SEDIMENT FEASIBILITY STUDY
SNOPAC PROPERTY

Facility Site ID #1523145
Cleanup Site ID #12463

Prepared for
5055 Properties LLC
5209 E Marginal Way S.
Seattle, WA 98134

Prepared by
integral consulting inc.
2025 1st Avenue
Suite 310
Seattle, WA 98121

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Integral Consulting Inc.

Jane L. Sund, P.E.
Senior Consultant/Engineer
jsund@integral-corp.com

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ACRONYMS AND ABBREVIATIONS

Agreed Order	Agreed Order No. DE16300
ARAR	applicable or relevant and appropriate requirement
Aspect	Aspect Consulting, LLC
bml	below mudline
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
COC	contaminant of concern
COPC	contaminant of potential concern
cPAH	carcinogenic polycyclic aromatic hydrocarbon
CUL	cleanup level
DCA	disproportionate cost analysis
Ecology	Washington Department of Ecology
ENR	enhanced natural recovery
EPA	U.S. Environmental Protection Agency
ESD	Explanation of Significant Differences
FS	feasibility study
Integral	Integral Consulting Inc.
LDW	Lower Duwamish Waterway
Manson	Manson Construction
MHHW	mean higher high water
MLLW	mean lower low water
MOA	memorandum of agreement
MTCA	Model Toxics Control Act
NAVD 88	North American Vertical Datum of 1988
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
RAL	remedial action level
RAO	remedial action objective
RI	remedial investigation
ROD	record of decision
SBG	sandblast grit

Snopac	Snopac Products Inc.
WAC	Washington Administrative Code

1 INTRODUCTION

This sediment feasibility study (Sediment FS) was prepared by Integral Consulting Inc. (Integral), on behalf of 5055 Properties LLC, for the Snopac Property (the Site). The Site is generally located at 5055 and 5053 East Marginal Way South in Seattle, Washington (the Property) and borders the eastern portion of Slip 1 of the Lower Duwamish Waterway (LDW) (Figure 1). The Site, as defined by Washington State's Model Toxics Control Act (MTCA), includes all upland and in-water areas impacted by disposal and releases of hazardous substances from the Property.

On July 15, 2019, 5055 Properties LLC entered Agreed Order No. DE16300 (Agreed Order) with the Washington State Department of Ecology (Ecology). This Sediment FS Report has been prepared to satisfy the requirements of the following documents to ensure protection of human health and the environment by eliminating, reducing, or otherwise controlling risk posed by exposure and migration of contaminated sediment: the Agreed Order and Washington Administrative Code (WAC) Sections 173-340-350(8) and WAC 173-204-550(7), and is consistent with MTCA, Sediment Management Standards, the LDW Record of Decision (ROD) (USEPA 2014), and the Explanation of Significant Differences (ESD) (USEPA 2021) . EPA's ESD documented an update to the carcinogenic polycyclic aromatic hydrocarbons (cPAHs) concentrations established in the ROD as remedial action levels (RALs) and cleanup levels (CULs). The updated RALs and CULs are provided in revised ROD Tables 19, 21, and 28, (Tables 1, 2, and 3 of the ESD) included in Appendix A. The ESD did not include revised Figures 19 and 20, which show cPAH RALs in Box 1 of the figures. For the purpose of this Sediment FS, it was assumed the revised ROD Table 28 supersedes the RALs provided in Box 1 of Figures 19 and 20.

The Project Area for this Sediment FS includes sediments within the Property boundary below mean higher high water (MHHW) as required by the Agreed Order, and includes adjacent sediments at the head of Slip 1 (Figure 2). The Project Area includes intertidal and subtidal sediments that are part of the LDW Superfund site where cleanup activities are administered by the U.S. Environmental Protection Agency (EPA). Aspect Consulting, LLC (Aspect) is preparing the complimentary Upland FS that will address the Site area above MHHW. Integral and Aspect are working cooperatively to develop and implement the preferred remedy for the entire Site.

In accordance with the Agreed Order, Aspect and Integral prepared a remedial investigation (RI) report for the Site (Aspect and Integral 2020) that addresses both the upland and sediment portions of the Site. A summary of the RI is provided in Section 3.

1.1 PURPOSE

Slip 1 sediments have been impacted by historical releases of hazardous substances from the Property, as summarized in this Sediment FS report and further detailed in the RI report (Aspect and Integral 2020). The purpose of the Sediment FS is to refine and present the preferred remedy for the Site sediments as first developed in the LDW FS (AECOM 2012) and selected in the LDW ROD (USEPA 2014). The focused approach for this Sediment FS was agreed upon at the Key Project Meeting with Ecology on August 13, 2020, and includes an evaluation of remedial technologies and development of a preferred remedy.

1.2 SCOPE OF WORK

The LDW FS (AECOM 2012) and the LDW ROD (USEPA 2014) selected remedy for Slip 1 consisted of partial dredge and cap and enhanced natural recovery (ENR; Appendix A, ROD Figure 18). The LDW ROD (USEPA 2014) classifies Slip 1 as a Category 2 and 3 recovery area[1] (Appendix A, LDW ROD Figure 12) and has identified a portion of Slip 1 as susceptible to tug scour (Appendix A, ROD Figure 17). For the Sediment FS, the remedial technologies selected for Slip 1 in the LDW ROD were evaluated and refined based on the sediment conditions (Category 2/3 Recovery Area and potential tug scour) and supplemental data collected as a part of the Snopac Property RI.

The following evaluations, discussed further in Section 4, were completed to arrive at the preferred remedy:

- Identification of remedial action objectives (RAOs), RALs, CULs, and potentially applicable regulatory requirements
- Evaluation and screening of sediment data within Slip 1 against appropriate CULs and RALs
- Evaluation for compliance with the applicable requirements of WAC 173-340-360 and WAC 173-204-570, including a detailed evaluation of remedial technologies relative to the following criteria::
  - Compliance with Cleanup Standards and Applicable Laws
  - Protection of Human Health
  - Protection of the Environment
  - Provision for a Reasonable Restoration Time Frame
  - Use of Permanent Solutions to the Maximum Extent Practicable
  - Short-Term Effectiveness

[1] Category 2 recovery area—recovery of sediments to meet CULs without active remediation is less certain.

- Long-Term Effectiveness
- Net Environmental Benefit
- Implementability
- Provision for Compliance Monitoring
- Cost-Effectiveness
- Prospective Community Acceptance.

2 BACKGROUND

A discussion of Site background, including Site description and history, primary contaminants of concern (COCs), potential historical contaminant sources, and Site bathymetry and bank topography, is provided below.

2.1 SITE DESCRIPTION

The Property is 1.33 acres in size, zoned for industrial use, and occupies both the 5055 and 5053 East Marginal Way South addresses. The Property is bordered by Slip 1 of the LDW to the west, East Marginal Way South and a rail spur to the east, Manson Construction (Manson) headquarters to the south (on property leased from King County), and Federal Center South to the north (Figure 2). More than half of the Property is used by Manson for the staging, storage, maintenance, mobilization, and demobilization of various marine construction equipment and materials. Vessels that are not needed on current construction jobs are temporarily moored in Slip 1.

A retaining wall is present on the west side of the Property bordering Slip 1. The retaining wall is approximately 7 ft high, 270 ft long, and extends the full length of the shoreface on the western property boundary (Figure 2). During low tides, an intertidal shoreline is exposed west of the retaining wall base. The retaining wall, apparently constructed between the late 1970s and early 1980s, is composed of vertical steel plates. The steel plates, at least in part, were salvaged from ship hulls, and were interwoven into pilings that supported an older dock structure. In August 2020, a sheet pile shoring wall was installed on the landward (east) side of the existing makeshift retaining wall to stabilize the shoreface and facilitate removal of fill containing spent sandblast grit (SBG) on the uplands side of the sheet pile shoring wall (Figure 2). This wall extends to an elevation of −28 ft North American Vertical Datum of 1988 (NAVD 88; a depth of approximately 45 ft below ground surface). The shoreface is relatively steep (approximately 1H:1V to 2.5H:1V), partially vegetated, and contains abundant debris (metal, concrete and wood pilings). This shoreface is considered unstable and is not used.

2.2 SITE HISTORY

The Property has a long industrial history that began with the construction of the LDW Slip 1 at the beginning of the 1900s. Approximately half the area directly east of Slip 1, at the head of the slip, is the former site of companies that include Glacier Sand and Gravel, Ladysmith Coal Company, Marine Leasing Corporation (a Woeck family company), and Snopac Products, Inc. Starting sometime in the 1970s, spent SBG was dumped directly on the bank adjacent to Slip 1, and then later behind the retaining wall.[2] The SBG was reportedly derived from smelter slag. The SBG-containing fill is the primary identified source of contamination in uplands soil and groundwater, and in sediments, at the Site. The Site dock structure was reportedly deemed unsafe in 1980 (Hart Crowser 2011), and only minor remnants of the dock structure now remain. Since 2012, the Snopac Property has been owned by 5055 Properties LLC, a Manson subsidiary, and operated by Manson for storage and parking.

Additional details regarding the Property history are available in the RI report (Aspect and Integral 2020).

2.3 PRIMARY CONTAMINANTS OF CONCERN

The primary COCs in and adjacent to Slip 1 identified in the LDW RI included polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), arsenic, and metals (Windward 2010). However, impacts in the Project Area at the head of Slip 1 area are primarily due to the presence of elevated arsenic and metals concentrations in nearshore surface sediments. The elevated metals concentrations in the shoreface and sediment are associated with the spent SBG that was historically disposed of on the bank adjacent to the slip.

2.4 POTENTIAL HISTORICAL CONTAMINANT SOURCES TO SLIP 1 AND SHOREFACE SEDIMENTS

While much of the COC contamination presently found in Slip 1 surface sediments was likely deposited in Slip 1 from upstream and regional sources, some of the businesses that have operated in and around Slip 1 also may have contributed contamination to the waterway. Evidence of historical sources of contamination can still be seen in the slip. Examples include detections of Aroclor 1242 in surface and subsurface sediments, some of which are likely associated with the 1974 U.S. Army Corps of Engineers PCB spill (USEPA 1977), and the high concentrations of arsenic and metals currently present at the head of the slip, which are attributed to disposal of SBG when Marine Leasing owned the Snopac Property in the 1970s to 1980s. Additional details on the SBG deposited on the banks adjacent to Slip 1 are provided in the RI report (Aspect and Integral 2020).

SAIC (2008) identified surface runoff, groundwater discharges, and bank erosion as potential sources of contamination. That said, much of the Snopac Property is unpaved, so most of the surface water infiltrates rather than running off. There is evidence of arsenic and other metals exceedances in a groundwater seep on the shoreface adjacent to the Snopac Property, presumably related to the SBG dumped in that area when Marine Leasing owned the Snopac

[2] As part of the upland interim action work plan, the retaining wall is being replaced with a sheet pile shoring wall. The sheet pile shoring wall will extend to a total embedment depth of approximately 45 ft.

Property. But there is no evidence of other groundwater discharges contributing COCs to Slip 1 from properties associated with 5055 Properties LLC. SAIC noted that the banks surrounding Slip 1 have been covered by wharfs, limiting bank erosion risks (SAIC 2008).

2.5 SITE BATHYMETRY AND BANK TOPOGRAPHY

The slip is relatively shallow, with surface elevations ranging from +0.96 ft NAVD 88 (or +3.34 ft mean lower low water [MLLW]) at the head of the slip to approximately −17 to −22 ft NAVD 88 (or –15 to −20 ft MLLW) within the Project Area. At low tide, bottom sediments are exposed at the head and along the adjacent eastern shoreface. The top of bank elevation ranges from about +15 to +17 ft NAVD 88. Much of the bank is within the tidal range. The existing bank slope is steep, consisting of some soil, SBG, and debris (metal, wood, and concrete). The Site's ordinary high water mark elevation is 10.4 ft NAVD 88 (ESA 2018) and the MHHW level is 9 ft NAVD 88 (or 11.38 ft MLLW vertical datum) (NOAA 2018).

3 REMEDIAL INVESTIGATION

The RI report for the Snopac Property, submitted to Ecology on May 26, 2020, describes the Site history, regulatory history, environmental and ecological settings, and environmental investigations that have been completed at the Site. The RI was completed for both the upland and sediment portions of the Site. As part of the RI, chemistry results from surface and subsurface sediment samples were screened against a variety of CULs and RALs to assess sources, magnitude, and spatial extent of sediment contamination at the Site (Table 1).[3] Data sets available to characterize sediment quality in the intertidal and subtidal areas off the Snopac Property include the following:

- LDW RI, 1997 and 2004–2006 (Windward 2010)
  - Subtidal surface (0–10 cm below mudline [bml]) sediment samples (*n*=3) and a sediment core (*n*=1)
  - Sediment core depths sampled: 0–1 ft, 1–2 ft, 2–4 ft, and 6–8.2 ft bml.
  - Figure 3
- 5055 Properties LLC's Supplemental Sampling, 2015 (Integral 2015)
  - Subtidal (*n*=20) and intertidal (*n*=12) surface (0–10 cm bml) sediment samples
  - Figure 4
- Snopac RI/FS Sampling, 2018 (Integral 2018)
  - Subtidal sediment cores (*n*=3)
  - Sediment core depth sampled: 3–5 ft bml
  - Figure 4.

In aggregate, these data sets were used to develop a robust characterization of surface sediment contamination at the Site. Additional subsurface data will be collected during the design phase to support the preferred remedy selected in this FS.

3.1 HISTORICAL LDW INVESTIGATION AND ROD SUMMARY

As part of the LDW RI/FS, a limited sampling program was conducted from 1997 to 1998 and 2004 to 2006 to assess sediment quality in the vicinity of Slip 1 (Windward 2010). At the head of the slip, sediments were evaluated at four locations (three surface sediment locations and one

[3] The RI was submitted to Ecology in 2020 and therefore does not include the updated cPAH RALs and CULs per EPA's 2021 ESD.

sediment core) as part of the LDW RI/FS sampling. All four of these sample locations were within 50 ft of one another.

The LDW RI (Windward 2010) defined, generally, the ecological and human health risks posed by the contamination in the LDW. Pursuant to WAC 173-340-350(6), this information on receptors is summarized below.

Based on the LDW RI ecological data summarized in the LDW FS (AECOM 2012), approximately 25 percent of the sediment within the LDW study area exceeded sediment quality standards, and in approximately 7 percent of this area, contaminant concentrations are above the CULs, which is likely to have adverse effects on the benthic invertebrate community. Of the 44 contaminants selected as contaminants of potential concern (COPCs) for benthic invertebrates that were evaluated during the RI, 41 were selected as risk drivers, with concentrations detected above the sediment quality standards (Table 3-1 of AECOM 2012).

The human health risk assessment estimates human health risk through exposure to contaminants in LDW seafood, sediment, and water. As summarized in the LDW FS (AECOM 2012), total risk for exposure through seafood ranged from 7 in 10,000 to 4 in 1,000 (PCBs, arsenic, and carcinogenic PAHs). Total excess cancer risk through direct contact with sediment during net fishing and clamming scenarios resulted in 3 in 100,000 and 1 in 10,000, respectively (AECOM 2012). Total excess cancer risk estimates for exposure during beach play ranged from 5 in 1,000,000 (5×10^{-6}) to 5 in 100,000 (5×10^{-5}) for the eight individual beach play areas evaluated (AECOM 2012).

3.2 SUPPLEMENTAL SLIP 1 SEDIMENT INVESTIGATIONS

Because of the sparse data available for the head of Slip 1 in the LDW RI/FS data set, 5055 Properties LLC conducted additional intertidal and subtidal surface sediment sampling within the Slip 1 area in 2015. The 2015 sampling was intended to be at the density typically required for defining spatial extent for remedial design purposes. The sample density for surface sediments is sufficient. Additional subsurface data will be collected during the design phase to support the preferred remedy.

The 2015 sampling included collection of surface sediment samples at five intertidal shoreface locations and at 18 subtidal locations (Figure 4). The 2015 supplemental sampling documented lower surface sediment concentrations than measured during the LDW RI studies and possible recovery, and defines a smaller area requiring active remediation based on the LDW ROD criteria (USEPA 2014). In particular, the assumed extent of arsenic and metals contamination in Slip 1 was less than estimated in LDW ROD Figure 18 (Appendix A; USEPA 2014). For the purposes of developing this Sediment FS, the RAL exceedances for arsenic, metals, PAHs, and total PCBs at the head of Slip 1 were used to characterize the spatial extent of contamination. Arsenic and metals concentrations exceeding RALs are spatially limited as defined by the data shown on Figure 4 and provided in Table 2a, and concentrations decrease rapidly away from the shoreface. The 2015 data set shows that all RAL exceedances for metals at the head of Slip 1 were located within 50–100 ft of the shoreface and are within the proposed remedial area (Figure 4). Additional bathymetric surveys and data collection will be conducted during future pre-design investigations to assess COC concentrations relative to changes in bathymetry, and determine natural recovery or sediment deposition.

To address data gaps for the Slip 1 remedial action, subsurface sediment samples were collected in February 2018 for chemical and geotechnical analyses. The 2018 sampling station locations were selected to provide pre-design information, including sediment concentrations that would be present below the partial dredge and cap area and geotechnical data for cap design. Three types of samples were collected at each station: subsurface sediment for chemical concentrations, porewater for chemical concentrations, and sediment for geotechnical properties. Subsurface sediment samples for chemical and geotechnical analysis were collected from depths of 3–5 ft bml. Chemical data characterize the sediments that will remain underlying the cap, and geotechnical data support the partial dredge and cap design with the objective of characterizing shallow and deep-seated conditions.

Analytical results for the supplemental sampling conducted in 2015 and 2018 within the project area are provided in Tables 2a and 2b, and the 2015 data set is shown on Figure 4. Elevated concentrations of PCBs, PAHs, and metals were found in sediment at 3–5 ft bml in the 2018 cores.

Additional detail and analytical results for the supplemental sampling conducted in 2015 and 2018 are provided in the Snopac Property RI (Aspect and Integral 2020).

3.3 UPLAND SOIL, GROUNDWATER, AND SHOREFACE SEDIMENT

In 2015, Aspect completed a data gaps evaluation for the upland portion of the property and collected Site characterization data to complete a MTCA-compliant RI. The objectives of the investigation were to evaluate the nature and extent of COPCs, which are primarily associated with SBG and other fill throughout the soil, sediment, and groundwater of the upland portion of the Site. These data are used to evaluate potential sources to Slip 1 sediments and support the development of the conceptual site model described in Section 5.

Results and characterization of the soil, shoreface sediment, groundwater, and seeps are described in detail in the Snopac Property RI (Aspect and Integral 2020). Investigations show that Site groundwater is tidally influenced, with hydraulic connection to the LDW. Elevated concentrations of COCs, including arsenic, metals (copper, chromium, lead, nickel, and zinc), PAHs, and PCBs, and the COPC tributyltin were found in the soil, shoreface sediments, and groundwater seeps. Although tributyltin was evaluated as COPC in the LDW ROD, the associated risk evaluation concluded that tributyltin is not considered a COC for sediment due to low detection frequency and low contribution to overall risk (USEPA 2014).

3.4 EXCEEDANCE SCREENING ASSESSMENT

Sediment COC data collected at the head of Slip 1 were evaluated to determine the extent of each type of active remediation (partial dredge and cap and ENR) as defined in the LDW ROD (USEPA 2014) and to ensure a protective remedy was selected (remedial technologies are defined in Section 6). Both partial dredge and cap and ENR are applicable technologies classified as Category 2—recovery less certain. The Category 2/3 classification was also confirmed based on the ROD and current and future slip use within the project area. This evaluation is based on the RAOs, RALs, CULs, point of compliance, and potentially applicable regulatory requirements defined in Section 4. The area at the head of Slip 1 is classified as a Category 2 recovery area (further described in Section 4.6). Sediment data were screened against the RALs and/or Upper Limits for ENR defined in the ROD for sediments located in Category 2, as presented in revised ROD Table 28 (USEPA 2021), which is included in Appendix A. The data are distributed into the following three categories:

- Sediment with COC concentrations greater than the Upper Limit for ENR requires capping, dredging, or partial dredging and capping.
- Sediment with COC concentrations greater than the RAL and less than the applicable Upper Limit for ENR requires ENR.
- Sediment with COC concentrations less than the RAL, but greater than the sediment cleanup objectives, is suitable for monitored natural attenuation.

Figures 19 and 20 from the LDW ROD (USEPA 2014), which are included in Appendix A, illustrate how RAL screening criteria are to be used to determine remedial technology assignments for intertidal (+11.3 ft MLLW to -4 ft MLLW) and subtidal (-4 ft MLLW and deeper) sediments, respectively. Based on the arsenic and metals contamination observed in the limited LDW RI/FS data set, partial dredge and cap was selected for the intertidal and subtidal area adjacent to the Snopac Property, shown in LDW ROD Figure 18 (Appendix A) and illustrated in Figure 3.

The LDW ROD RAL screening criteria described above were used to evaluate the supplemental surface (0–10 cm) sediment data collected in 2015 and the subsurface (3–5 ft bml) sediment data collected in 2018. This data evaluation is summarized in Figure 4, and tabulated data results are provided in Table 2a, Table 2b and the Snopac Property RI (Aspect and Integral 2020). As shown in Figure 4, the 2015 data support refining the footprint of the partial dredge and cap area and implementing ENR along the western portion of the remedial area. Additional data will be collected to confirm that ENR is an appropriate remedial technology to apply within the project area as shown on Figure 4. Additional bathymetric surveys will be conducted to assess changes in bathymetry, sediment deposition, and depths of concentrations in comparison to historical depths.

