat for migratory or resident biota. Results of the risk assessments and input from stakeholders need to be considered in the detailed analysis of alternatives regarding habitat enhancement. Habitat enhancement details are site-specific and would typically be developed at the design phase of an individual cleanup area.

- **Depth of Contaminated Sediments**. Results of the subsurface sediment investigation will be integrated into the FS work plan. Any correlation that can be made between chemical concentrations and sediment stratigraphy or depositional history will help refine the CSM and modify assumptions regarding the extent and depth of sediments that may require remediation.

- **Physical Treatment**. The viability of physical treatment (i.e., sediment washing) as a remedial alternative is largely dependent on the amount and size of the sand fraction and the organic matter content, along with site-specific performance and economics. Results of the subsurface coring will be considered in the FS to refine estimates concerning the volume of sediments that may be suitable for physical treatment, if treatment is retained as a remedy component.

- **CAD Feasibility**. If CAD disposal is incorporated into an alternative in the FS, the FS will further evaluate the administrative and technical implementability issues associated with this disposal option.

- **Effectiveness of Natural Recovery and ENR**. This PSA does not evaluate the expected long-term effectiveness of MNR. The long-term effectiveness of natural recovery processes (i.e., sedimentation and burial) will need to be evaluated within any areas identified in this PSA as being potentially suitable for natural recovery and within the LDW system as a whole. Further analysis of the short- and long-term effectiveness of natural recovery and ENR will be conducted in the FS.

- **Other COPCs**. This PSA has used total PCBs as the primary indicator of the extent of sediment contamination. Additional COPCs will be considered in the FS, once the draft risk assessment and RI reports are available.

- **Preliminary Dataset and Bedmapping**. Estimates of the SWAC of total PCBs are presented in this document for baseline and post-remedy conditions. The SWAC estimates were developed using IDW interpolation methods and a preliminary baseline dataset. The SWAC estimates may be revised in the future, pending decisions on input parameters to the IDW mapping model, mapping techniques, and the appropriate surface sediment dataset for interpolation.

6.3 Conclusions and Recommendations

This document fulfills the requirement listed in the AOC for the development and preliminary screening of remedial alternatives. As established in the *RI/FS Integration Memorandum* (RETEC 2005a), this PSA builds from the CTM (RETEC 2005b), and follows CERCLA and MTCA guidance for selecting and screening representative remedial alternatives considering their implementability, effectiveness, and cost. The remedial alternatives retained above will carry forward to the FS. The following conclusions and recommendations are carried forward into the FS:

1) Reductions in the SWAC of total PCBs were used as an indicator of relative risk reduction for this analysis. The largest incremental SWAC reduction is achieved after remediation of the sponsored EAAs and PPAs, with diminishing return at the lower multiples of the SQS. Additional factors that affect risk reduction will be integrated into the FS, once the risk assessments are available.

2) Following completion of the sponsored EAAs and PPAs, the cost of achieving an incremental reduction in the total PCB SWAC (immediately following active remedial measures) increases as AOIs are defined at progressively smaller multiples of the SQS for total PCBs (see Figure 6-1).

3) Alternatives that include ENR are more cost-effective than a stand-alone dredge and disposal alternative for the same RAL, once the sponsored EAAs and PPAs have been addressed.

4) Each alternative, along with treatment and CAD cell disposal process options, may have site-specific applicability within the LDW. Because implementation of the ROD may involve phased or separate designs for individual cleanup areas, it is important to maintain flexibility in the FS and ROD so that site-specific considerations can appropriately be accommodated in the remedial design phase.

5) A combination of processes and RALs applied to different parts of the waterway appears to offer the most cost-effective approach to achieving risk reduction. One or more remedial alternatives that include a combination of both different actions and different RALs and areas will be further developed in the FS.

6) Remedial alternatives that include CAD disposal are technically feasible, but have significant implementation challenges on a site-wide basis. These options are retained as site-specific options, once SMAs are defined.

7) The rates of natural recovery processes are likely to vary across the LDW. The FS will present a detailed analysis of natural recovery processes.