The 2018 sediment core data were used to evaluate if COC concentrations at greater than 1 ft below the partial dredge and cap area (depth interval shown in LDW ROD Figure 19 and Revised Figure 20 [USEPA 2014, 2015]) would exceed the RALs. Based on existing sample data, there is no scientific basis to anticipate concentrations from a 3–4 ft bml or 4–5 ft bml sample interval will be substantially different from what was observed in 2–4 ft bml or 3–5 ft bml sample intervals. Although these cores were collected outside of the area with surface RAL exceedances, it was assumed that similar concentrations would extend to the subsurface area within the partial dredge and cap area. Sediment data collected in 2018 do exceed the surface human health RALs or benthic COCs, which indicates that partial dredge and cap is required versus dredging as defined in LDW ROD Figure 19 and 20 (USEPA 2014, 2015).

In summary, based on comparing surface sediment concentrations to the top 10 cm RAL (revised ROD Table 28 [USEPA 2021]), ENR would not be protective within the intertidal area, and partial dredge and cap or dredging would be required. Partial dredge and cap or dredging to 4 ft bml would remove the top 45 cm of sediment, so comparison to the subsurface (0–45 cm) intertidal Recovery Category 2 and 3 RALs and Upper Limits for ENR was not necessary. Select subsurface data collected between 2 and 5 ft bml exceed the surface human health RALs, indicating that partial dredge and cap versus dredging is an appropriate technology. The majority of surface sediment concentrations outside of the intertidal area were below the surface Upper Limits for ENR. Additional data will be collected during design to evaluate sediment concentrations in the top 60 cm and the extent of ENR.

3.5 REMEDIAL INVESTIGATION CONCLUSIONS

Sediment data collected from the intertidal and subtidal sediments of the Snopac Property confirm that arsenic and metals are the primary COCs driving the need for remediation at the Site. Other COCs (PAHs and total PCBs) detected above RALs in surface sediments within the head of the slip are limited and co-located with the arsenic and metals, so the other COCs will be addressed by remediating the arsenic and metals. PAHs were detected above RALs in one subtidal and one intertidal surface sediment samples, and PCBs were detected above RALs in one subtidal and four intertidal surface sediment samples. The elevated metals concentrations extend from the upland and intertidal area at the head of Slip 1 into the adjacent subtidal area (Aspect and Integral 2020). The spatial extent of the elevated arsenic and metals concentrations is well characterized by the sampling conducted at the head of Slip 1 and the shoreface. The arsenic and metals contamination in sediment is likely due to disposal of SBG in the 1980s, when Marine Leasing owned the Snopac Property. These data were used to refine the remedy assigned for Slip 1 in the LDW ROD (USEPA 2014). Exceedances of the Recovery Category 2 and 3 RALs and Upper Limits for ENR for the top 10 cm mostly occurred within the intertidal area, requiring dredging or partial dredge and cap in this area. Based on the existing subsurface core data, the subsurface sediment COC concentrations would most likely exceed the human health RALs at greater than 1 ft below the dredged area, which indicates that partial dredge and cap is required. Outside of the intertidal areas, sediment in the western portion of the project area does not exceed the surface Upper Limit for ENR, indicating that ENR may be a protective remedial technology. Additional data will be collected during design to confirm this remedy refinement is protective.

4 REMEDIAL ACTION REQUIREMENTS

The following sections identify RAOs, RALs, CULs, point of compliance, and potentially applicable regulatory requirements. RAOs, RALs and CULs for this Sediments FS were developed to address applicable or relevant and appropriate requirements (ARARs) and EPA ROD requirements applicable to LDW-wide cleanup efforts. These goals and related regulatory requirements address river-wide conditions relative to potential impacts to human and ecological receptors, as well as land use, habitat, cultural resources, and other considerations. Project RAOs provide the framework for evaluating remedial technologies described subsequently in this Sediment FS, and for selecting a preferred remedy.

4.1 APPLICABLE STATE AND FEDERAL LAWS (ARARS)

ARARs are legally applicable or relevant and appropriate substantive (as opposed to administrative) standards, requirements, criteria, or limitations under any federal environmental law, or promulgated under any state environmental or facility siting law that is more stringent than federal law. Federal, state, and local laws governing activities related to the head of Slip 1 sediment remedial area are included in Table 3.

4.2 REMEDIAL ACTION OBJECTIVES

The primary objective for this Sediment FS and subsequent cleanup actions includes substantially eliminating, reducing, and/or controlling unacceptable risks to human health and the environment posed by COCs and SBG waste in the sediment remedial area in accordance with MTCA, the EPA ROD, and other applicable regulatory requirements. EPA developed RAOs to describe what the proposed cleanup is expected to accomplish to protect human health and the environment. The RAOs for the LDW are based on results of the Site-wide human health and ecological risk assessments. RAOs help focus the development and evaluation of remedial alternatives and form the basis for establishing CULs in the ROD (USEPA 2014). Applicable ROD CULs/RALs for sediments based on the RAOs are provided in Table 1 and described below.

4.3 REMEDIAL ACTION LEVELS

MTCA allows for the use of RALs, which are concentrations (or other method of identification) of a hazardous substance in soil, water, air, or sediment above which a particular cleanup action component will be required as part of a cleanup action at a site (WAC 173-340- 200). As part of the LDW ROD, EPA defined "Remedial Action Levels" under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) for the entire LDW. These RALs are set forth in the ROD and ESD excerpts included as Appendix A. For this remedial action, the RALs defined in ROD Figures 19 and 20 in Box 1 are selected and incorporated by reference to be consistent with EPA's chosen remedy for the LDW.

These RALs vary by Recovery Category and remedial technologies as defined in the LDW ROD (USEPA 2014). These RALs are set by EPA so that in each area, CULs will be met either immediately after construction, or in the long term after natural recovery, to the extent practicable.

4.4 CLEANUP LEVELS

The CULs described in Section 8 of the LDW ROD (USEPA 2014) and cPAH updates described in the ESD (USEPA 2021) are provided in Table 1 and Appendix A. To be consistent with EPA's selected remedy for the LDW, these CULs were applied to this Sediment FS. CULs for Slip 1 sediments were developed to address ARARs (Table 3), state Sediment Management Standards, and EPA ROD requirements applicable to LDW site cleanup efforts. These goals and related regulatory requirements address river-wide conditions relative to potential impacts to human and ecological receptors, as well as land use, habitat, cultural resources, and other considerations.

4.5 POINT OF COMPLIANCE

Point of compliance is defined by MTCA as the point or points where CULs shall be achieved (WAC 173-340-200) (AECOM 2012). Human health CULs for RAO 1 (seafood consumption), ecological CULs, and CULs for subtidal and intertidal areas must be met in surface sediments (top 10 cm and top 60 cm for subtidal; top 10 cm and top 45 cm for intertidal). Sediment concentrations are compared to the RALs identified in Table 28 of the LDW ROD (USEPA 2014), which were set by EPA so that CULs will be met either immediately after construction, or in the long term after natural recovery, to the extent practicable. Consistent with the Sediment Management Standards, the top 10 cm represents the biologically active zone where most of the benthic invertebrates reside. The point of compliance for this remedy is the upper 45 cm in intertidal and upper 10 cm for subtidal areas in the entire project area as defined in Table 19 of the LDW ROD (USEPA 2014).

4.6 RECOVERY CATEGORIES

Recovery Categories were used in the LDW ROD to assign remedial technologies to specific areas based on information about the potential for sediment contaminant concentrations to be reduced through natural recovery or for subsurface contamination to be exposed at the surface due to erosion or scour. Recovery Category 1 refers to areas where recovery is presumed to be limited; Categories 2 and 3 refer to areas where recovery is less certain (Category 2) and areas that are presumed to recover (Category 3). Slip 1 is under Recovery Category 2 and 3 (ROD Figure 12) and the ROD selected remedies include ENR, monitored natural recovery, cap, and partial dredge and cap (ROD Figure 18). The head of Slip 1 addressed in this Sediment FS is Category 2.

The use of Recovery Categories allows for more aggressive remedial technologies (such as capping and dredging) in areas with less potential for natural recovery and a higher likelihood of scour or other disturbance, and less aggressive remedial technologies (such as ENR and monitored natural recovery) in areas where recovery is predicted to occur more readily and disturbance is less likely.

The RALs and Upper Limits for ENR were used to evaluate the extent of partial dredge and cap and ENR, which are defined in the LDW ROD Table 28 (Appendix A) for Recovery Category 2 Intertidal Sediments (top 10 cm and top 45 cm) and subtidal sediments (top 10 cm and top 60 cm) to be consistent with EPA's selected remedy for the LDW. Sediment analytical data are compared to the human health and benthic COC RALs and the ENR Upper Limits (Appendix A, Table 28) in Table 1.

4.7 POTENTIALLY APPLICABLE REGULATORY REQUIREMENTS

MTCA and EPA ROD regulatory provisions form the primary basis for evaluating and implementing appropriate remedial alternatives through the FS process. Following selection of a preferred alternative through this Sediments FS, MTCA requirements guide the process for preparing a cleanup action plan, engineering design report, and engineering plans and specifications that address specific MTCA, LDW ROD, and other regulatory requirements. 5055 Properties LLC will work with EPA, Ecology, and other parties to implement this work. Potentially applicable state and local laws and related permitting requirements include the following:

- Chapter 70.94 RCW – Washington Clean Air Act
- Chapter 70.95 RCW – Solid Waste Management – Reduction and Recycling
- Chapter 70.105 RCW – Hazardous Waste Management
- Chapter 75.20 RCW – Construction Projects in State Waters
- Chapter 90.48 RCW – Water Pollution Control
- Chapter 90.58 RCW – Shoreline Management Act.

Federal permitting for in-water work could likely be conducted under the Nationwide 38 permit program administered by the U.S. Army Corps of Engineers, or, alternatively, under a Clean Water Act Section 404 permit. Additional permitting requirements include Clean Water

Act Section 401 (Water Quality Certification), the Endangered Species Act (agency consultation), and other state or local approvals.

5 CONCEPTUAL SITE MODEL

This section of the Sediment FS provides a summary of the conceptual site model of contaminant sources, fate and transport, and potential exposure routes. Historical Site activities and operations and sources of contamination to Slip 1 are described in Section 2 of this Sediment FS, and routes of contaminant transport to Slip 1 based on Site geology and hydrogeology are summarized below and described in detail in Section 6 of in the RI (Aspect and Integral 2020). The conceptual site model is shown on Figure 5 and described below.

5.1 COC SOURCES AND FATE AND TRANSPORT

Upland Site activities and operations, such as spent SBG landfilling, coal burning, and releases from underground storage tanks have impacted soil, groundwater, and seeps discharging to Slip 1. Spent SBG with associated waste paint, placed as fill in nearshore areas of the Site, is considered to be the primary source of arsenic and metals exceedances in Site groundwater discharging to surface water. Based on visual observations during the RI, it is likely that fill behind much of the immediate landward side of the existing retaining wall consists primarily of SBG. Elevated concentrations of COCs, including arsenic, metals (copper, chromium, lead, nickel, and zinc), PAHs, and PCBs, and the COPC tributyltin, have been detected in upland soil and groundwater. Migration of COCs has been observed through the following pathways (summarized from the RI, Aspect and Integral 2020):

- Groundwater seeps from upland COC sources to sediments. Groundwater at the Site is tidally influenced, which facilitates migration of COCs to the sediments. Groundwater in the Fill and Alluvium Units is hydraulically separated by the Estuarine unit and flows to the west with discharge to the LDW. Tidal fluctuations in the LDW hydraulically influence both Fill and Alluvium Unit groundwater, with the Alluvium having a much greater tidal efficiency than the Fill Unit. During high tides, local and temporary groundwater flow direction reversals are observed in the Fill Unit. During low tides, groundwater discharges through seeps observed on the existing intertidal shoreface.
- Rainwater infiltration and leaching of COCs from upland vadose soil to groundwater. Contaminants are then transported through the tidal mixing zone to sediments, and to surface water discharge along the Slip 1 shoreface.
- Surface water leaching of COCs from SBG in shoreface sediments seaward of the retaining wall. COCs may then be subsequently transported to sediments and surface water located further seaward in Slip 1.
- Erosion of bank soil and sediment from areas around the retaining wall to intertidal and subtidal sediments.

5.2 EXPOSURE PATHWAYS

The following exposure pathways were evaluated as a part of the RI (Aspect and Integral 2020) and are currently considered complete at the Site for COC exposure pathways through sediment (Figure 5).

- Direct contact of ecological (benthic) receptors to contaminated sediment
- Direct contact of human receptors to contaminated sediment
- Human exposure via consumption of aquatic organisms exposed to contaminated sediment.

6 IDENTIFICATION AND SCREENING OF REMEDIAL TECHNOLOGIES

This section identifies remedial action technologies and evaluates these technologies for their applicability to the Slip 1 sediment remedial area located seaward of the MHHW level. The identification and evaluation of technologies for the Slip 1 sediment remedial area are consistent with the technologies identified in the LDW ROD (USEPA 2014). The remedial action technologies considered included methodologies capable of achieving the RAOs, including the preliminary MTCA/Sediment Management Standards, RALs, and RAOs presented in the LDW ROD (USEPA 2014), and other regulatory requirements. The complementary Upland FS completed by Aspect provides a comparable evaluation of remedial technologies and proposed remedy for the portions of the Site landward of MHHW.

Remedial action technologies evaluated for the Slip 1 remedial action included:

- No action
- Institutional controls
- Partial dredge and cap
- Engineered sediment cap
- ENR
- Shoreface/bank excavation and backfill
- Shoreface/bank capping
- Habitat restoration.

6.1 NO ACTION

Included as a baseline or null case for comparison, "no action" does not achieve RAOs, including protection of the environment. It does not satisfy MTCA evaluation criteria or mitigate site impacts. The "no action" case is, therefore, eliminated from further consideration. This technology was evaluated in the LDW FS, but was only retained for comparative purposes.

6.2 INSTITUTIONAL CONTROLS

Institutional controls represent non-engineering measures designed to prevent or limit exposure to hazardous substances left in place at the Site, and/or assure the integrity, effectiveness, and long-term performance of the chosen remedy. Institutional controls are particularly effective if contaminants are not completely removed, and may include physical measures such as fences, use restrictions, maintenance requirements, educational programs, or financial assurances. Institutional controls can be used as the primary component of a remedial alternative or in combination with other remediation technologies to minimize or prevent exposure to contaminated media left in place at a given site. The MTCA ARAR requires institutional controls whenever hazardous substances remain above CULs (WAC 173-340-440(4)). Institutional controls are meant to supplement remediation technologies during all phases of cleanup and may be a necessary component of the final remedy.

6.3 PARTIAL DREDGE AND CAP

This remedial technology includes partial dredging and offsite disposal to preserve berthing depth, followed by the application of an engineered cap with a suitable habitat layer (in intertidal and subtidal area to -10 ft MLLW). Engineered sediment caps are described in Section 6.4. Sediments that exceed RALs can be physically removed by dredging and transported to a permanent disposal location. Dredging can be accomplished either by mechanical or hydraulic methods, depending on such factors as site access constraints, availability of adjacent upland space, and the final disposal destination. Dredged sediment can be loaded or pumped onto barges, or onto an adjacent upland space, and transported via barge, truck, rail, or pipeline to a final disposal facility.

Testing of the excavated dredge material is required for compliance with applicable Ecology Dangerous Waste regulations (WAC 173-303). The type of chemical present, its source, its concentration, and its physical characteristics (leachability, corrosivity, etc.) all can factor in determining treatment/disposal requirements. Depending on test results, excavated Site sediment would require either disposal at a nonhazardous waste (Subtitle D) landfill or disposal at a hazardous waste (Subtitle C) facility. The actual offsite treatment/disposal requirements would be determined in the remedial design, and ultimately with final waste characterization and acceptance.

Allowable in-water construction windows would be determined by EPA in consultation with Ecology, National Oceanic and Atmospheric Administration Fisheries, U.S. Fish and Wildlife Service, Washington Department of Fish and Wildlife, and the Muckleshoot Tribe. EPA and Ecology may allow work below ordinary high water outside the established in-water construction window if the work is effectively completed in-the-dry when tides are out.[4]

As part of the design process, best management practices would be defined to reduce the potential for sediment resuspension and to reduce water quality impacts during dredging. The selected contractor would be required to include best management practices in its remedial action work plan.

[4] See WAC 220-660-110 (https://app.leg.wa.gov/wac/default.aspx?cite=220-660-110).

6.4 ENGINEERED SEDIMENT CAP

Engineered sediment caps are designed to isolate impacted sediments by placing a layer of clean sand, and possible amendment such as activated carbon, on top of the contaminated sediment, followed by gravel and rock for scour and erosion protection. A suitable habitat layer will be applied to the surface of the cap to reestablish the benthic community. The impacted sediments are isolated beneath the cap to prevent migration and exposure of contaminants to the surface and water column habitat above. Sediment cap thickness would be 3 ft in subtidal areas and 4 ft in intertidal areas. Cap and scour protection material will be evaluated during the design phase to determine the best cap material, amendment, and scour protection necessary to prevent migration of COCs and protect the cap from erosion and scour.

6.5 ENHANCED NATURAL RECOVERY

ENR is the process of placing a thin layer (6 to 9 in.) of sand on sediments to facilitate the process of natural recovery. By applying thin layers of clean material over an area and allowing natural re-sorting or bioturbation to mix the contaminated sediment and clean material layers, the natural recovery process is accelerated, resulting in a surface layer with chemical concentrations that are within acceptable levels. ENR reduces contaminant concentrations in surface sediments more quickly than would happen by natural sedimentation processes alone. With ENR, placement of 6–9 in. of sand would improve habitat function by isolating contaminated sediment while also maintaining productive, fine-grained substrate on the benthic surface. A long-term monitoring program would likely be conducted in conjunction with ENR to verify the effectiveness of the technology. EPA is conducting a pilot study to evaluate whether ENR with amendments is effective in reducing toxicity and bioavailability of COCs while avoiding unacceptable impacts to biota (USEPA 2014). The estimated protectiveness, design, and associated cost of ENR are dependent on completion of the EPA pilot study.

6.6 SHOREFACE/BANK EXCAVATION AND BACKFILL

Upland remediation activities are estimated to be completed prior to the start of in-water and shoreface restoration work. Because of this, shoreface excavation and backfill would be conducted using typical earthmoving equipment operated from a barge. Excavation would generally be used on embankments and potentially at the head of Slip 1 at elevations above approximately +1 ft NAVD88. (The ability to excavate at the head of the slip depends on the bottom elevation of the cut.) Excavated material would be loaded onto haul barges, as described for dredging operations.

Shoreface excavation would remove degraded/over-steepened slopes and anthropogenic debris such as remnant bulkheads, piles, concrete, wood structure, and refuse in addition to the SBG to be removed. Post-remedial backfill would re-establish stable slopes that both avoid a net fill below ordinary high water mark and preserve upland land uses. Over-steepened and vertical sections would be replaced with stable slopes. The backfill surface would consist of the smallest substrate that would remain stable on the slopes. Above ordinary high water mark the slope would be flattened to the extent possible up to the existing grade at the sheet pile. The shoring would be cut off at or below grade following completion of the new slopes.

Excavated soil would require testing for compliance with applicable Ecology Dangerous Waste regulations (WAC 173-303). The type of chemical present, its source, its concentration, and its physical characteristics (leachability, corrosivity, etc.) all can factor in determining treatment/disposal requirements. Depending on test results, excavated Site soil would require either disposal at a nonhazardous waste (Subtitle D) landfill, or disposal at a hazardous waste (Subtitle C) facility. The actual offsite treatment/disposal requirements would be determined in the remedial design, and ultimately with final waste characterization and acceptance.

The existing shoreface remedial area is relatively steep (approximately 1H: 1V to 2.5H: 1V), with slopes continuing in-water down below −20 ft MLLW. The shoreface located above MHHW is included in the Upland FS, and the preferred remedy would include complete excavation of the SBG and associated fill landward to the location of the sheet pile shoring wall, and would extend to a depth of approximately +1 ft NAVD88. This area would then be backfilled with clean material as part of remedial actions. The new shoreface will be designed to ensure bank stability and habitat function and will address both seismic potential and anticipated sea level rise.

Allowable in-water construction windows would be determined by EPA in consultation with Ecology, National Oceanic and Atmospheric Administration Fisheries, U.S. Fish and Wildlife Service, Washington Department of Fish and Wildlife, and the Muckleshoot Tribe. EPA and Ecology may allow work below ordinary high water outside the established in-water construction window if the work is effectively completed in-the-dry when tides are out.

6.7 SHOREFACE/BANK CAPPING

Shoreface and riverbank soils would be excavated to a depth that would allow for placement of an engineered cap to prevent migration of contaminants and to provide a stable bank. Excavation would be completed in the same manner as described in Section 6.6. Cap material may consist of clean sand, sand and gravel, or armoring rock. The re-establishment of the existing over-steepened slopes would require substantial engineering and construction cost. Further, heavy armoring and steep slopes are viewed as unfavorable habitat by permitting agencies, increasing potential mitigation need from remedial actions.

6.8 HABITAT RESTORATION

The post-remedial design attempts to achieve a balance that considers the existing slopes, post-remediation habitat function, avoiding net in-water fill, and upland land uses while minimizing cost. To this end, the remediated shoreface would entail new slopes that are stable, improve on the existing habitat function, and also accommodate upland uses. In the intertidal and subtidal area to −10 ft MLLW, a habitat layer will be placed that will generally consist of the smallest rock size or graded mixture that would be stable given slope and energy. The final makeup of the habitat layer will be determined during design.

The landward end of the remedial area is defined by the area above MHHW (see Upland FS), separating sediment work from upland work. Shoreface excavation would remove degraded/over-steepened slopes and anthropogenic debris, such as remnant bulkheads, piles, concrete, wood structure, and refuse, in addition to the SBG to be removed. Post-remedial backfill would re-establish stable slopes that both avoid a net fill below ordinary high water mark and preserve upland land uses. Over-steepened and vertical sections would be replaced with stable slopes. The backfill surface would consist of the smallest substrate that would remain stable on the slopes. Above ordinary high water mark the slope would be flattened to the extent possible up to the existing grade at the shoring. The shoring would be cut off at or below grade following completion of the new slopes.

Though the surface of the new and re-sloped aquatic habitat along the shoreface would likely need rock to prevent erosion, the substrate and slope improvement would provide greater habitat function than existing conditions. Following grading, all areas landward of the ordinary high water mark, within the project area along the shoreline, that are not occupied by buildings would be planted with a community of native trees, shrubs, and herbaceous species to increase riparian habitat function onsite. The plantings would be designed to integrate with human upland uses to create an aesthetically pleasing, yet functioning, native riparian habitat.

6.9 TECHNOLOGY SCREENING SUMMARY

To select the most appropriate cleanup action for the Slip 1 sediment remedial area, the feasibility of each remedial technology was evaluated by balancing selected criteria, in accordance with WAC 173-340-360. The evaluation of remedial technologies is provided in Table 4 and addresses the following criteria:

- Protectiveness and compliance with cleanup standards
- Permanence
- Relative cost
- Technical effectiveness over the long term

- Management of short-term risk
- Implementability
- Consideration of public concerns.

"No action" as a remedial alterative was screened out during the evaluation, because it would not provide any protection and would not meet cleanup requirements. An engineered sediment cap, alone, is not a feasible option in Slip 1 because water depths must be maintained for habitat and site vessel activity. A combination of the compared remedial technologies is necessary to meet all of the cleanup requirements.

Remedial technologies were selected based on the LDW FS (AECOM 2012) evaluation of alternatives and the LDW ROD (USEPA 2014) selected remedy for Slip 1 (partial dredge and cap with ENR in applicable areas towards the mouth of Slip 1). The selected remedy presented in the LDW ROD (defined in the ROD as the modified Alternative 5C Plus) emphasizes using combined technologies—dredging with upland disposal, capping, and ENR/*in situ* treatment where appropriate. Remedial technologies that will be carried forward for the selected remedy include the following (additional detail is provided in Section 7):

- Institutional controls
- Partial dredge and cap
- ENR
- Shoreface /bank excavation and backfill
- Habitat restoration.

7 PREFERRED REMEDY

The preferred remedy was developed based on review of the selected remedial technologies in the LDW ROD (USEPA 2014), review and screening of recent Site data against criteria provide in the LDW ROD and ESD, and review of MTCA screening criteria. The footprint of the preferred remedy and associated data used in the screening of technologies are shown on Figure 6. Figure 7 provides a plan view and selected cross sections for the preferred remedy, and Figure 8 presents a conceptual design of the shoreface that incorporates both the upland and sediment sections of the shoreface.

7.1 PREFERRED REMEDIAL ACTION

The preferred remedy consists of the following:

- Partial dredge and cap of approximately 0.27 acre of contaminated sediments (approximately 1,303 cubic yards) where there is sufficient water depth for a cap, shown in the blue areas of Figures 6 and 7. Based on the LDW ROD (USEPA 2014), the expected dredge and associated cap thickness will be 3 ft in subtidal and 4 ft in intertidal areas. The final cap thickness will be determined during remedial design in accordance with USEPA and USACE (1998) guidance. A suitable habitat layer will be added in intertidal areas and to −10 ft MLLW in subtidal areas.
- ENR of sediment areas with constituent concentrations lower than the upper limit of the permissible contaminant concentration range suitable for ENR, as described in the LDW ROD (USEPA 2014). ENR will be applied in approximately 0.27 acre, shown in the purple area of Figures 6 and 7.
- Excavation, backfill, and restoration of shoreface below MHHW, shown in the green area on Figure 6 and 7. Remediation of shoreface sediments above the MHHW level are included in the Upland FS, but will be implemented with the sediment remedial action. The following remedial actions will be completed:
  - Excavation of debris and SBG from approximately 0.18 acre of the adjacent intertidal and subtidal shoreface. Volume below MHHW includes 1,955 cubic yards.
  - Backfill and restoration of excavated area below MHHW. Backfill material and native vegetation will be selected to enhance the intertidal habitat. Where needed, rock will be used to improve erosion resistance and/or slope stability, and a surface layer of sandy gravel habitat mix will be applied over and between the rocks to improve the ecological function of the surface substrate. The slope in this area will be maintained but will become more gradual as the remedial action moves landward of the MHHW. This area landward of the MHHW will be planted with a community

of native trees, shrubs and herbaceous species to increase riparian habitat function onsite. Additional details on the remedial action above MHHW are provided in the Upland FS.

- Institutional controls will be put in place to restrict barge and tug movement within the partial dredge and cap area. Barges will be restricted to spudding only in areas outside of the partial dredge and cap area.

This preferred remedy incorporates the assigned remedy provided in the LDW ROD (USEPA 2014) and refines the extent of the assigned technologies based on supplemental data collected in 2015 and 2018 (Figure 6). Based on the criteria provided in Figures 19 and 20 of the LDW ROD (USEPA 2014) and the ESD (USEPA 2021), the area of partial dredge and cap was reduced and replaced with ENR.

The preferred remedy considers the basic constraints of state and federal laws, and regulations on nearshore sediment work, including (but not limited to) the following, as provided in the LDW FS (AECOM 2012):

- No net loss of aquatic habitat
- Preference for intertidal (−4 to +11.4 ft MLLW) and shallow subtidal (−4 to −10 ft MLLW) habitat restoration
- Preference for flatter/stable slopes
- Preference for finer substrate
- Importance of riparian vegetation.

7.1.1 Long-Term Monitoring and Maintenance for Preferred Remedy

Construction, post-construction, and long-term monitoring will be completed as part of the Slip 1 sediment remedial action to ensure compliance with RALs and ARARs and effectiveness of the remedy:

- Construction Monitoring—Monitoring during and after construction will include environmental monitoring to ensure compliance with RALs and ARARs, and monitoring of physical as-built conditions (e.g., bathymetry) to ensure compliance with construction standards and project design documents.
- Long-Term Monitoring—Long-term monitoring of the cap and ENR will be conducted to ensure protectiveness of human health and the environment, to ensure attainment of CULs and compliance with ARARs, to protect the integrity of the remedial actions, and to aid in the evaluation of source control effectiveness.

- Habitat Monitoring—Baseline and long-term monitoring will include appropriate habitat monitoring, including plant growth and bank conditions. The long-term monitoring and maintenance plan will address bank and habitat inspections and maintenance.

The details of long-term monitoring and maintenance, including performance standards, sampling density and frequency, interim benchmarks, and associated additional actions, as well as maintenance of remedy elements such as caps and habitat areas, will be provided in a long-term monitoring and maintenance plan to be developed in remedial design.

7.1.2 Cost Estimate for Preferred Remedial Action

A cost estimate summary for the preferred remedy is provided in Table 5 and is based on the best available information regarding its anticipated scope. Refinement of the cost elements is likely to occur during the remedial design process and a more detailed estimate will be provided as part of the design documents.

The cost estimate was prepared in general accordance with regulatory guidance for cost estimating for feasibility studies (USEPA and USACE 2000) and, as such, is intended to provide values within −30 to +50 percent of actual cost.

7.2 SUMMARY OF PREFERRED REMEDY

The preferred remedy consists of partial dredge and cap, ENR, excavation and restoration of the shoreface below MHHW, monitoring, and institutional controls (Figures 5 and 6). This remedy is consistent with the selected remedy provided in the LDW ROD (USEPA 2014) for Slip 1 with the exception that supplemental data collected since the LDW RI/FS supports refining the remedial area footprint designated for dredge and cap and ENR. This refined area results in replacing a portion of the dredge and cap area with ENR. Implementing ENR as a remedial technology increases the overall feasibility and lowers the cost of the preferred remedy in comparison to partial dredge and cap of the entire remedial area. An evaluation of the preferred remedy in comparison to the MTCA threshold, selection, and ranking criteria is provided in Table 6 and described in the following section.

8 EVALUATION OF PREFERRED REMEDIAL ACTION

The selected remedy must meet the MTCA threshold requirements and use permanent solutions to the maximum extent practicable. An evaluation of the preferred remedy is summarized below and provided in Table 6.

8.1 MTCA THRESHOLD AND OTHER CRITERIA

Cleanup actions selected under MTCA must meet four "threshold" requirements identified in WAC 173-340-360(2)(a) to be accepted by Ecology. The threshold requirements and an evaluation of the remedial alternatives with respect to each requirement are presented below:

1. Protect human health and the environment.
   The preferred remedy would be protective of human health and the environment. Protection of human health and the environment is provided through removal and isolation of contaminated material through dredging and capping, excavation and backfill, and ENR.
2. Comply with cleanup standards.
   Compliance with cleanup standards for eliminating, reducing, and/or controlling unacceptable risks to human health and the environment posed by COCs and SBG waste in the marine environment and adjacent shoreface, in accordance with MTCA and the LDW ROD (USEPA 2014), would be achieved through isolation and removal of contaminated material, and long-term compliance monitoring after construction.
3. Comply with applicable state and federal laws.
   Applicable CULs/RALs for sediments and the adjacent shoreface are described in the LDW ROD (USEPA 2014). ARARs and potentially applicable state and federal laws are identified in Table 3 and discussed in Section 4.1 and were a basis for the preferred remedy development. The preferred remedy is expected to comply with all applicable state and federal laws because the required engineering design and agency-review process would include steps to ensure compliance. The laws may affect implementation, but they do not have a significant effect on whether a remedial alternative is fundamentally viable. The means of compliance would be documented in the remedial design, and other preconstruction documentation to be prepared during design.
4. Provide for compliance monitoring.
   The preferred remedy would provide for compliance monitoring. Partial dredge and cap with ENR, and shoreface excavation and restoration will include performance monitoring to confirm performance objectives associated with the sediment remedial

action are met. Following construction, long-term monitoring will be completed to ensure the sediment remedial action is effective.

The following three criteria must be evaluated and meet (WAC 173-340-360(2)(b)):

1. Use of permanent solutions to maximum extent practicable.
   The preferred remedy meets the permanence criterion. Permanence is discussed in Section 8.2. Long-term monitoring will be performed to ensure permanence.
2. Provide reasonable restoration time frame.
   As discussed under MTCA ranking criteria (WAC 173-340-360[4][a]), the preferred remedy will meet cleanup criteria within a reasonable time frame in consideration of the following factors: potential risks to human health and the environment posed by the site and construction process, practicality of the preferred remedial option, current and future use of the site and surrounding areas, likely effectiveness of the remediation, institutional controls, and control of migration of COCs:
   - Partial dredge and cap. Immediately following implementation, risks to human health and the environment will be reduced by removing COCs and isolating underlying sediment to prevent migration and exposure. Partial dredge and capping requires more time to implement than other remedial options, such as ENR, but combining remedial options will reduce the overall construction time frame.
   - ENR. With the addition of clean substrate, sediment COC concentrations will be reduced following construction and will continue to decrease over time. ENR has a longer restoration time frame than partial dredge and cap, but a shorter restoration time frame than monitored natural attenuation. Combining ENR and partial dredge and cap reduced the overall construction time frame and associated short-term risks (discussed in Section 8.2).
3. Consider public concerns.
   Consideration of public concern is an important part of the MTCA cleanup process. The preferred remedy will be protective of human and ecological health. The implementation of the remedy will comply with the requirements of WAC 173-340-600, which includes public notice and an opportunity for the public to review and comment on the preferred remedy.

8.2 MTCA CRITERIA

The preferred remedy as presented in this Sediment FS was compared to the remedy presented in the LDW ROD using the MTCA Ranking Criteria [WAC 173-340-360(3)(f)] summarized below and provided in Table 6. The criteria include the following requirements:

1. Protectiveness.
   Overall protectiveness of human health and the environment would be achieved. The preferred remedy includes mass removal through partial dredging of subtidal and intertidal sediments within the head of Slip 1. The preferred remedy also provides isolation of contaminated sediment through capping and reduced exposure through ENR. The dredge and cap footprint with the application of ENR would meet the cleanup criteria and would have a similar level of protectiveness as the LDW ROD remedy for the head of Slip 1.

2. Permanence.
   The preferred remedy permanently reduces the toxicity, mobility, or volume of hazardous substances. Treatment capability, reduction of releases, management of the sources of release, degree of irreversibility of treatment, and the quantity and quality of treatment wastes were considered in the development of the preferred remedy. Partial dredge and cap of sediments reduces volume through removal and prevents migration through isolation. Contaminated sediment will be removed and disposed of offsite as a part of partial dredge and cap, eliminating risks of exposure associated with these sediments. Capping then physically contains contaminants beneath the cap, thereby reducing mobility and exposure potential. ENR reduces mobility and toxicity. The dredge and cap footprint with the application of ENR would meet the cleanup criteria and would have a similar level of permanence as the LDW ROD selected remedy for the head of Slip 1

   The preferred remedy provides a net environmental benefit by providing a permanent solution that improves benthic habitat, which outweighs short-term risks that may occur during implementation.

3. Cost.
   Refining the cap and dredge footprint and implementing ENR reduces the overall cost relative to the technology footprint assignment presented in Figure 18 of the LDW ROD (USEPA 2014).

4. Effectiveness over the long-term.
   The degree of certainty for cleanup success, long-term reliability, magnitude of residual risk, management of treatment wastes, and management of wastes left untreated were considered when selecting the preferred remedy. This remedy will provide cleanup and long-term effectiveness with proper controls and long-term monitoring, equivalent to that established in the LDW ROD.

5. Management of short-term risks.
   Risk to human health and the environment associated with the preferred remedy during construction and implementation will be reduced with application of proper best management practices to limit contaminant release or exposure. Furthermore, the reduced partial dredge and cap footprint would result in a lesser amount of material

requiring offsite transportation, with less short-term human health risk due to truck, rail, and/or barge operations, and lower concomitant air emissions, than what was assumed in the LDW ROD, which was based on a more limited data set.

6. Technical and administrative implementability.
   The ability for the remedy to be implemented, including consideration of whether the remedy is technically and administratively possible, was evaluated. Partial dredge and cap would meet the cleanup criteria for the refined footprint and would be more feasible to implement under the constraints of site operations, relative to the ROD remedy. The application of ENR will be evaluated during design. Additional data will be collected to confirm its technical implementability.

7. Consider public concerns.
   The preferred remedy was developed in consideration of public concern, and to prevent release and exposure of contaminated material by removal, capping, and restoration of the remedial areas. The reduced partial dredge and cap footprint would result in a lesser amount of material requiring offsite transportation, with less public concern due to truck, rail, and/or barge traffic, relative to the remedy presented in the LDW ROD.

8.3 DISPROPORTIONATE COST ANALYIS

The purpose of a disproportionate cost analysis (DCA) is to facilitate selection of the remedial alternative providing the highest degree of permanence to the maximum extent practicable. Costs are considered disproportionate if the incremental costs of one alternative versus a less expensive alternative exceed the incremental benefit achieved by the more expensive alternative. For the DCA, each alternative is evaluated and scored against the MTCA threshold and screening criteria described in the previous section. The overall MTCA score is evaluated against the cost of the corresponding alternative.

A DCA was conducted as a part of the LDW FS (AECOM 2012), where Alternative 3C obtained the highest benefit per cost (LDW FS Figure 11-3). Alternative 3C included combined technologies of dredging, capping, and ENR. The DCA that was included in the LDW FS was used for this Sediment FS because the preferred remedy employs the same remedial technologies as were included in Alternative 3C. The preferred remedy in this Sediments FS achieves equivalent environmental benefit with reduced cost by implementing ENR over partial dredge and cap in areas where the recent supplemental data show the concentrations meet the ENR criteria.

The preferred remedy was developed in direct accordance with the federally reviewed and approved LDW FS (AECOM 2012) and the EPA-prepared LDW ROD (USEPA 2014). As part of the administrative process for completing a CERCLA FS, the potential remedial alternatives undergo screening against the two CERCLA threshold criteria and five balancing criteria, which include evaluation of cost. The outcome of this process, the selected remedy, is detailed in the EPA-developed ROD. The FS and ROD were prepared by EPA with Ecology participation, in accordance with the Memorandum of Agreement (MOA) (USEPA and Ecology 2014) between the two agencies. Therefore, implementation of the in-water portion of the ROD, including this action at the head of Slip 1, meets the substantial equivalent of the MTCA DCA and has been approved in accordance with the agency-executed MOA.

For sediment along the shoreface, the preferred remedy is excavation and backfill, which is a more conservative approach for addressing contaminated sediment containing SBG. As discussed in the RI, SBG is mostly limited to the shoreface, and COCs associated with SBG decrease rapidly as one moves away from the shoreface where SBG was deposited (Aspect and Integral 2020). Removal and backfill of the shoreface sediment are consistent with the remedy proposed for the upland portion of the site (Upland Feasibility Study, Snopac Property; Aspect 2023). Alternatives to removal of the shoreface material were not considered in the upland DCA because the benefits of removing COC source material outweigh the associated costs by providing an effective and long-term option for achieving the cleanup goals.

8.4 REMEDY SELECTION

After performing the evaluation of the preferred remedy in accordance with the MTCA criteria, the preferred remedy—partial dredge and cap, ENR, excavation and restoration of the shoreface below MHHW, monitoring, and institutional controls—is the most feasible and cost-effective cleanup action. The preferred remedy should be selected for the Site because it achieves the RAOs, meets the requirements set forth in WAC 173-340-360(3) and WAC 173-340-370, and meets the MTCA evaluation and ranking criteria.

In addition, this remedy for the Site sediment remedial area is consistent with the selected remedy for the subtidal and intertidal sediments provided in the LDW ROD (USEPA 2014), with the addition of ENR in areas where sediment COC concentrations meet the concentration requirements to be remediated through ENR. The selected remedy achieves the RAOs, including preliminary MTCA/Sediment Management Standards CULs and other regulatory requirements, and is compatible with current site usage as the berthing area for work barges and with current site development of the upland property. The preferred remedy is more feasible in those areas where berthing and spudding are occurring. Reducing the dredge and cap footprint from the remedy provided in the LDW ROD (USEPA 2014) by applying ENR will reduce the amount of material to be dredged and disposed of, lowering the costs. Complete excavation of SBG and restoration of the shoreface within the project area will assist with source control to eliminate further contamination of the sediments and enhance nearshore habitat.