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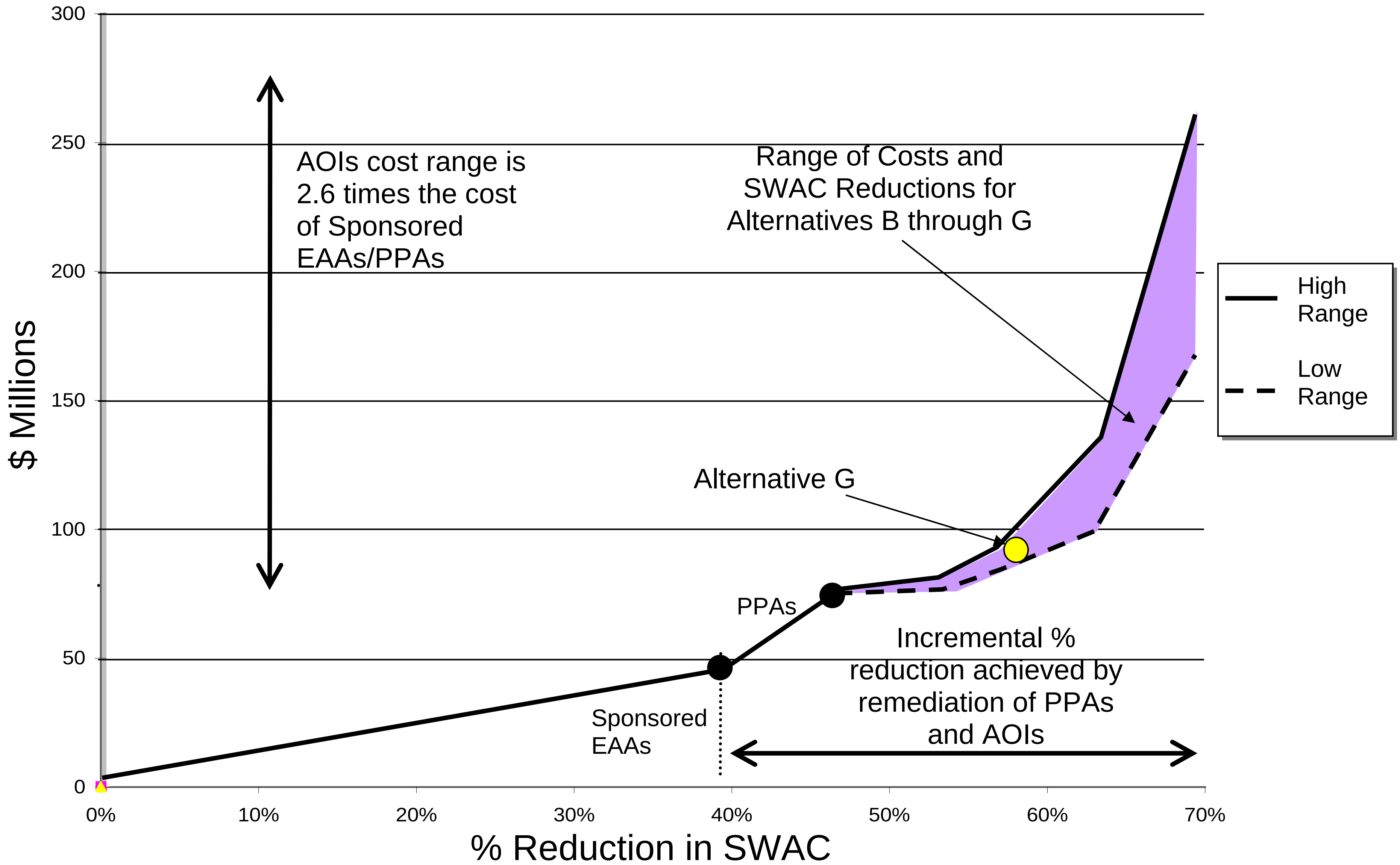

LDW DRAFT PRELIMINARY SCREENING OF ALTERNATIVES (PORS5-18220-603)		INCREMENTAL COSTS & SWAC REDUCTIONS ACHIEVED BY THE RANGE OF ALTERNATIVES (INCLUDING ALTERNATIVE A; NO FURTHER ACTION)
Date: 09/11/2006	File: ProjW/LDW/PSA	FIGURE 6-1

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