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Figures

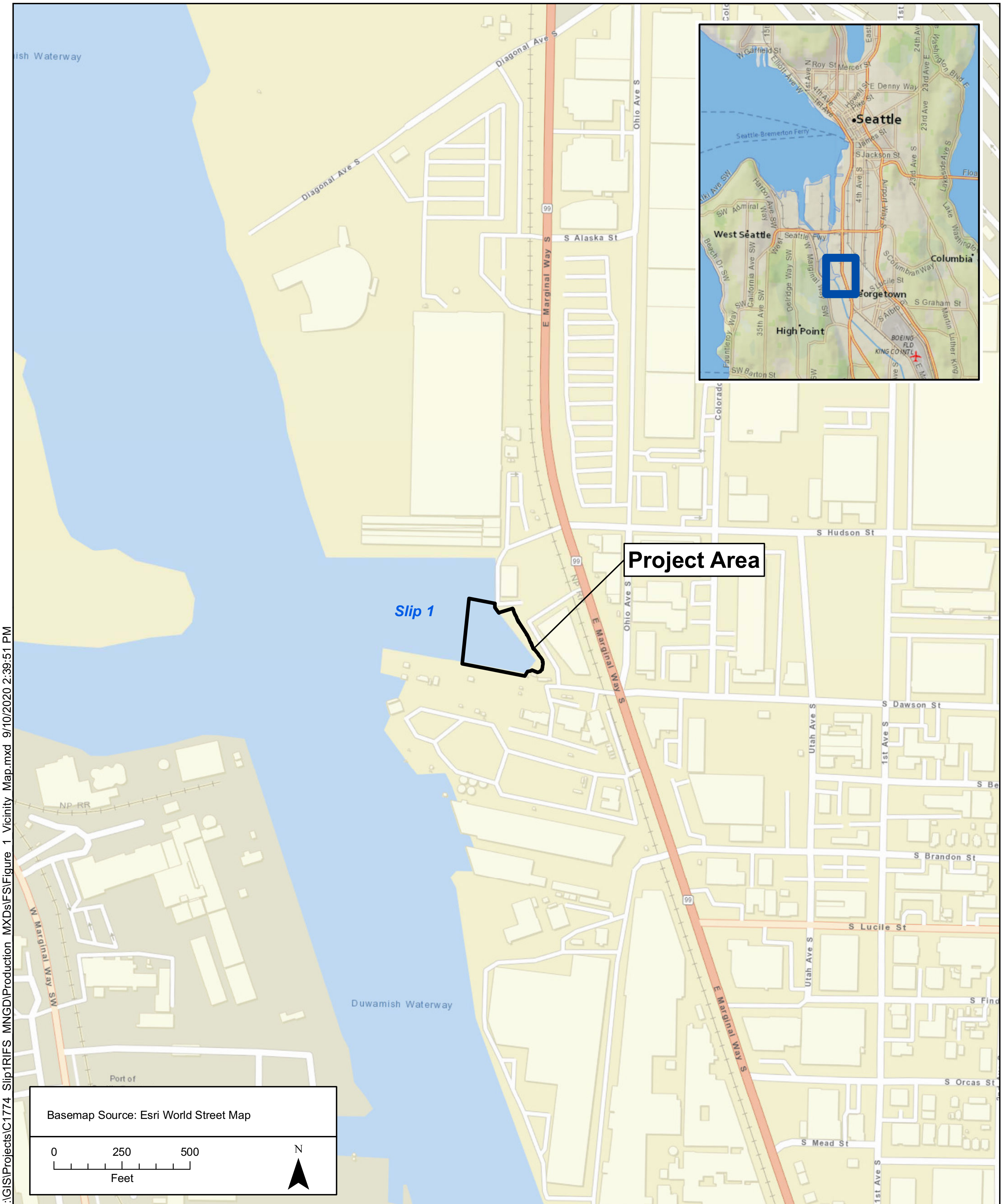

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Figure 1.
Vicinity Map
Sediment Feasibility Study
Snopac Property

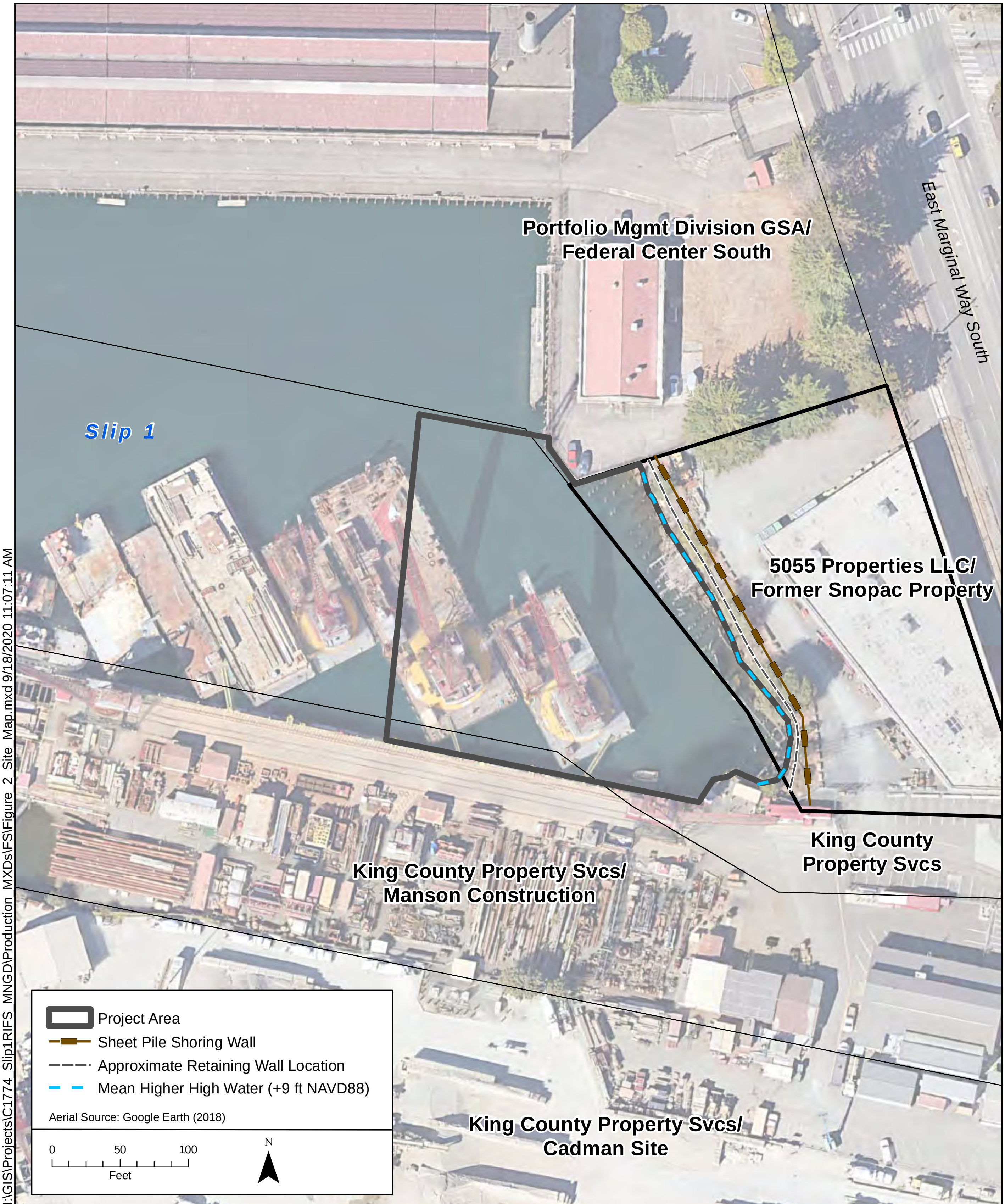

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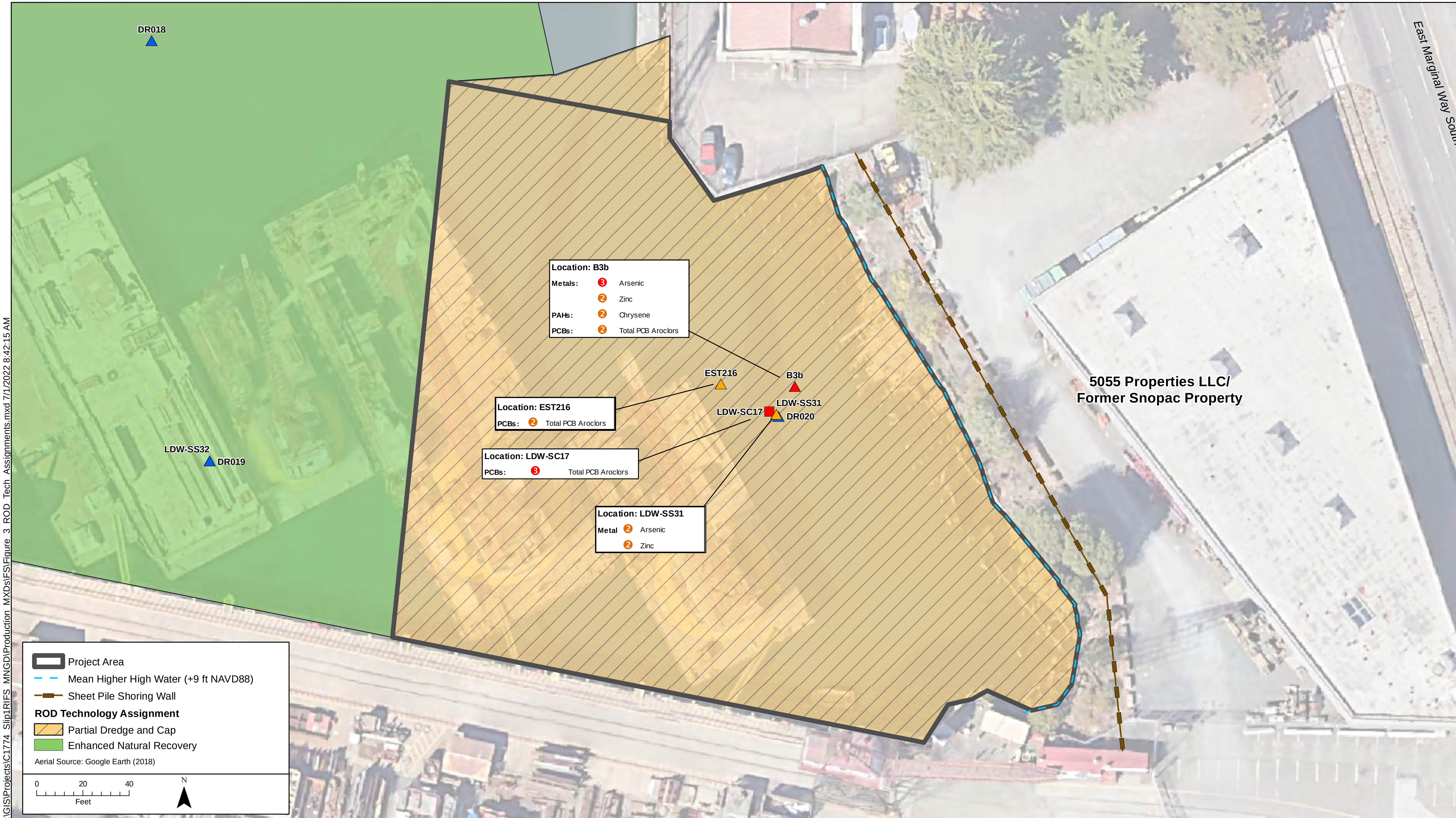
Figure 2.
Site Map
Sediment Feasibility Study
Snopac Property



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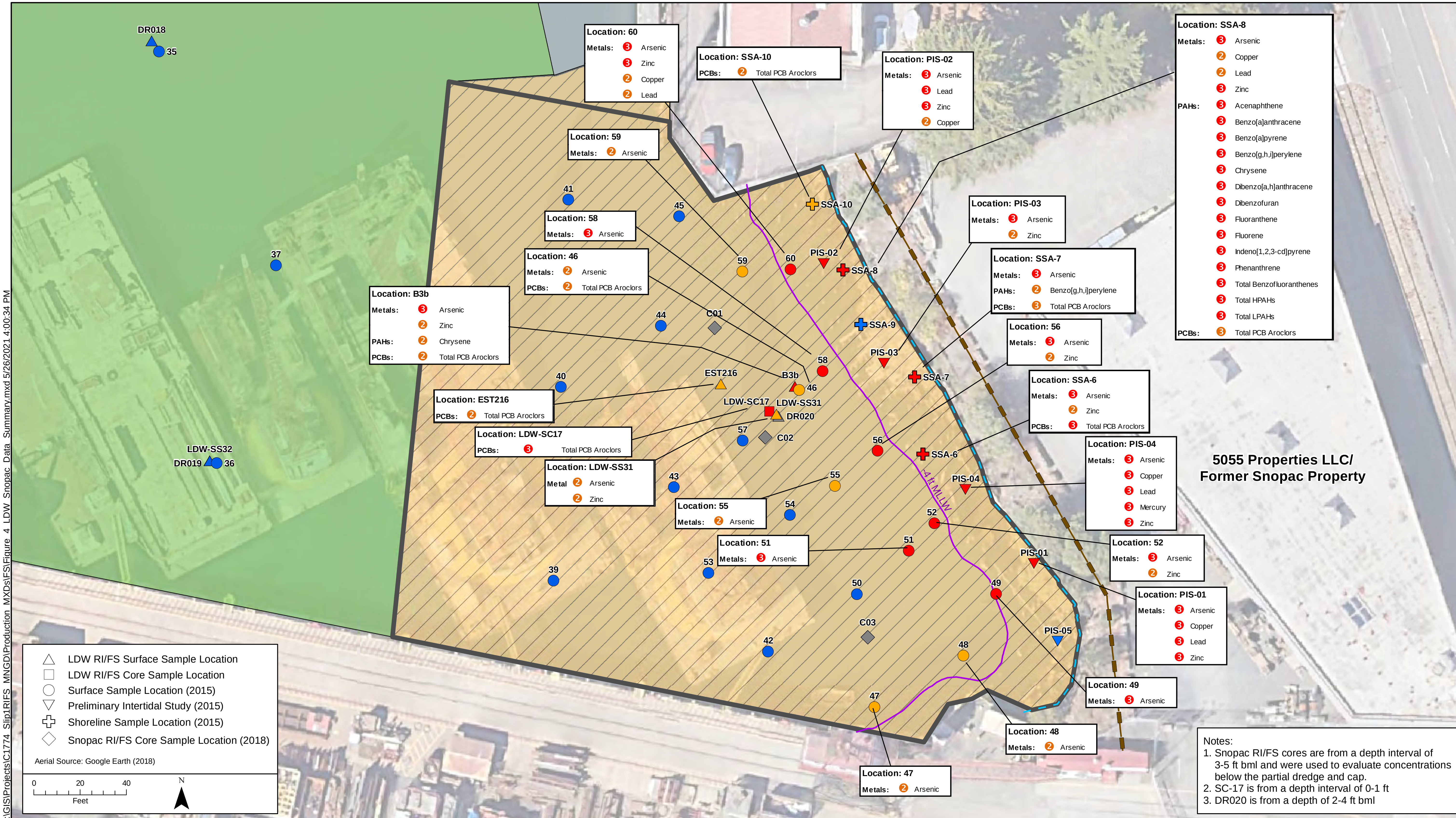
COC = chemical of concern
ENR = enhanced natural recovery
MNR = monitored natural recovery
RAL = remedial action level
UL = upper limit

△ LDW RI/FS Surface Sample Location
□ LDW RI/FS Core Sample Location

Exceedance Category

- ≤Cat 2/3 RAL (MNR)
- 2 >Cat 2/3 RAL and ≤UL for ENR (ENR)
- 3 >UL for ENR

Figure 3.
LDW RI/FS Data and ROD Technology Assignments
Sediment Feasibility Study
Snopac Property



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COC = chemical of concern
ENR = enhanced natural recovery
MNR = monitored natural recovery
RAL = remedial action level
UL = upper limit

Exceedance Category for Surface Sediments
- ≤Cat 2/3 RAL (MNR)
- 2 >Cat 2/3 RAL and ≤UL for ENR (ENR)
- 3 >UL for ENR (Requires Partial Dredge and Cap)

- Project Area
- Sheet Pile Shoring Wall
- Mean Higher High Water (+9 ft NAVD88)
- Intertidal/Subtidal Dividing Line (-4 ft MLLW)

ROD Technology Assignment
- Partial Dredge and Cap
- Enhanced Natural Recovery

Figure 4.
LDW RI/FS and Snopac RI/FS Data Summary
Sediment Feasibility Study
Snopac Property

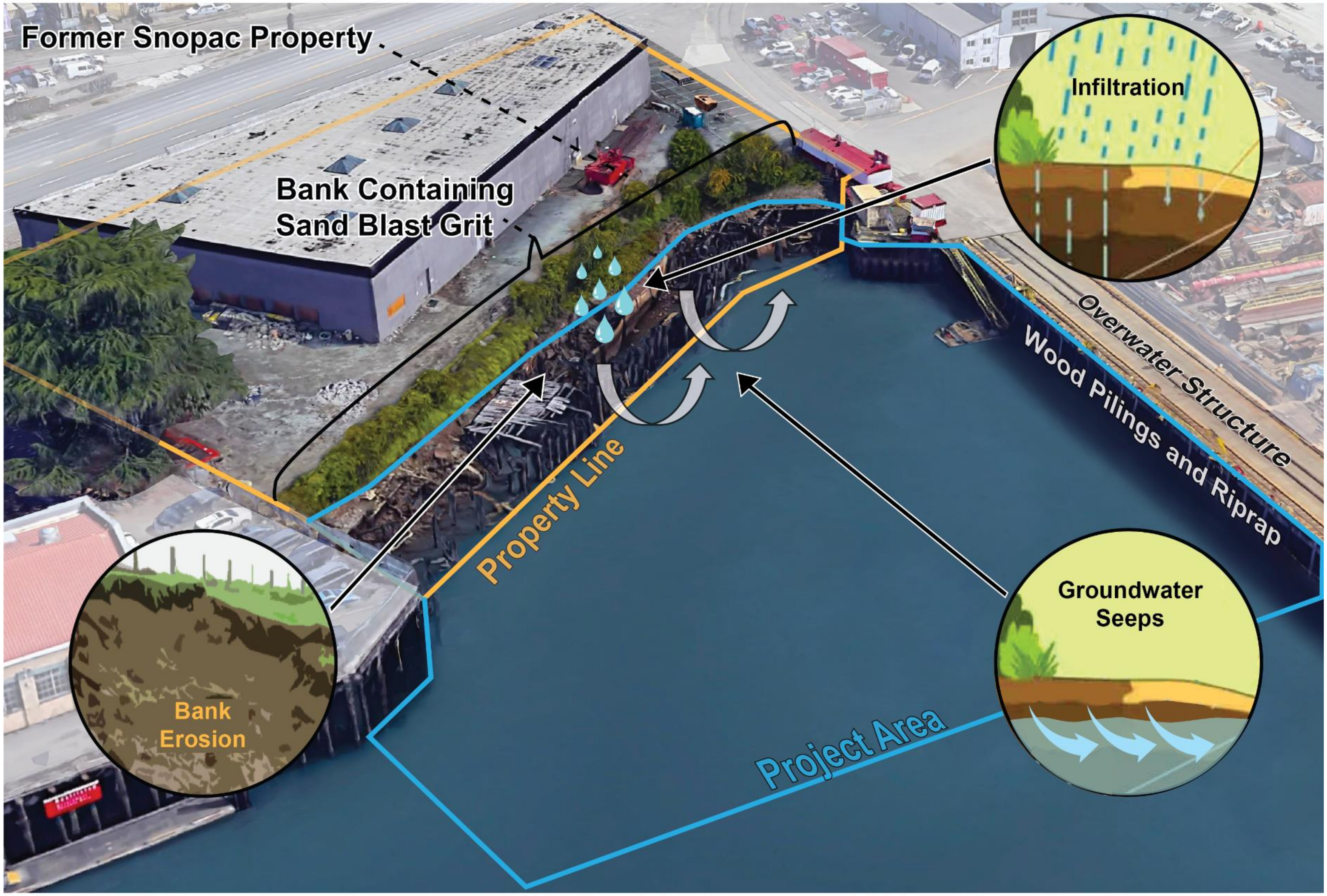

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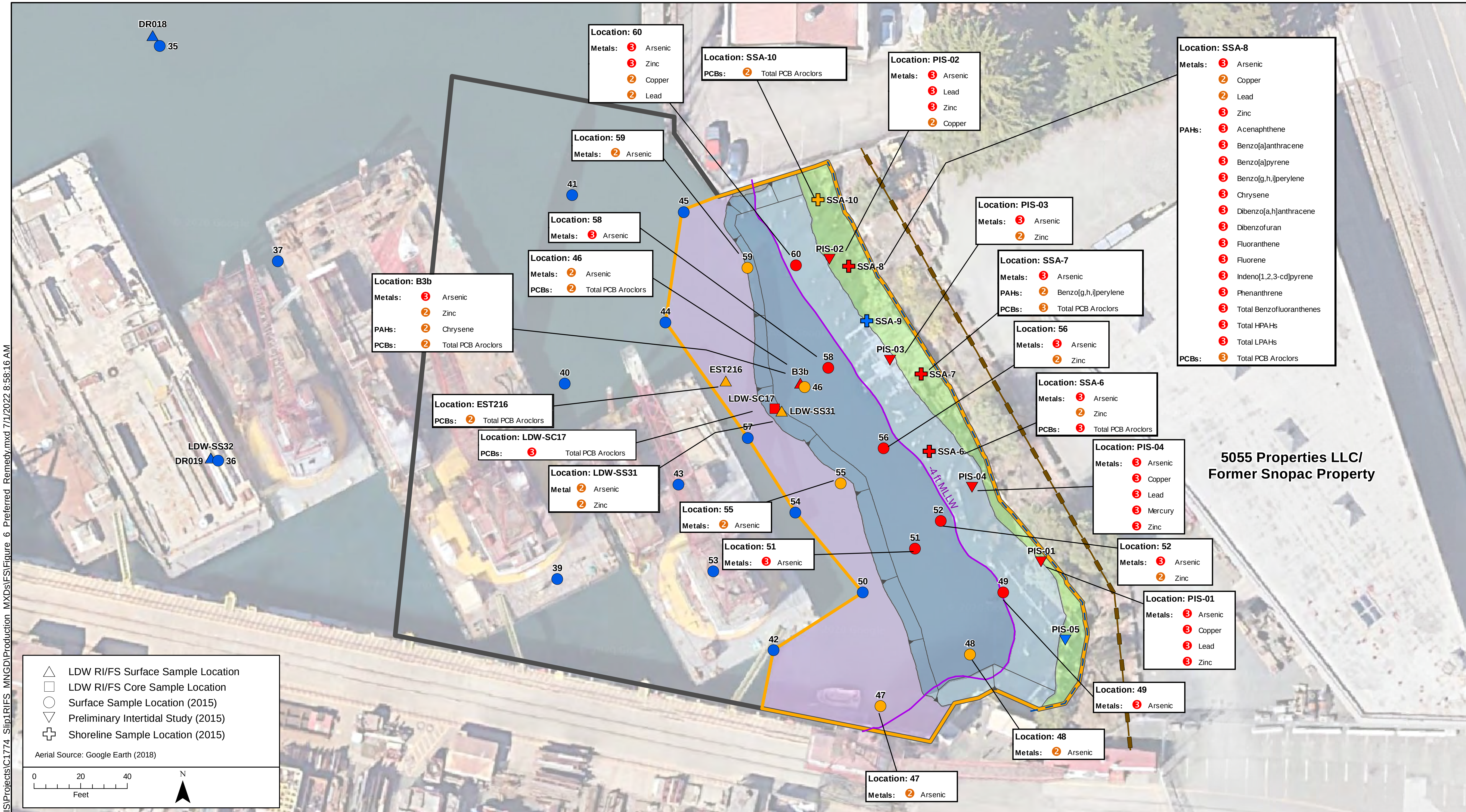
Figure 5.
Conceptual Site Model



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COC = chemical of concern
ENR = enhanced natural recovery
MNR = monitored natural recovery
RAL = remedial action level
UL = upper limit

Exceedance Category for Surface Sediments

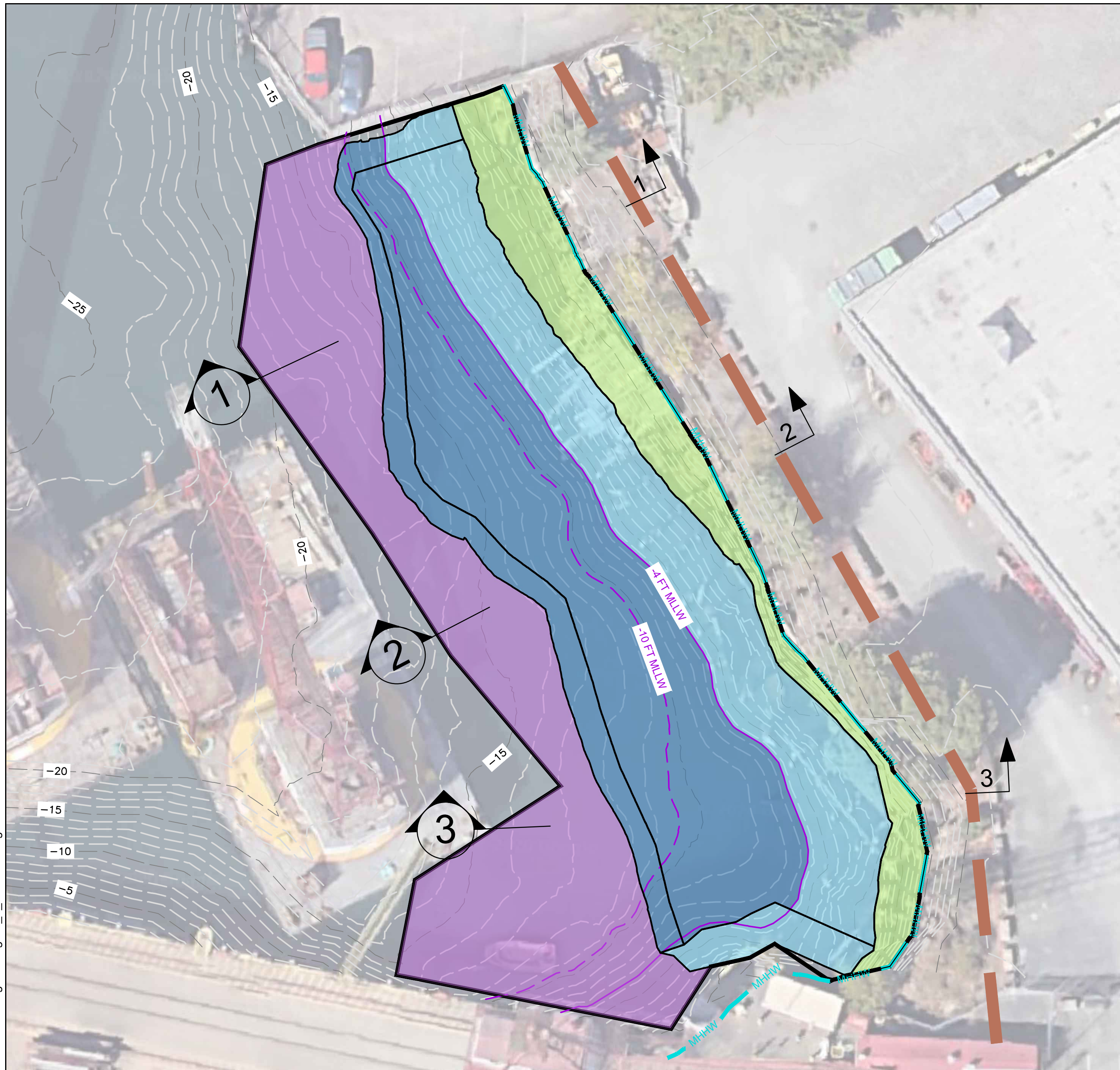
- ≤Cat 2/3 RAL (MNR)
- 2 >Cat 2/3 RAL and ≤UL for ENR (ENR)
- 3 >UL for ENR (Partial Dredge and Cap)

- Project Area
- Remedial Area
- Sheet Pile Shoring Wall
- Mean Higher High Water (+9 ft NAVD88)
- Intertidal/Subtidal Dividing Line (-4 ft MLLW)

Preferred Remedy

- Sediment Partial Dredge and Cap (3 ft Subtidal)
- Sediment Partial Dredge and Cap (4 ft Intertidal)
- Shoreface Excavations and Bank Restoration
- Enhanced Natural Recovery

Figure 6.
Preferred Remedy
Sediment Feasibility Study
Snopac Property



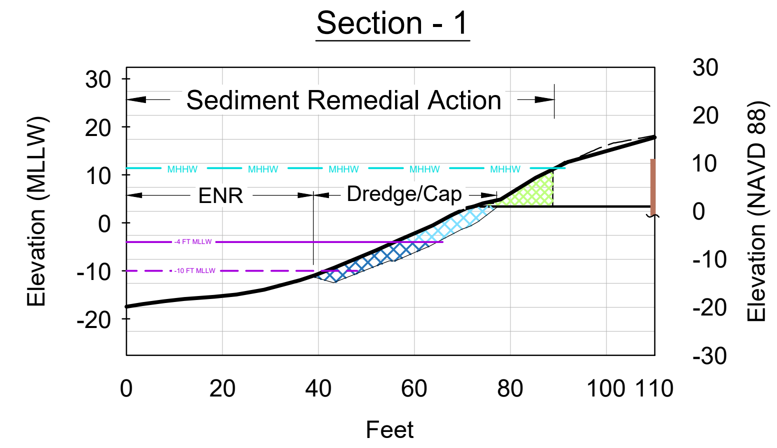
- Sediment Partial Dredge and Cap (3 ft Subtidal)
- Sediment Partial Dredge and Cap (4 ft Intertidal)
- Shoreface Excavation and Restoration
- Enhanced Natural Recovery
- Remedial Area
- Sheet Pile Shoring Wall
- Mean Higher High Water (+9 ft NAVD 88)
- Intertidal/Subtidal Dividing Line (-6.38 ft NAVD88, -4 ft MLLW)

0 20 40
Feet

N

Aerial Source: Google Earth (2018)

Section - 1



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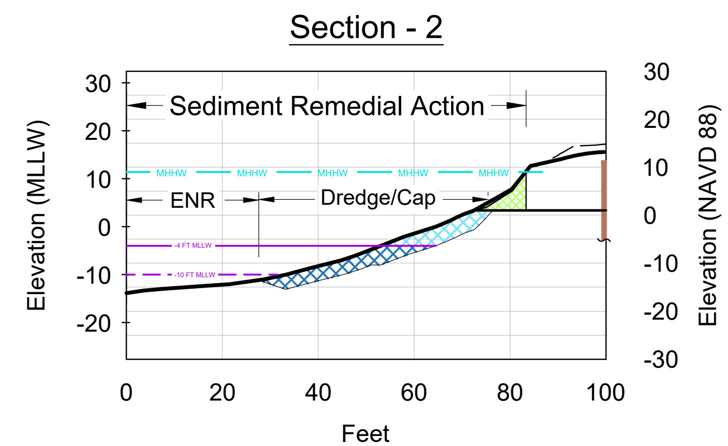

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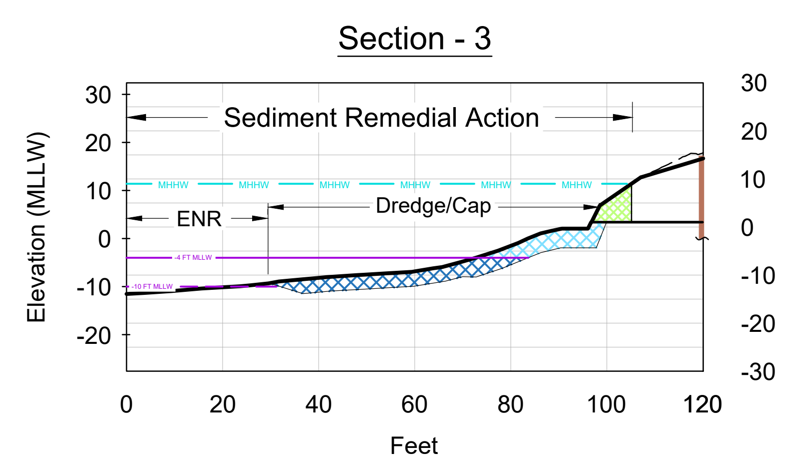

- Sediment Partial Dredge and Cap (3 ft Subtidal)
- Sediment Partial Dredge and Cap (4 ft Intertidal)
- Shoreface Excavation and Restoration
- Final Grade
- Sheet Pile Shoring Wall
- Mean Higher High Water (+9 ft NAVD88, +11.38 MLLW)
- Intertidal/Subtidal Dividing Line (-6.38 ft NAVD88, -4 ft MLLW)
- Existing Ground/Mudline Surface

0 20 40
Feet

Notes:
1. Shoreface remedial area between MHHW and Sheet Pile Wall documented in Uplands Feasibility Study.
2. Shoreface excavation extends down to +1 ft elevation.

Figure 7.
Preferred Remedy Cross Sections
Sediment Feasibility Study
Snopac Property

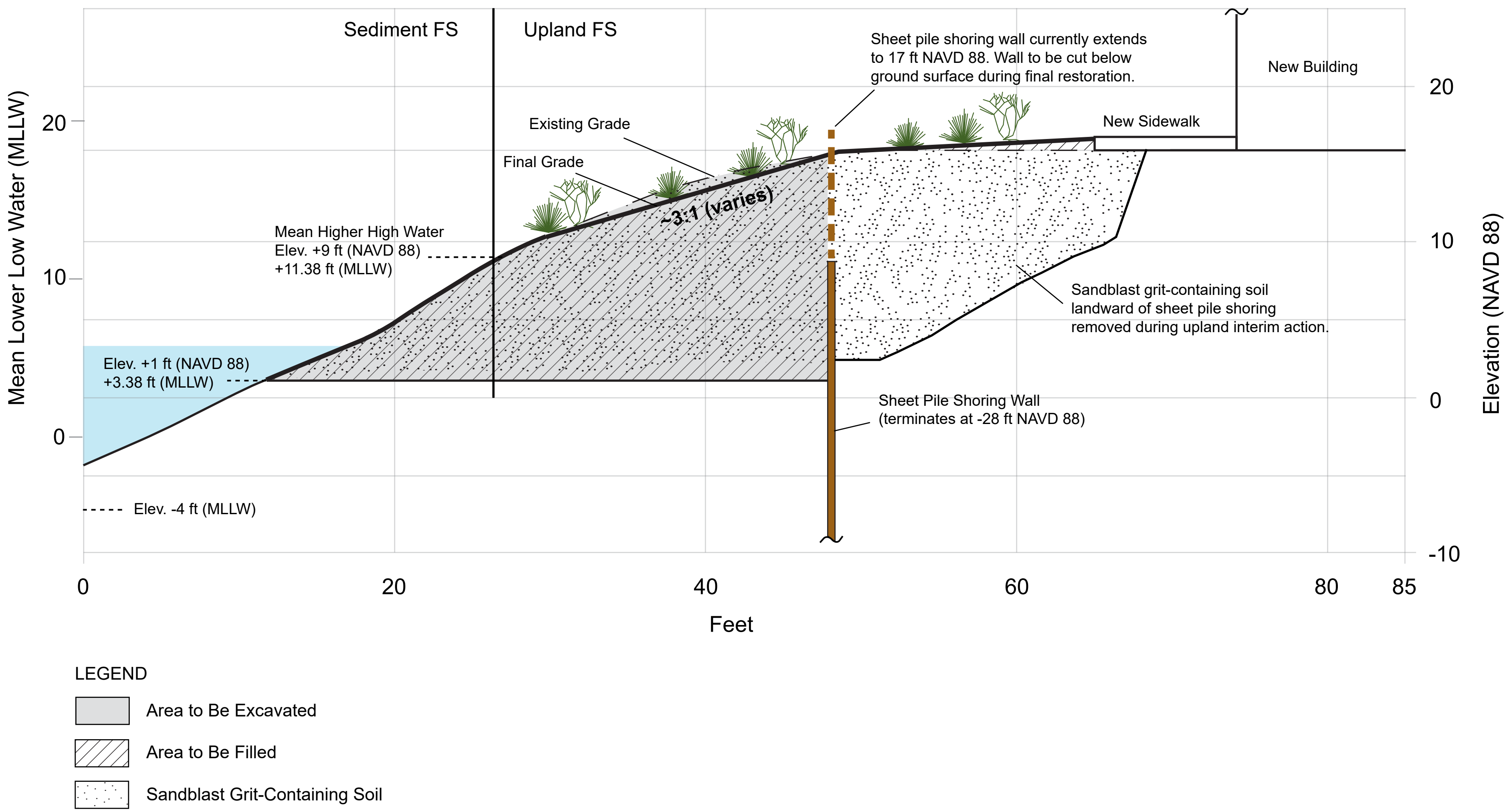

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Figure 8.
Conceptual Design for Shoreface Remedy
Sediment Feasibility Study
Snopac Property

Tables

Table 1. Sediment Cleanup Levels and Remedial Action Levels

		[a]ARAR-Based Cleanup Levels				[b]LDW ROD Remedial Action Levels	
Analyte	Units	RAO 1: Human Seafood Comsumption	RAO 2: Human Direct Contact	RAO 3: Benthic Invertebrate	RAO 4: Ecological	Health & Benthic COC RALs	Upper Limit for ENR
Polychlorinated Biphenyls							
Aroclor 1016	mg/kg dw	--	--	--	--	--	--
Aroclor 1221	mg/kg dw	--	--	--	--	--	--
Aroclor 1232	mg/kg dw	--	--	--	--	--	--
Aroclor 1242	mg/kg dw	--	--	--	--	--	--
Aroclor 1248	mg/kg dw	--	--	--	--	--	--
Aroclor 1254	mg/kg dw	--	--	--	--	--	--
Aroclor 1260	mg/kg dw	--	--	--	--	--	--
Total PCB Aroclors	mg/kg dw	0.002	1.3	--	0.128	--	--
Total PCB Aroclors	mg/kg OC	--	--	12	--	12	36
Polycyclic Aromatic Hydrocarbons							
1-Methylnaphthalene	mg/kg dw	--	--	--	--	--	--
2-Methylnaphthalene	mg/kg dw	--	--	--	--	--	--
Acenaphthene	mg/kg dw	--	--	--	--	--	--
Anthracene	mg/kg dw	--	--	--	--	--	--
Benz(a)anthracene	mg/kg dw	--	--	--	--	--	--
Benzo(a)pyrene	mg/kg dw	--	--	--	--	--	--
Benzo(b)fluoranthene	mg/kg dw	--	--	--	--	--	--
Benzo(k)fluoranthene	mg/kg dw	--	--	--	--	--	--
Chrysene	mg/kg dw	--	--	--	--	--	--
Dibenz(a,h)anthracene	mg/kg dw	--	--	--	--	--	--
Dibenzofuran	mg/kg dw	--	--	--	--	--	--
Fluoranthene	mg/kg dw	--	--	--	--	--	--
Fluorene	mg/kg dw	--	--	--	--	--	--
Indeno(1,2,3-cd)pyrene	mg/kg dw	--	--	--	--	--	--
Naphthalene	mg/kg dw	--	--	--	--	--	--
Pyrene	mg/kg dw	--	--	--	--	--	--
2-Methylnaphthalene	mg/kg OC	--	--	38	--	76	228
Acenaphthene	mg/kg OC	--	--	16	--	32	96
Acenaphthylene	mg/kg OC	--	--	--	--	--	--
Anthracene	mg/kg OC	--	--	220	--	440	1320
Benz(a)anthracene	mg/kg OC	--	--	110	--	220	660
Benzo(a)pyrene	mg/kg OC	--	--	99	--	198	594
Benzo(g,h,i)perylene	mg/kg OC	--	--	31	--	62	186
Total benzofluoranthenes	mg/kg OC	--	--	230	--	460	1380
Chrysene	mg/kg OC	--	--	110	--	220	660
Dibenz(a,h)anthracene	mg/kg OC	--	--	12	--	24	72
Dibenzofuran	mg/kg OC	--	--	15	--	30	90
Fluoranthene	mg/kg OC	--	--	160	--	320	960
Fluorene	mg/kg OC	--	--	23	--	46	138
Indeno(1,2,3-cd)pyrene	mg/kg OC	--	--	34	--	68	204
Naphthalene	mg/kg OC	--	--	99	--	198	594
Phenanthrene	mg/kg OC	--	--	100	--	200	600
Pyrene	mg/kg OC	--	--	1000	--	2000	6000
Total HPAHs	mg/kg OC	--	--	960	--	1920	5760
Total LPAHs	mg/kg OC	--	--	370	--	740	2220
cPAH	µg TEQ/kg dw	NA	2800	--	NA	5500	16500
Metals							
Arsenic	mg/kg dw	NA	7	57	NA	57	171
Cadmium	mg/kg dw	--	--	5.1	--	10.2	30.6
Chromium	mg/kg dw	--	--	260	--	520	1560
Copper	mg/kg dw	--	--	390	--	780	2340
Lead	mg/kg dw	--	--	450	--	900	2700
Mercury	mg/kg dw	--	--	0.41	--	0.82	2.46
Silver	mg/kg dw	--	--	6.1	--	12.2	36.6
Zinc	mg/kg dw	--	--	410	--	820	2460
Organotin Compounds							
Tributyltin ion	µg/kg dw	--	--	--	--	--	--

Table 1. Sediment Cleanup Levels and Remedial Action Levels

		[a]ARAR-Based Cleanup Levels				[b]LDW ROD Remedial Action Levels	
Analyte	Units	RAO 1: Human Seafood Comsumption	RAO 2: Human Direct Contact	RAO 3: Benthic Invertebrate	RAO 4: Ecological	Health & Benthic COC RALs	Upper Limit for ENR
Phthalates							
Bis(2-ethylhexyl)phthalate	mg/kg dw	--	--	--	--	--	--
Bis(2-ethylhexyl)phthalate	mg/kg OC	--	--	47	--	94	282
Chlorobenzenes							
1,2,4-Trichlorobenzene	mg/kg dw	--	--	--	--	--	--
1,2,4-Trichlorobenzene	mg/kg OC	--	--	0.81	--	1.62	4.86
Other SVOCs and COCs							
Benzoic acid	µg/kg dw	--	--	650	--	1300	3900
Organic Carbon							
Total Organic Carbon	%	--	--	--	--	--	--

Notes:

Table presents the site specific COCs, CULs and RALs for relevant application areas for the Former Snopac site (Category 2 Recovery Area and ENR criteria).

ARAR = applicable or relevant and appropriate requirement
COC = contaminant of concern
CUL = cleanup level
dw = dry weight
ENR = enhanced natural recovery
LDW = Lower Duwamish Waterway
OC = organic carbon
RAL = remedial action level
RAO = remedial action objective
ROD = record of decision
SVOC = semivolatile organic compound
TEQ = toxicity equivalence
-- = no data available

[a]ARAR-based cleanup levels adapted from Tables 19 and 20 of LDW ROD (USEPA 2014) and revised Table 19 (USEPA 2021), which are presented in Appendix A.

[b]LDW ROD remedial action levels are adapted from Tables 20 and 28 from the LDW ROD (USEPA 2014) and revised Table 28 (USEPA 2021) for Category 2/3 Recovery Areas, which are presented in Appendix A.

Table 2a. Intertidal and Subtidal Surface Sediment Data

					Subtidal Samples (Below -4 MLLW)								
				Sample Location:	EST216	B3b	LDW-SS31	LDW-SC17	LDW-SC17	39	40	41	42
				Sample ID:	EST20-06	LDW-B3b-S	LDW-SS31_0-10	LDW-SC17_0-1	LDW-SC17_1-2	SL1-SS-SD-G039	SL1-SS-SD-G040	SL1-SS-SD-G041	SL1-SS-SD-G042
				Sample Date:	9/17/1997	8/17/2004	1/21/2005	2/23/2006	2/23/2006	6/1/2015	6/1/2015	6/1/2015	6/1/2015
				Matrix:	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment
				Sediment Interval (ft):	0 - 0.33	0 - 0.33	0 - 0.33	0 - 1	1- 2	0 - 0.33	0 - 0.33	0 - 0.33	0 - 0.33
		LDW ROD Remedial Action Levels		Sediment Interval (cm):	0-10	0-10	0-10	0-30	30.5-61	0-10	0-10	0-10	0-10
Analyte	**Units**	**Human Health & Benthic COC RALs**	**Upper Limit for ENR**										
Polychlorinated Biphenyls (PCBs)													
Aroclor 1016	mg/kg dw	--	--		--	0.005 U	0.01 U	0.11 U	0.0425 U	0.006 U	0.006 U	0.0065 U	0.0065 U
Aroclor 1221	mg/kg dw	--	--		--	0.01 U	0.01 U	0.11 U	0.0425 U	0.011 U	0.012 U	0.0125 U	0.0125 U
Aroclor 1232	mg/kg dw	--	--		--	0.005 U	0.01 U	0.11 U	0.0425 U	0.0055 U	0.006 U	0.0065 U	0.0065 U
Aroclor 1242	mg/kg dw	--	--		--	0.005 U	0.01 U	0.11 U	0.0425 U	0.026	0.0285	0.04	0.028
Aroclor 1248	mg/kg dw	--	--		--	0.005 U	0.195 U	0.39	0.32	0.0055 U	0.006 U	0.0065 U	0.0065 U
Aroclor 1254	mg/kg dw	--	--		--	0.18	0.053	0.51	0.5	0.059	0.065	0.091	0.1
Aroclor 1260	mg/kg dw	--	--		--	0.17	0.043	0.32	0.22	0.051	0.0505	0.088	0.062
Total PCB Aroclors	mg/kg dw				0.3	0.35	0.096	1.22	1.04	0.136	0.144	0.219	0.19
Total PCB Aroclors	mg/kg OC	12 (195 for top 2 ft)	36 (195 for top 2 ft)		13.6	19.2	4.42	39.9	32	4.3	3.8	5.7	3.95
Polynuclear Aromatic Hydrocarbons (PAHs)													
1-Methylnaphthalene	mg/kg dw	--	--			0.01		0.03 U	0.05 U	0.01	0.01	0.02	0.01
2-Methylnaphthalene	mg/kg dw	--	--			0.03	0.05 U	0.07	0.05 U	0.02	0.01	0.03	0.02
Acenaphthene	mg/kg dw	--	--			0.04	0.05 U	0.07	0.38	0.02	0.02	0.06	0.03 J
Anthracene	mg/kg dw	--	--			1.10	0.17	0.52	1.60	0.24	0.15	0.17	0.71 J
Benz(a)anthracene	mg/kg dw	--	--			2.80	0.28	1.10	1.50 J	0.59	0.29	0.37	1.00 J
Benzo(a)pyrene	mg/kg dw	--	--			1.40	0.42	1.30	1.40	0.52	0.31	0.36	1.20 J
Benzo(b)fluoranthene	mg/kg dw	--	--			1.70	0.58	2.20	1.80	0.87	0.51	0.68	2.00 J
Benzo(k)fluoranthene	mg/kg dw	--	--			1.20	0.57	1.30	1.40	0.28	0.16	0.22	0.55 J
Chrysene	mg/kg dw	--	--			5.40	0.63	1.80	2.40 J	0.98	0.46	0.69	2.30 J
Dibenz(a,h)anthracene	mg/kg dw	--	--			0.24	0.049 U	0.08	0.14	0.09	0.05	0.06	0.21 J
Dibenzofuran	mg/kg dw	--	--			0.036	0.049 U	0.077	0.21	0.03	0.02	0.06	0.033 J
Fluoranthene	mg/kg dw	--	--			3.6	0.67	2	5.6	1.0	0.5	2.2	1.6 J
Fluorene	mg/kg dw	--	--			0.15	0.049 U	0.11	0.34	0.1	0.0	0.1	0.068 J
Indeno(1,2,3-cd)pyrene	mg/kg dw	--	--			0.66	0.11	0.32	0.57 J	0.34	0.21	0.24	0.82 J
Naphthalene	mg/kg dw	--	--			0.036	0.049 U	0.120	0.150	0.025	0.017	0.020	0.043
Pyrene	mg/kg dw	--	--			2.3	0.7	2.4	3.7 J	0.8	0.5	1.6	1.1 J
2-Methylnaphthalene	mg/kg OC	76	228			1.87	2.24 U	2.25	1.52 U	0.9	0.6	2.1	0.437
Acenaphthene	mg/kg OC	32	96			1.92	2.24 U	2.12	11.7	7.6	3.9	4.5	0.707 J
Acenaphthylene	mg/kg OC	--	--			4.40	2.24 U	2.19	2.77 J	0.9	0.4	0.6	1.02
Anthracene	mg/kg OC	440	1,320			60.4	7.83	17	49.2	7.6	3.9	4.5	14.8 J
Benz(a)anthracene	mg/kg OC	220	660			154	12.9	35.9	46.2 J	18.8	7.7	9.7	20.8 J
Benzo(a)pyrene	mg/kg OC	198	594			76.9	19.4	42.5	43.1	16.6	8.1	9.4	24.9 J
Benzo(g,h,i)perylene	mg/kg OC	62	186			33	5.07	8.17	15.1	9.9	5.1	5.8	15.4
Total benzofluoranthenes	mg/kg OC	460	1,380			159	53	114	98.5	36.6	17.8	23.6	53 J
Chrysene	mg/kg OC	220	660			297	29	58.8	73.8 J	31.2	12.3	18.1	47.8 J
Dibenz(a,h)anthracene	mg/kg OC	24	72			13.2	2.24 U	2.61	4.31	2.9	1.4	1.5	4.37 J
Dibenzofuran	mg/kg OC	30	90			1.98	2.24 U	2.52	6.46	0.9	0.5	1.6	0.686 J
Fluoranthene	mg/kg OC	320	960			198	30.9	65.4	172	31.8	13.9	57.7	33.3 J
Fluorene	mg/kg OC	46	138			8.24	2.24 U	3.59	10.5	1.6	0.8	2.2	1.41 J
Indeno(1,2,3-cd)pyrene	mg/kg OC	68	204			36.3	5.07	10.5	17.5 J	10.8	5.5	6.3	17 J
Naphthalene	mg/kg OC	198	594			1.98	2.24 U	3.92	4.62	0.8	0.4	0.5	0.894
Phenanthrene	mg/kg OC	200	600			41.8	11.1	18.3	36.9	10.2	4.0	34.1	6.86 J
Pyrene	mg/kg OC	2,000	6,000			126	32.3	78.4	114 J	25.8	12.3	42.0	22.9 J
Total HPAHs	mg/kg OC	1,920	5,760			1,090	188	418	585 J	184.39	84.01	174.20	240 J
Total LPAHs	mg/kg OC	740	2,220			121	18.9	47.1	117 J	21.91	9.89	43.39	25.7 J
cPAH	µg TEQ/kg dw	5,500 (0-10cm subtidal and intertidal) 5,900 (0-45cm intertidal)	16,500 (0-10cm subtidal and intertidal) 8,850 (0-45cm intertidal)			2,200	600	1,800	2,000 J	770	450	540	1,740 J

Table 2a. Intertidal and Subtidal Surface Sediment Data

					Subtidal Samples (Below -4 MLLW)								
				Sample Location:	EST216	B3b	LDW-SS31	LDW-SC17	LDW-SC17	39	40	41	42
				Sample ID:	EST20-06	LDW-B3b-S	LDW-SS31_0-10	LDW-SC17_0-1	LDW-SC17_1-2	SL1-SS-SD-G039	SL1-SS-SD-G040	SL1-SS-SD-G041	SL1-SS-SD-G042
				Sample Date:	9/17/1997	8/17/2004	1/21/2005	2/23/2006	2/23/2006	6/1/2015	6/1/2015	6/1/2015	6/1/2015
				Matrix:	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment
				Sediment Interval (ft):	0 - 0.33	0 - 0.33	0 - 0.33	0 - 1	1- 2	0 - 0.33	0 - 0.33	0 - 0.33	0 - 0.33
		LDW ROD Remedial Action Levels		Sediment Interval (cm):	0-10	0-10	0-10	0-30	30.5-61	0-10	0-10	0-10	0-10
Analyte	**Units**	**Human Health & Benthic COC RALs**	**Upper Limit for ENR**										
Metals													
Arsenic	mg/kg dw	57	171		--	725 J	122	110	170	26.6 J	23.25 J	22.2	24.9 J
Cadmium	mg/kg dw	10.2	30.6		--	1.67	3.2	4.5	7.6	0.597 J	0.5665 J	0.534	0.6175 J
Chromium	mg/kg dw	520	1,560		--	42.5	55	47	47	46.2 J	34.25 J	34.2	25.8 J
Copper	mg/kg dw	780	2,340		--	495 J	245	187	224	130 J	99.15 J	89.7	87.3 J
Lead	mg/kg dw	900	2,700		--	437	172	173	286	37.2 J	46.8 J	42.8 J	39.85 J
Mercury	mg/kg dw	0.82	2.46		--	0.059	0.33	0.5	0.6	0.193	0.222	0.254	0.2405
Silver	mg/kg dw	12.2	36.6		--	0.891	1.2	1	1.4	0.3 J	0.3605 J	0.385	0.274 J
Zinc	mg/kg dw	820	2,460		--	2,080	997	1,260	2,050	249 J	192 J	156	209 J
Organotin Compounds													
Tributyltin ion	µg/kg dw	--	--		--	320	81	--	--				--
Phthalates													
Bis(2-ethylhexyl)phthalate	mg/kg dw	--	--		--	0.26 J	0.16	0.570	0.44 J				--
Bis(2-ethylhexyl)phthalate	mg/kg OC	94	282		--	14.3 J	7.37	18.6	13.5 J				--
Chlorobenzenes													
1,2,4-Trichlorobenzene	mg/kg dw	--	--		--	0.025 U	0.049 U	0.009 J	0.017 J				--
1,2,4-Trichlorobenzene	mg/kg OC	1.62	4.86		--	1.37 U	2.24 U	0.304 J	0.523 J				--
Other SVOCs and COCs													
Benzoic acid	µg/kg dw	1,300	3,900		--	500 U	485 U	320	320				--
Organic Carbon													
Total Organic Carbon	%	--	--		2.21	1.82	2.17	3.06	3.25	3.14	3.745	3.81	4.81

Notes:
cPAHs caculated using method from LDW RI Appendix E.3 (Windward 2010) as defined by the California Environmental Protection Agency
Nondetects reported as 1/2 detection limit.
Lab duplicates have been averaged.
>Cat 2/3 RAL and ≤UL for ENR (ENR)
>UL for ENR (Partial Dredge and Cap)

COC = contaminant of concern
dw = dry weight
ENR = enhanced natural recovery
LDW = Lower Duwamish Waterway
OC = organic carbon
RAL = remedial action level
Data Qualifiers: J = result is estimated, U = result is not detected

ROD = record of decision
SVOC = semivolatile organic compound
TEQ = toxicity equivalence
UL = upper limit
-- = no data available

Table 2a. Intertidal and Subtidal Surface Sediment Data

					Subtidal Samples (Below -4 MLLW)							
				Sample Location:	43	44	45	46	47	48	50	51
				Sample ID:	SL1-SS-SD-G043	SL1-SS-SD-G044	SL1-SS-SD-G045	SL1-SS-SD-G046	SL1-SS-SD-G047	SL1-SS-SD-G048	SL1-SS-SD-G050	SL1-SS-SD-G051
				Sample Date:	6/1/2015	6/2/2015	6/2/2015	6/4/2015	6/3/2015	6/3/2015	6/1/2015	6/3/2015
				Matrix:	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment
				Sediment Interval (ft):	0 - 0.33	0 - 0.33	0 - 0.33	0 - 0.33	0 - 0.33	0 - 0.33	0 - 0.33	0 - 0.33
		LDW ROD Remedial Action Levels		Sediment Interval (cm):	0-10	0-10	0-10	0-10	0-10	0-10	0-10	0-10
Analyte	**Units**	**Human Health & Benthic COC RALs**	**Upper Limit for ENR**									
Polychlorinated Biphenyls (PCBs)												
Aroclor 1016	mg/kg dw	--	--		0.006 U	0.006 U	0.0065 U	0.006 U	--	--	--	--
Aroclor 1221	mg/kg dw	--	--		0.012 U	0.0115 U	0.0125 U	0.012 U	--	--	--	--
Aroclor 1232	mg/kg dw	--	--		0.006 U	0.006 U	0.0065 U	0.006 U	--	--	--	--
Aroclor 1242	mg/kg dw	--	--		0.025	0.074	0.054	0.03	--	--	--	--
Aroclor 1248	mg/kg dw	--	--		0.006 U	0.006 U	0.0065 U	0.006 U	--	--	--	--
Aroclor 1254	mg/kg dw	--	--		0.057	0.11	0.11	0.24	--	--	--	--
Aroclor 1260	mg/kg dw	--	--		0.047	0.11	0.13	0.18	--	--	--	--
Total PCB Aroclors	mg/kg dw				0.129	0.294	0.294	0.45	--	--	--	--
Total PCB Aroclors	mg/kg OC	12 (195 for top 2 ft)	36 (195 for top 2 ft)		3.3	8.33	7	12.6	--	--	--	--
Polynuclear Aromatic Hydrocarbons (PAHs)												
1-Methylnaphthalene	mg/kg dw	--	--		0.01	0.009	0.009	0.017 J	--	--	--	--
2-Methylnaphthalene	mg/kg dw	--	--		0.01	0.013	0.015	0.024 J	--	--	--	--
Acenaphthene	mg/kg dw	--	--		0.03	0.015	0.024	0.038 J	--	--	--	--
Anthracene	mg/kg dw	--	--		0.16	0.14	0.22	0.25 J	--	--	--	--
Benz(a)anthracene	mg/kg dw	--	--		0.36	0.44	0.53	0.5 J	--	--	--	--
Benzo(a)pyrene	mg/kg dw	--	--		0.40	0.41	0.51	0.56 J	--	--	--	--
Benzo(b)fluoranthene	mg/kg dw	--	--		0.65	0.68	0.83	0.94 J	--	--	--	--
Benzo(k)fluoranthene	mg/kg dw	--	--		0.20	0.24	0.28	0.3 J	--	--	--	--
Chrysene	mg/kg dw	--	--		0.63	0.66	0.91	0.85 J	--	--	--	--
Dibenz(a,h)anthracene	mg/kg dw	--	--		0.07	0.068	0.087	0.096 J	--	--	--	--
Dibenzofuran	mg/kg dw	--	--		0.21	0.018	0.028	0.027 J	--	--	--	--
Fluoranthene	mg/kg dw	--	--		0.6	0.8	0.96	0.85 J	--	--	--	--
Fluorene	mg/kg dw	--	--		0.032	0.03	0.049	0.045 J	--	--	--	--
Indeno(1,2,3-cd)pyrene	mg/kg dw	--	--		0.28	0.27	0.34	0.4 J	--	--	--	--
Naphthalene	mg/kg dw	--	--		0.022	0.022	0.021	0.042 J	--	--	--	--
Pyrene	mg/kg dw	--	--		0.6	0.76	0.86	0.85 J	--	--	--	--
2-Methylnaphthalene	mg/kg OC	76	228		0.9	0.368	0.357	0.67 J	--	--	--	--
Acenaphthene	mg/kg OC	32	96		4.1	0.425	0.571	1.06 J	--	--	--	--
Acenaphthylene	mg/kg OC	--	--		0.5	0.51	0.548	0.894 J	--	--	--	--
Anthracene	mg/kg OC	440	1,320		4.1	3.97	5.24	6.98 J	--	--	--	--
Benz(a)anthracene	mg/kg OC	220	660		9.1	12.5	12.6	14 J	--	--	--	--
Benzo(a)pyrene	mg/kg OC	198	594		10.1	11.6	12.1	15.6 J	--	--	--	--
Benzo(g,h,i)perylene	mg/kg OC	62	186		6.3	7.08	7.62	10.6 J	--	--	--	--
Total benzofluoranthenes	mg/kg OC	460	1,380		21.5	26.1	26.4	34.6 J	--	--	--	--
Chrysene	mg/kg OC	220	660		15.9	18.7	21.7	23.7 J	--	--	--	--
Dibenz(a,h)anthracene	mg/kg OC	24	72		1.8	1.93	2.07	2.68 J	--	--	--	--
Dibenzofuran	mg/kg OC	30	90		5.3	0.51	0.667	0.754 J	--	--	--	--
Fluoranthene	mg/kg OC	320	960		16.2	22.7	22.9	23.7 J	--	--	--	--
Fluorene	mg/kg OC	46	138		0.8	0.85	1.17	1.26 J	--	--	--	--
Indeno(1,2,3-cd)pyrene	mg/kg OC	68	204		7.1	7.65	8.1	11.2 J	--	--	--	--
Naphthalene	mg/kg OC	198	594		0.6	0.623	0.5	1.17 J	--	--	--	--
Phenanthrene	mg/kg OC	200	600		4.6	5.38	7.14	8.66 J	--	--	--	--
Pyrene	mg/kg OC	2,000	6,000		13.9	21.5	20.5	23.7 J	--	--	--	--
Total HPAHs	mg/kg OC	1,920	5,760		102.05	130	134	160 J	--	--	--	--
Total LPAHs	mg/kg OC	740	2,220		14.89	11.8	15.2	20 J	--	--	--	--
cPAH	µg TEQ/kg dw	5,500 (0-10cm subtidal and intertidal) 5,900 (0-45cm intertidal)	16,500 (0-10cm subtidal and intertidal) 8,850 (0-45cm intertidal)		580	607	752	821 J	--	--	--	--

Table 2a. Intertidal and Subtidal Surface Sediment Data

		LDW ROD Remedial Action Levels			Subtidal Samples (Below -4 MLLW)							
				Sample Location:	43	44	45	46	47	48	50	51
				Sample ID:	SL1-SS-SD-G043	SL1-SS-SD-G044	SL1-SS-SD-G045	SL1-SS-SD-G046	SL1-SS-SD-G047	SL1-SS-SD-G048	SL1-SS-SD-G050	SL1-SS-SD-G051
				Sample Date:	6/1/2015	6/2/2015	6/2/2015	6/4/2015	6/3/2015	6/3/2015	6/1/2015	6/3/2015
				Matrix:	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment
				Sediment Interval (ft):	0 - 0.33	0 - 0.33	0 - 0.33	0 - 0.33	0 - 0.33	0 - 0.33	0 - 0.33	0 - 0.33
				Sediment Interval (cm):	0-10	0-10	0-10	0-10	0-10	0-10	0-10	0-10
Analyte	**Units**	**Human Health & Benthic COC RALs**	**Upper Limit for ENR**									
Metals												
Arsenic	mg/kg dw	57	171		32	23.4	36.4	102 J	66.2	121	52 J	173
Cadmium	mg/kg dw	10.2	30.6		0.602	0.625	0.61	0.841 J	1.54	1.68	1.25 J	1.38
Chromium	mg/kg dw	520	1,560		34.2	32.5	31.9	36.4 J	38.6	30.2	36.8 J	44.3
Copper	mg/kg dw	780	2,340		98.9	91.1	100	143 J	156	143	128 J	199
Lead	mg/kg dw	900	2,700		47.8	41.2 J	45.1 J	81.2 J	88.7 J	113 J	66 J	155 J
Mercury	mg/kg dw	0.82	2.46		0.163	0.274	0.238	0.239	0.284 J	0.261 J	0.288	0.437 J
Silver	mg/kg dw	12.2	36.6		0.343	0.362	0.344	0.439	0.423	0.459	0.376 J	0.546
Zinc	mg/kg dw	820	2,460		227	194	206	406 J	527 J	639 J	421 J	720 J
Organotin Compounds												
Tributyltin ion	µg/kg dw	--	--			--	--	--	--	--	--	--
Phthalates												
Bis(2-ethylhexyl)phthalate	mg/kg dw	--	--			--	--	--	--	--	--	--
Bis(2-ethylhexyl)phthalate	mg/kg OC	94	282			--	--	--	--	--	--	--
Chlorobenzenes												
1,2,4-Trichlorobenzene	mg/kg dw	--	--			--	--	--	--	--	--	--
1,2,4-Trichlorobenzene	mg/kg OC	1.62	4.86			--	--	--	--	--	--	--
Other SVOCs and COCs												
Benzoic acid	µg/kg dw	1,300	3,900			--	--	--	--	--	--	--
Organic Carbon												
Total Organic Carbon	%	--	--		3.95	3.53	4.2	3.58	3.95	4.07	3.59	4.08

Notes:

cPAHs caculated using method from LDW RI Appendix E.3 (Windward 2010) as defined by the California Environmental Protection Agency

Nondetects reported as 1/2 detection limit.

Lab duplicates have been averaged.

>Cat 2/3 RAL and ≤UL for ENR (ENR)

>UL for ENR (Partial Dredge and Cap)

COC = contaminant of concern
dw = dry weight
ENR = enhanced natural recovery
LDW = Lower Duwamish Waterway
OC = organic carbon
RAL = remedial action level
Data Qualifiers: J = result is estimated, U = result is not detected

ROD = record of decision
SVOC = semivolatile organic compound
TEQ = toxicity equivalence
UL = upper limit
-- = no data available

Table 2a. Intertidal and Subtidal Surface Sediment Data

					Subtidal Samples (Below -4 MLLW)							
				Sample Location:	52	53	54	55	56	57	58	59
				Sample ID:	SL1-SS-SD-G052	SL1-SS-SD-G053	SL1-SS-SD-G054	SL1-SS-SD-G055	SL1-SS-SD-G056	SL1-SS-SD-G057	SL1-SS-SD-G058	SL1-SS-SD-G059
				Sample Date:	6/3/2015	6/1/2015	6/1/2015	6/1/2015	6/3/2015	6/1/2015	6/3/2015	6/4/2015
				Matrix:	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment
				Sediment Interval (ft):	0 - 0.33	0 - 0.33	0 - 0.33	0 - 0.33	0 - 0.33	0 - 0.33	0 - 0.33	0 - 0.33
		LDW ROD Remedial Action Levels		Sediment Interval (cm):	0-10	0-10	0-10	0-10	0-10	0-10	0-10	0-10
Analyte	**Units**	**Human Health & Benthic COC RALs**	**Upper Limit for ENR**									
Polychlorinated Biphenyls (PCBs)												
Aroclor 1016	mg/kg dw	--	--		--	--	--	--	--	--	--	--
Aroclor 1221	mg/kg dw	--	--		--	--	--	--	--	--	--	--
Aroclor 1232	mg/kg dw	--	--		--	--	--	--	--	--	--	--
Aroclor 1242	mg/kg dw	--	--		--	--	--	--	--	--	--	--
Aroclor 1248	mg/kg dw	--	--		--	--	--	--	--	--	--	--
Aroclor 1254	mg/kg dw	--	--		--	--	--	--	--	--	--	--
Aroclor 1260	mg/kg dw	--	--		--	--	--	--	--	--	--	--
Total PCB Aroclors	mg/kg dw				--	--	--	--	--	--	--	--
Total PCB Aroclors	mg/kg OC	12 (195 for top 2 ft)	36 (195 for top 2 ft)		--	--	--	--	--	--	--	--
Polynuclear Aromatic Hydrocarbons (PAHs)												
1-Methylnaphthalene	mg/kg dw	--	--		--	--	--	--	--	--	--	--
2-Methylnaphthalene	mg/kg dw	--	--		--	--	--	--	--	--	--	--
Acenaphthene	mg/kg dw	--	--		--	--	--	--	--	--	--	--
Anthracene	mg/kg dw	--	--		--	--	--	--	--	--	--	--
Benz(a)anthracene	mg/kg dw	--	--		--	--	--	--	--	--	--	--
Benzo(a)pyrene	mg/kg dw	--	--		--	--	--	--	--	--	--	--
Benzo(b)fluoranthene	mg/kg dw	--	--		--	--	--	--	--	--	--	--
Benzo(k)fluoranthene	mg/kg dw	--	--		--	--	--	--	--	--	--	--
Chrysene	mg/kg dw	--	--		--	--	--	--	--	--	--	--
Dibenz(a,h)anthracene	mg/kg dw	--	--		--	--	--	--	--	--	--	--
Dibenzofuran	mg/kg dw	--	--		--	--	--	--	--	--	--	--
Fluoranthene	mg/kg dw	--	--		--	--	--	--	--	--	--	--
Fluorene	mg/kg dw	--	--		--	--	--	--	--	--	--	--
Indeno(1,2,3-cd)pyrene	mg/kg dw	--	--		--	--	--	--	--	--	--	--
Naphthalene	mg/kg dw	--	--		--	--	--	--	--	--	--	--
Pyrene	mg/kg dw	--	--		--	--	--	--	--	--	--	--
2-Methylnaphthalene	mg/kg OC	76	228		--	--	--	--	--	--	--	--
Acenaphthene	mg/kg OC	32	96		--	--	--	--	--	--	--	--
Acenaphthylene	mg/kg OC	--	--		--	--	--	--	--	--	--	--
Anthracene	mg/kg OC	440	1,320		--	--	--	--	--	--	--	--
Benz(a)anthracene	mg/kg OC	220	660		--	--	--	--	--	--	--	--
Benzo(a)pyrene	mg/kg OC	198	594		--	--	--	--	--	--	--	--
Benzo(g,h,i)perylene	mg/kg OC	62	186		--	--	--	--	--	--	--	--
Total benzofluoranthenes	mg/kg OC	460	1,380		--	--	--	--	--	--	--	--
Chrysene	mg/kg OC	220	660		--	--	--	--	--	--	--	--
Dibenz(a,h)anthracene	mg/kg OC	24	72		--	--	--	--	--	--	--	--
Dibenzofuran	mg/kg OC	30	90		--	--	--	--	--	--	--	--
Fluoranthene	mg/kg OC	320	960		--	--	--	--	--	--	--	--
Fluorene	mg/kg OC	46	138		--	--	--	--	--	--	--	--
Indeno(1,2,3-cd)pyrene	mg/kg OC	68	204		--	--	--	--	--	--	--	--
Naphthalene	mg/kg OC	198	594		--	--	--	--	--	--	--	--
Phenanthrene	mg/kg OC	200	600		--	--	--	--	--	--	--	--
Pyrene	mg/kg OC	2,000	6,000		--	--	--	--	--	--	--	--
Total HPAHs	mg/kg OC	1,920	5,760		--	--	--	--	--	--	--	--
Total LPAHs	mg/kg OC	740	2,220		--	--	--	--	--	--	--	--
cPAH	µg TEQ/kg dw	5,500 (0-10cm subtidal and intertidal) 5,900 (0-45cm intertidal)	16,500 (0-10cm subtidal and intertidal) 8,850 (0-45cm intertidal)		--	--	--	--	--	--	--	--

Table 2a. Intertidal and Subtidal Surface Sediment Data

					Subtidal Samples (Below -4 MLLW)							
				Sample Location:	52	53	54	55	56	57	58	59
				Sample ID:	SL1-SS-SD-G052	SL1-SS-SD-G053	SL1-SS-SD-G054	SL1-SS-SD-G055	SL1-SS-SD-G056	SL1-SS-SD-G057	SL1-SS-SD-G058	SL1-SS-SD-G059
				Sample Date:	6/3/2015	6/1/2015	6/1/2015	6/1/2015	6/3/2015	6/1/2015	6/3/2015	6/4/2015
				Matrix:	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment
				Sediment Interval (ft):	0 - 0.33	0 - 0.33	0 - 0.33	0 - 0.33	0 - 0.33	0 - 0.33	0 - 0.33	0 - 0.33
		LDW ROD Remedial Action Levels		Sediment Interval (cm):	0-10	0-10	0-10	0-10	0-10	0-10	0-10	0-10
Analyte	**Units**	**Human Health & Benthic COC RALs**	**Upper Limit for ENR**									
Metals												
Arsenic	mg/kg dw	57	171		474	29.3 J	44.9 J	60.9 J	511	40.7 J	632	121.75 J
Cadmium	mg/kg dw	10.2	30.6		1.86	0.63 J	0.453 J	1.05 J	1.5	0.741 J	0.722	0.9635 J
Chromium	mg/kg dw	520	1,560		50	29.5 J	21.7 J	46 J	41.3	35.5 J	31.1	56.7 J
Copper	mg/kg dw	780	2,340		308	114 J	89.3 J	130 J	298	105 J	174	137 J
Lead	mg/kg dw	900	2,700		299 J	41.4 J	36.5 J	62.7 J	377 J	61.1 J	162 J	90.85 J
Mercury	mg/kg dw	0.82	2.46		0.32 J	0.194	0.185	0.224	0.136 J	0.255	0.118 J	0.213
Silver	mg/kg dw	12.2	36.6		0.761	0.317 J	0.233 J	0.357 J	0.669	0.385 J	0.389	0.4155
Zinc	mg/kg dw	820	2,460		1,560 J	216 J	193 J	424 J	1,580 J	278 J	799 J	448.5 J
Organotin Compounds												
Tributyltin ion	µg/kg dw	--	--		--	--	--	--	--	--	--	--
Phthalates												
Bis(2-ethylhexyl)phthalate	mg/kg dw	--	--		--	--	--	--	--	--	--	--
Bis(2-ethylhexyl)phthalate	mg/kg OC	94	282		--	--	--	--	--	--	--	--
Chlorobenzenes												
1,2,4-Trichlorobenzene	mg/kg dw	--	--		--	--	--	--	--	--	--	--
1,2,4-Trichlorobenzene	mg/kg OC	1.62	4.86		--	--	--	--	--	--	--	--
Other SVOCs and COCs												
Benzoic acid	µg/kg dw	1,300	3,900		--	--	--	--	--	--	--	--
Organic Carbon												
Total Organic Carbon	%	--	--		3.83	3.78	4.27	3.53	1.59	4.05	2.56	3.49

Notes:

cPAHs caculated using method from LDW RI Appendix E.3 (Windward 2010) as defined by the California Environmental Protection Agency

Nondetects reported as 1/2 detection limit.

Lab duplicates have been averaged.

>Cat 2/3 RAL and ≤UL for ENR (ENR)

>UL for ENR (Partial Dredge and Cap)

COC = contaminant of concern
dw = dry weight
ENR = enhanced natural recovery
LDW = Lower Duwamish Waterway
OC = organic carbon
RAL = remedial action level
Data Qualifiers: J = result is estimated, U = result is not detected

ROD = record of decision
SVOC = semivolatile organic compound
TEQ = toxicity equivalence
UL = upper limit
-- = no data available

Table 2a. Intertidal and Subtidal Surface Sediment Data

					Intertidal Samples (-4 to +11.4 ft MLLW)														
				Sample Location:	PIS-01	PIS-02	PIS-03	PIS-04	PIS-05	SSA-6		SSA-7		SSA-8		SSA-9		SSA-10	
				Sample ID:	SL1-PIS-SD-01	SL1-PIS-SD-02	SL1-PIS-SD-03	SL1-PIS-SD-04	SL1-PIS-SD-05	SSA-6		SSA-7		SSA-8		SSA-9		SSA-10	
				Sample Date:	5/6/2015	5/6/2015	5/6/2015	5/6/2015	5/6/2015	7/2/2015		7/2/2015		7/2/2015		7/2/2015		7/2/2015	
				Matrix:	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment		Sediment		Sediment		Sediment		Sediment	
				Sediment Interval (ft):	surface (depth not specified)					0 - 0.25		0 - 0.25		0 - 0.25		0 - 0.25		0 - 0.25	
		LDW ROD Remedial Action Levels		Sediment Interval (cm):						0 - 7.62		0 - 7.62		0 - 7.62		0 - 7.62		0 - 7.62	
Analyte	Units	Human Health & Benthic COC RALs	Upper Limit for ENR																
Polychlorinated Biphenyls (PCBs)																			
Aroclor 1016	mg/kg dw	--	--		--					0.02	U	0.01	U	0.01	U	0.01	U	0.01	U
Aroclor 1221	mg/kg dw	--	--		--					0.02	U	0.01	U	0.01	U	0.01	U	0.01	U
Aroclor 1232	mg/kg dw	--	--		--					0.02	U	0.01	U	0.01	U	0.01	U	0.01	U
Aroclor 1242	mg/kg dw	--	--		--					0.02	U	0.01	U	0.01	U	0.01	U	0.01	U
Aroclor 1248	mg/kg dw	--	--		--					0.02	U	0.01	U	0.01	U	0.01	U	0.01	U
Aroclor 1254	mg/kg dw	--	--		--					0.4		0.39		0.19		0.039		0.01	U
Aroclor 1260	mg/kg dw	--	--		--					0.02	U	0.01	U	0.1		0.027		0.071	
Total PCB Aroclors	mg/kg dw				--					0.4		0.39		0.29		0.066		0.071	
Total PCB Aroclors	mg/kg OC	12 (195 for top 2 ft)	36 (195 for top 2 ft)		--					69.2		167		110		11.5		21.6	
Polynuclear Aromatic Hydrocarbons (PAHs)																			
1-Methylnaphthalene	mg/kg dw	--	--		--					0.1	U	0.02		0.15		0.005	U	0.005	U
2-Methylnaphthalene	mg/kg dw	--	--		--					0.1	U	0.02		0.13		0.005	U	0.005	U
Acenaphthene	mg/kg dw	--	--		--					0.1	U	0.027		0.36		0.005	U	0.005	U
Anthracene	mg/kg dw	--	--		--					0.1	U	0.077		0.89		0.016		0.015	
Benz(a)anthracene	mg/kg dw	--	--		--					0.46		0.19		2.1		0.051		0.037	
Benzo(a)pyrene	mg/kg dw	--	--		--					0.31		0.27		2.35	J	0.066		0.059	
Benzo(b)fluoranthene	mg/kg dw	--	--		--					0.53		0.49		3	J	0.12		0.1	
Benzo(k)fluoranthene	mg/kg dw	--	--		--					0.1	U	0.15		1.1	J	0.038		0.032	
Chrysene	mg/kg dw	--	--		--					0.58		0.33		2.05		0.11		0.063	
Dibenz(a,h)anthracene	mg/kg dw	--	--		--					0.1	U	0.036		0.25	J	0.012		0.005	U
Dibenzofuran	mg/kg dw	--	--		--					0.005	UJ	0.025	U	0.3		0.025	U	0.025	U
Fluoranthene	mg/kg dw	--	--		--					0.52		0.38		4.85		0.086		0.12	
Fluorene	mg/kg dw	--	--		--					0.1	U	0.027		0.54		0.005	U	0.005	U
Indeno(1,2,3-cd)pyrene	mg/kg dw	--	--		--					0.1	U	0.14		1.55	J	0.048		0.044	
Naphthalene	mg/kg dw	--	--		--					0.1	U	0.022		0.26		0.005	U	0.011	
Pyrene	mg/kg dw	--	--		--					1.8		0.27		4.2		0.082		0.083	
2-Methylnaphthalene	mg/kg OC	76	228		--					17.3	U	8.58		49.8		0.87	U	1.52	U
Acenaphthene	mg/kg OC	32	96		--					17.3	U	11.6		138		0.87	U	1.52	U
Acenaphthylene	mg/kg OC	--	--		--					17.3	U	9.01		61.3		0.87	U	1.52	U
Anthracene	mg/kg OC	440	1,320		--					17.3	U	33		341		2.78		4.57	
Benz(a)anthracene	mg/kg OC	220	660		--					79.6		81.5		805		8.87		11.3	
Benzo(a)pyrene	mg/kg OC	198	594		--					53.6		116		900	J	11.5		18	
Benzo(g,h,i)perylene	mg/kg OC	62	186		--					36.3		64.4		536	J	9.39		14.9	
Total benzofluoranthenes	mg/kg OC	460	1,380		--					91.7		275		1,570	J	27.5		40	
Chrysene	mg/kg OC	220	660		--					100		142		785		19.1		19.2	
Dibenz(a,h)anthracene	mg/kg OC	24	72		--					17.3	U	15.5		95.8	J	2.09		1.52	U
Dibenzofuran	mg/kg OC	30	90		--					0.865	UJ	10.7	U	115		4.35	U	7.62	U
Fluoranthene	mg/kg OC	320	960		--					90		163		1,860		15		36.6	
Fluorene	mg/kg OC	46	138		--					17.3	U	11.6		207		0.87	U	1.52	U
Indeno(1,2,3-cd)pyrene	mg/kg OC	68	204		--					17.3	U	60.1		594	J	8.35		13.4	
Naphthalene	mg/kg OC	198	594		--					17.3	U	9.44		99.6		0.87	U	3.35	
Phenanthrene	mg/kg OC	200	600		--					17.3	U	85.8		1,670		8.35		19.2	
Pyrene	mg/kg OC	2,000	6,000		--					311		116		1,610		14.3		25.3	
Total HPAHs	mg/kg OC	1,920	5,760		--					763		1,030		8,750	J	116		180	
Total LPAHs	mg/kg OC	740	2,220		--					17.3	U	161		2,510		11.1		27.1	
cPAH	µg TEQ/kg dw	5,500 (0-10cm subtidal and intertidal) 5,900 (0-45cm intertidal)	16,500 (0-10cm subtidal and intertidal) 8,850 (0-45cm intertidal)		--					475		385		3,250	J	97.6		83	

Table 2a. Intertidal and Subtidal Surface Sediment Data

					Intertidal Samples (-4 to +11.4 ft MLLW)									
				Sample Location:	PIS-01	PIS-02	PIS-03	PIS-04	PIS-05	SSA-6	SSA-7	SSA-8	SSA-9	SSA-10
				Sample ID:	SL1-PIS-SD-01	SL1-PIS-SD-02	SL1-PIS-SD-03	SL1-PIS-SD-04	SL1-PIS-SD-05	SSA-6	SSA-7	SSA-8	SSA-9	SSA-10
				Sample Date:	5/6/2015	5/6/2015	5/6/2015	5/6/2015	5/6/2015	7/2/2015	7/2/2015	7/2/2015	7/2/2015	7/2/2015
				Matrix:	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment
				Sediment Interval (ft):	surface (depth not specified)					0 - 0.25	0 - 0.25	0 - 0.25	0 - 0.25	0 - 0.25
		LDW ROD Remedial Action Levels		Sediment Interval (cm):						0 - 7.62	0 - 7.62	0 - 7.62	0 - 7.62	0 - 7.62
Analyte	**Units**	**Human Health & Benthic COC RALs**	**Upper Limit for ENR**											
Metals														
Arsenic	mg/kg dw	57	171		6,280	5,590	620	620	56	340	315	2,760 J	49.4	15.9
Cadmium	mg/kg dw	10.2	30.6		8	8	1.3	10	1.1	1.44	0.5 U	1.65 J	0.5	0.5 U
Chromium	mg/kg dw	520	1,560		176	221	43	190	39.1	20.4	24.9	104 J	6.93	6.61
Copper	mg/kg dw	780	2,340		3,790	2,200	361	2,760	112	164	165	1,330 J	53.1	21.1
Lead	mg/kg dw	900	2,700		3,650	2,870	433	3,640	95	237	305	2,400	35.5	34.7
Mercury	mg/kg dw	0.82	2.46		0.15	0.05	0.13	3.18	0.13	0.025 U	0.66	0.067	0.038	0.0125 U
Silver	mg/kg dw	12.2	36.6		6	4	0.9 U	5	0.5 U	--	--	--	--	--
Zinc	mg/kg dw	820	2,460		15600	14400	1580	16,800	309	1,110	738	8,300 J	162	168
Organotin Compounds														
Tributyltin ion	µg/kg dw	--	--		--					--	--	280	--	--
Phthalates														
Bis(2-ethylhexyl)phthalate	mg/kg dw	--	--		--					0.3 J	0.4 U	0.4 U	0.4 U	0.4 U
Bis(2-ethylhexyl)phthalate	mg/kg OC	94	282		--					51.9 J	172 U	153 U	69.6 U	122 U
Chlorobenzenes														
1,2,4-Trichlorobenzene	mg/kg dw	--	--		--					0.005 U	0.025 U	0.025 U	0.025 U	0.025 U
1,2,4-Trichlorobenzene	mg/kg OC	1.62	4.86		--					0.865 U	5.4 U	9.6 U	4.3 U	7.62 U
Other SVOCs and COCs														
Benzoic acid	µg/kg dw	1,300	3,900		--					250 U	1,250 U	1,250 U	1,250 U	1,250 U
Organic Carbon														
Total Organic Carbon	%	--	--		--					0.578	0.233	0.261	0.575	0.328

Notes:

cPAHs caculated using method from LDW RI Appendix E.3 (Windward 2010) as defined by the California Environmental Protection Agency

Nondetects reported as 1/2 detection limit.

Lab duplicates have been averaged.

>Cat 2/3 RAL and ≤UL for ENR (ENR)

>UL for ENR (Partial Dredge and Cap)

COC = contaminant of concern
dw = dry weight
ENR = enhanced natural recovery
LDW = Lower Duwamish Waterway
OC = organic carbon
RAL = remedial action level
ROD = record of decision
SVOC = semivolatile organic compound
TEQ = toxicity equivalence
UL = upper limit
-- = no data available

Data Qualifiers: J = result is estimated, U = result is not detected

Table 2a. Intertidal and Subtidal Surface Sediment Data

					Intertidal Samples (-4 to +11.4 ft MLLW)		
				Sample Location:	49	60	60
				Sample ID:	SL1-SS-SD-G049	SL1-SS-SD-G060	SL1-SS-SD-G061 (field rep)
				Sample Date:	6/3/2015	6/5/2015	6/5/2015
				Matrix:	Sediment	Sediment	Sediment
				Sediment Interval (ft):	0 - 0.33	0 - 0.33	0 - 0.33
		LDW ROD Remedial Action Levels		Sediment Interval (cm):	0-10	0-10	0-10
Analyte	**Units**	**Human Health & Benthic COC RALs**	**Upper Limit for ENR**				
Polychlorinated Biphenyls (PCBs)							
Aroclor 1016	mg/kg dw	--	--		--	--	--
Aroclor 1221	mg/kg dw	--	--		--	--	--
Aroclor 1232	mg/kg dw	--	--		--	--	--
Aroclor 1242	mg/kg dw	--	--		--	--	--
Aroclor 1248	mg/kg dw	--	--		--	--	--
Aroclor 1254	mg/kg dw	--	--		--	--	--
Aroclor 1260	mg/kg dw	--	--		--	--	--
Total PCB Aroclors	mg/kg dw				--	--	--
Total PCB Aroclors	mg/kg OC	12 (195 for top 2 ft)	36 (195 for top 2 ft)		--	--	--
Polynuclear Aromatic Hydrocarbons (PAHs)							
1-Methylnaphthalene	mg/kg dw	--	--		--	--	--
2-Methylnaphthalene	mg/kg dw	--	--		--	--	--
Acenaphthene	mg/kg dw	--	--		--	--	--
Anthracene	mg/kg dw	--	--		--	--	--
Benz(a)anthracene	mg/kg dw	--	--		--	--	--
Benzo(a)pyrene	mg/kg dw	--	--		--	--	--
Benzo(b)fluoranthene	mg/kg dw	--	--		--	--	--
Benzo(k)fluoranthene	mg/kg dw	--	--		--	--	--
Chrysene	mg/kg dw	--	--		--	--	--
Dibenz(a,h)anthracene	mg/kg dw	--	--		--	--	--
Dibenzofuran	mg/kg dw	--	--		--	--	--
Fluoranthene	mg/kg dw	--	--		--	--	--
Fluorene	mg/kg dw	--	--		--	--	--
Indeno(1,2,3-cd)pyrene	mg/kg dw	--	--		--	--	--
Naphthalene	mg/kg dw	--	--		--	--	--
Pyrene	mg/kg dw	--	--		--	--	--
2-Methylnaphthalene	mg/kg OC	76	228		--	--	--
Acenaphthene	mg/kg OC	32	96		--	--	--
Acenaphthylene	mg/kg OC	--	--		--	--	--
Anthracene	mg/kg OC	440	1,320		--	--	--
Benz(a)anthracene	mg/kg OC	220	660		--	--	--
Benzo(a)pyrene	mg/kg OC	198	594		--	--	--
Benzo(g,h,i)perylene	mg/kg OC	62	186		--	--	--
Total benzofluoranthenes	mg/kg OC	460	1,380		--	--	--
Chrysene	mg/kg OC	220	660		--	--	--
Dibenz(a,h)anthracene	mg/kg OC	24	72		--	--	--
Dibenzofuran	mg/kg OC	30	90		--	--	--
Fluoranthene	mg/kg OC	320	960		--	--	--
Fluorene	mg/kg OC	46	138		--	--	--
Indeno(1,2,3-cd)pyrene	mg/kg OC	68	204		--	--	--
Naphthalene	mg/kg OC	198	594		--	--	--
Phenanthrene	mg/kg OC	200	600		--	--	--
Pyrene	mg/kg OC	2,000	6,000		--	--	--
Total HPAHs	mg/kg OC	1,920	5,760		--	--	--
Total LPAHs	mg/kg OC	740	2,220		--	--	--
cPAH	µg TEQ/kg dw	5,500 (0-10cm subtidal and intertidal) 5,900 (0-45cm intertidal)	16,500 (0-10cm subtidal and intertidal) 8,850 (0-45cm intertidal)		--	--	--

Table 2a. Intertidal and Subtidal Surface Sediment Data

Analyte	Units	LDW ROD Remedial Action Levels: Human Health & Benthic COC RALs	LDW ROD Remedial Action Levels: Upper Limit for ENR		Intertidal Samples (-4 to +11.4 ft MLLW)		
				Sample Location:	49	60	60
				Sample ID:	SL1-SS-SD-G049	SL1-SS-SD-G060	SL1-SS-SD-G061 (field rep)
				Sample Date:	6/3/2015	6/5/2015	6/5/2015
				Matrix:	Sediment	Sediment	Sediment
				Sediment Interval (ft):	0 - 0.33	0 - 0.33	0 - 0.33
				Sediment Interval (cm):	0-10	0-10	0-10
Metals							
Arsenic	mg/kg dw	57	171		733	1,940	1,970
Cadmium	mg/kg dw	10.2	30.6		1.28	2.44	2.45
Chromium	mg/kg dw	520	1,560		47.8	68.6 J	89.3 J
Copper	mg/kg dw	780	2,340		240	848	860
Lead	mg/kg dw	900	2,700		176 J	820	1,060
Mercury	mg/kg dw	0.82	2.46		0.601 J	0.129	0.069
Silver	mg/kg dw	12.2	36.6		0.473	1.55	1.61
Zinc	mg/kg dw	820	2,460		804 J	3,960	5,590
Organotin Compounds							
Tributyltin ion	µg/kg dw	--	--		--	--	--
Phthalates							
Bis(2-ethylhexyl)phthalate	mg/kg dw	--	--		--	--	--
Bis(2-ethylhexyl)phthalate	mg/kg OC	94	282		--	--	--
Chlorobenzenes							
1,2,4-Trichlorobenzene	mg/kg dw	--	--		--	--	--
1,2,4-Trichlorobenzene	mg/kg OC	1.62	4.86		--	--	--
Other SVOCs and COCs							
Benzoic acid	µg/kg dw	1,300	3,900		--	--	--
Organic Carbon							
Total Organic Carbon	%	--	--		6.52	1.89	2.18

Notes:

cPAHs caculated using method from LDW RI Appendix E.3 (Windward 2010) as defined by the California Environmental Protection Agency

Nondetects reported as 1/2 detection limit.

Lab duplicates have been averaged.

>Cat 2/3 RAL and ≤UL for ENR (ENR)

>UL for ENR (Partial Dredge and Cap)

COC = contaminant of concern
dw = dry weight
ENR = enhanced natural recovery
LDW = Lower Duwamish Waterway
OC = organic carbon
RAL = remedial action level
Data Qualifiers: J = result is estimated, U = result is not detected

ROD = record of decision
SVOC = semivolatile organic compound
TEQ = toxicity equivalence
UL = upper limit
-- = no data available

Table 2b. Subtidal Subsurface Sediment Data

			Subtidal Samples (Below -4 ft MLLW)											
		Sample Location:	DR020		LDW-SC17		LDW-SC17		C01		C02		C03	
		Sample ID:	SD-020-0000		LDW-SC17_2-4		LDW-SC17_6-8.2		C01-SD-3-5		C02-SD-3-5		C03-SD-3-5	
		Sample Date:	8/17/1998		2/23/2006		2/23/2006		2/6/2018		2/6/2018		2/7/2018	
		Matrix:	Sediment		Sediment		Sediment		Sediment		Sediment		Sediment	
		Sediment Interval (ft):	2 - 4		2 - 4		6 - 8.2		3 - 5		3 - 5		3 - 5	
		LDW ROD Remedial Action Levels	61-121.92 cm		61-121.92 cm		183-250 cm		91.4-152.4 cm		91.4-152.4 cm		91.4-152.4 cm	
Analyte	**Units**	**Recovery Category 2 and 3 Areas**												
Polychlorinated Biphenyls (PCBs)														
Aroclor 1016	mg/kg dw	--	0.01	UJ	0.45	U	0.09	U	0.0065	U	0.14	U	0.0055	U
Aroclor 1221	mg/kg dw	--	0.02	U	0.45	U	0.09	U	0.013	U	0.27	U	0.011	U
Aroclor 1232	mg/kg dw	--	0.01	U	0.45	U	0.09	U	0.0065	U	0.14	U	0.0055	U
Aroclor 1242	mg/kg dw	--	0.01	U	0.45	U	0.48		0.053	J	0.72		0.06	J
Aroclor 1248	mg/kg dw	--	0.01	U	1.7		0.09	U	0.0065	U	0.14	U	0.0055	U
Aroclor 1254	mg/kg dw	--	0.099		2.7		1		0.19		1.9		0.11	
Aroclor 1260	mg/kg dw	--	0.07	J	5.4		0.45		0.2		0.56	J	0.025	
Total PCB Aroclors	mg/kg dw		0.169		9.8		1.9		0.44	J	3.2	J	0.2	J
Total PCB Aroclors	mg/kg OC	12 (195 for top 2 ft)	6.3		154		58.6		19	J	77	J	26	J
Polycyclic Aromatic Hydrocarbons (PAHs)														
1-Methylnaphthalene	mg/kg dw	--			2.60		0.40							
2-Methylnaphthalene	mg/kg dw	--	0.07		4.50		0.61		0.099		0.033		0.012	
Acenaphthene	mg/kg dw	--	0.09		4.60		1.20		0.15		0.061		0.083	
Anthracene	mg/kg dw	--	0.37		1.90		1.70		0.24		0.39		5.4	
Benz(a)anthracene	mg/kg dw	--	1.1		1.50		2.10		0.47		1.7		14	
Benzo(a)pyrene	mg/kg dw	--	1.30		0.94		1.60		0.73		1.5		4	
Benzo(b)fluoranthene	mg/kg dw	--	1.90		1.70		2.50		1.1		2.3		7.6	
Benzo(k)fluoranthene	mg/kg dw	--	1.00		0.99		1.30		0.34		0.8		2.4	
Chrysene	mg/kg dw	--	1.80		1.80		2.60		0.78		2.0		16	
Dibenz(a,h)anthracene	mg/kg dw	--	0.24		0.07	U	0.26		0.096		0.18		0.43	
Dibenzofuran	mg/kg dw	--	0.09		1.7		0.71		0.13		0.053		0.034	
Fluoranthene	mg/kg dw	--	2.7		7.4		7.1		0.96		4.2		34	
Fluorene	mg/kg dw	--	0.1		4.3		1.4		0.15		0.086		0.26	
Indeno(1,2,3-cd)pyrene	mg/kg dw	--	0.77		0.18		0.32		0.35		0.67		1.3	
Naphthalene	mg/kg dw	--	0.090		3.400		1.200		0.28		0.094		0.028	
Pyrene	mg/kg dw	--	2.3		5.7		7.6		3.5		6.5		33	
2-Methylnaphthalene	mg/kg OC	76	3.3		70.9		18.8		4.2		0.8		1.6	
Acenaphthene	mg/kg OC	32	13.7		72.4		37		6.3		1.5		11	
Acenaphthylene	mg/kg OC	--	1.9		1.46	J	3.02		2.1		1.3		8.2	
Anthracene	mg/kg OC	440	13.7		29.9		52.5		10		9.4		710	
Benz(a)anthracene	mg/kg OC	220	40.7		23.6		64.8		20		41		1800	
Benzo(a)pyrene	mg/kg OC	198	48.1		14.8		49.4		31		36		530	
Benzo(g,h,i)perylene	mg/kg OC	62	25.6		2.2	J	10.8		14		13		120	
Total benzofluoranthenes	mg/kg OC	460	107.4		42.5		117		61		75		1300	
Chrysene	mg/kg OC	220	66.7		28.3		80.2		33		48		2100	
Dibenz(a,h)anthracene	mg/kg OC	24	8.9		1.1	U	8.02		4.1		4.3		57	
Dibenzofuran	mg/kg OC	30	3.3		26.8		21.9		5.5		1.3		4.5	
Fluoranthene	mg/kg OC	320	100.0		117		219		41		100		4500	
Fluorene	mg/kg OC	46	4.1		67.7		43.2		6.3		2.1		34	
Indeno(1,2,3-cd)pyrene	mg/kg OC	68	28.5		2.83		9.88		15		16		170	
Naphthalene	mg/kg OC	198	3.3		53.5		37		12		2.3		3.7	
Phenanthrene	mg/kg OC	200	32.2		205		130		17		8.9		200	
Pyrene	mg/kg OC	2,000	85.2		89.8		235		150		160		4300	
Total HPAHs	mg/kg OC	1,920	511.11		321	J	793		370		490		15000	
Total LPAHs	mg/kg OC	740	58.52		425	J	302		54		25		960	
cPAH	µg TEQ/kg dw	5,500	1,900		1,400		2,400		1000		2100		6900	

Table 2b. Subtidal Subsurface Sediment Data

			Subtidal Samples (Below -4 ft MLLW)					
		Sample Location:	DR020	LDW-SC17	LDW-SC17	C01	C02	C03
		Sample ID:	SD-020-0000	LDW-SC17_2-4	LDW-SC17_6-8.2	C01-SD-3-5	C02-SD-3-5	C03-SD-3-5
		Sample Date:	8/17/1998	2/23/2006	2/23/2006	2/6/2018	2/6/2018	2/7/2018
		Matrix:	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment
		Sediment Interval (ft):	2 - 4	2 - 4	6 - 8.2	3 - 5	3 - 5	3 - 5
		LDW ROD Remedial Action Levels	61-121.92 cm	61-121.92 cm	183-250 cm	91.4-152.4 cm	91.4-152.4 cm	91.4-152.4 cm
Analyte	**Units**	**Recovery Category 2 and 3 Areas**						
Metals								
Arsenic	mg/kg dw	57	99	60	76	11	33	7.3
Cadmium	mg/kg dw	10.2	3.1	15	20.4	0.77	16	10
Chromium	mg/kg dw	520	38	386	50.3	34	41	13
Copper	mg/kg dw	780	180	219	235	79	160	53
Lead	mg/kg dw	900	150	1,740	470	71	410	79
Mercury	mg/kg dw	0.82	0.47	1.29	0.75	0.42	0.6	0.13
Silver	mg/kg dw	12.2	0.67	2	2.2	0.84	1.9	0.65
Zinc	mg/kg dw	820	1,100	3,840	4,550	150	3900	2200
Organotin Compounds								
Tributyltin ion	µg/kg dw	--		--	--	--	--	--
Phthalates								
Bis(2-ethylhexyl)phthalate	mg/kg dw	--		2.3	1	--	--	--
Bis(2-ethylhexyl)phthalate	mg/kg OC	94		36.2	30.9	--	--	--
Chlorobenzenes								
1,2,4-Trichlorobenzene	mg/kg dw	--	0.020 U	0.11 J	0.003 U	--	--	--
1,2,4-Trichlorobenzene	mg/kg OC	1.62	0.74 U	1.73 J	0.102 U	--	--	--
Other SVOCs and COCs								
Benzoic acid	µg/kg dw	1,300	200 U	3,000 J	295 U	--	--	--
Organic Carbon								
Total Organic Carbon	%	--	2.7	6.35	3.24	2.4	4.2	0.76

Notes:

Data shown here is to represent what will remain after partial dredge and cap (3 ft in subtidal and 4 ft in intertidal). Data was compared to RALs for Recovery Category 2/3 Area in LDW ROD Figure 19 and Revised Figure 20 (USEPA 2014, 2015).

cPAHs caculated using method from LDW RI Appendix E.3 (Windward 2010) as defined by the California Environmental Protection Agency

Nondetects reported as 1/2 detection limit.

Lab duplicates have been averaged.

COC = contaminant of concern

dw = dry weight

LDW = Lower Duwamish Waterway

OC = organic carbon

RAL = remedial action level

Data Qualifiers: J = result is estimated, U = result is not detected

ROD = record of decision

SVOC = semivolatile organic compound

TEQ = toxicity equivalence

-- = no data available

Table 3. ARARs for Slip 1 Lower Duwamish Waterway

Topic	Standard or Requirement	Regulatory Citation		Comment
		Federal	State	
Sediment Quality	Sediment quality standards; cleanup screening levels	--	Sediment Management Standards (WAC 173-204)	The SMS are MTCA rules and an ARAR under CERCLA. Numerical standards for the protection of benthic marine invertebrates.
Fish Tissue Quality	Concentrations of contaminants in fish tissues	Food and Drug Administration Maximum Concentrations of Contaminants in Fish Tissue (49 CFR 10372-10442)	--	The Washington State Department of Health assesses the need for fish consumption advisories.
Surface Water Quality	Surface Water Quality Standards	Ambient Water Quality Criteria established under Section 304(a) of the Clean Water Act (33 USC 1251 et seq) http://www.epa.gov/ost/criteria/wqctable/	Surface Water Quality Standards (RCW 90-48; WAC 173-201A)	State surface water quality standards apply where the State has adopted, and EPA has approved, Water Quality Standards that are more stringent than Federal recommended Water Quality Criteria established under Section 304(a) of the Clean Water Act. Both chronic and acute standards, and marine and freshwater are used as appropriate.
Land Disposal of Waste	Disposal of materials containing PCBs	Toxic Substances Control Act (15 USC 2605; 40 CFR Part 761)	--	--
	Hazardous waste	Resource Conservation and Recovery Act Land Disposal Restrictions (42 USC 7401-7642; 40 CFR 268)	Dangerous Waste Regulations Land Disposal Restrictions (RCW 70.105; WAC 173-303, 140- 141)	--
Waste Treatment Storage and Disposal	Disposal limitations	Resource Conservation and Recovery Act (42 USC 7401-7642;40 CFR 264 and 265)	Dangerous Waste Regulations (RCW 70.105; WAC 173-303)	--
Noise	Maximum noise levels	--	Noise Control Act of 1974 (RCW 80.107; WAC 173-60)	
Groundwater	Groundwater quality	Safe Drinking Water Act MCLs and non-zero MCLGs (40 CFR 141)	RCW 43.20A.165 and WAC 173-290-310	For onsite potable water, if any.

Table 3. ARARs for Slip 1 Lower Duwamish Waterway

Topic	Standard or Requirement	Regulatory Citation		Comment
		Federal	State	
Dredge/Fill and Other In-water Construction Work	Discharge of dredged/fill material into navigable waters or wetlands	Clean Water Act (33 USC 401 et seq.; 33 USC 141; 33 USC 1251-1316; 40 CFR 230, 231, 404; 33 CFR 320-330) Rivers and Harbors Act (33 USC 401 et seq.)	Hydraulic Code Rules (RCW 75.20; WAC 220-110)	For in-water dredging, filling, or other construction.
	Open-water disposal of dredged sediments	Marine Protection, Research and Sanctuaries Act (33 USC 1401-1445; 40 CFR 227)	DMMP (RCW 79.90; WAC 332-30-166)	--
Solid Waste Management and Disposal	Requirements for solid waste handling management, disposal, waste reduction, and recycling.	Solid Waste Disposal Act (42 USC 215103259-6901-6991; 40 CFR 257-258)	Solid Waste Handling Standards (RCW 70.95; WAC 173-350)	--
Discharge to Surface Water	Point source standards for new discharges to surface water	National Pollutant Discharge Elimination System (40 CFR 122, 125)	Discharge Permit Program (RCW 90.48; WAC 173-216, 222)	--
Shoreline	Construction and development	--	Shoreline Management Act (RCW 90.58; WAC 173-16); King County and City of Seattle Shoreline Master Plans (KCC Title 25; SMC 23.60); City of Tukwila Shoreline Master Program (TMC 18.44)	For construction within 200 feet of the shoreline.
Floodplain Protection	Avoid adverse impacts, minimize potential harm	Executive Order 11988, Protection of Floodplains (40 CFR 6, Appendix A); FEMA National Flood Insurance Program Regulations (44 CFR 60.3Ld)(3)).	--	For in-water construction activities, including any dredge or fill operations. Includes local ordinances: KCC Title 9 and SMC 25.09.

Table 3. ARARs for Slip 1 Lower Duwamish Waterway

Topic	Standard or Requirement	Regulatory Citation		Comment
		Federal	State	
Critical (or Sensitive) Area ARAR	Evaluate and mitigate impacts	--	Growth Management Act (RCW 36.70a); King County Critical Area Ordinance (KCC Title 21A.24); City of Seattle (SMC 25.09); City of Tukwila Sensitive Area Ordinance (TMC 18.45)	--
Habitat for Fish, Plants, or Birds ARAR	Evaluate and mitigate habitat impacts	Clean Water Act (Section 404 (b)(1)); U.S. Fish and Wildlife Mitigation Policy (44 CFR 7644); U.S. Fish and Wildlife Coordination Act (16 USC 661 et seq.); Migratory Bird Treaty Act (16 USC 703-712)	--	--
Pretreatment Standards	National Pretreatment Standards	--	40 CFR Part 403; Metro District Wastewater Discharge Ordinance (KCC) to be considered (as is local requirement)	--
Environmental Impact Review	State Environmental Policy Act	--	State Environmental Policy Act RCW 43.21C; WAC 197-11-790)	Applicable to MTCA cleanups. Because the LDW is under a joint EPA/Ecology Order, Ecology has determined that CERCLA requirements are the functional equivalent of NEPA and SEPA.
Washington Clean Air Act	Requirements for emissions and air quality control.		Washington Clean Air Act (70.94 RCW).	--

Notes:
ARAR = applicable or relevant and appropriate requirement
CERCLA = Comprehensive Environmental Response, Compensation and Liability Act
CFR = Code of Federal Regulations
Ecology = Washington State Department of Ecology
EPA = U.S. Environmental Protection Agency
LDW = Lower Duwamish Waterway
MCL = maximum contaminant level
MTCA = Model Toxics Control Act
NEPA = National Environmental Policy Act
PCB = polychlorinated biphenyl
SEPA = State Environmental Policy Act
SMS = sediment management standards
USC = United States Code
WAC = Washington Administrative Code
-- = not applicable

Table 4. Evaluation of Remedial Technologies

Remedial Technology	Protectiveness and Compliance with Cleanup Standards	Permanence	Relative Cost	Technical Effectiveness Over the Long Term	Management of Short-Term Risk	Technical and Administrative Implementability	Consideration of Public Concern	Retained
No Action	Is not protective and is not in compliance with cleanup standards	Is not a permanent solution	None	Does not provide long-term effectiveness	Does not manage risk	Easy	Does not address potential exposure to contaminated media	No
Institutional Controls	Is not protective as a standalone technology and is not in compliance with cleanup standards	Is not a permanent solution	Low	Does not provide long-term effectiveness as a standalone technology	Does not manage risk	Easy	Can be effective in preventing exposure to contaminated media	Yes. To be use in conjunction with other remedial technology.
Partial Dredge and Cap	Partial dredge and cap is the preferred remedy provided in the LDW ROD	Can be effective with appropriate institutional controls and routine monitoring	High	Provides long-term effectiveness with proper controls and long-term monitoring	Effective in managing risk	Moderate	Effective in preventing exposure to contaminated media	Yes
Shoreline/Bank Excavation and Capping	Provides protectiveness but does not provide a favorable habitat	Can be effective but may require increased maintenance due to steep slope	High	Provides long-term effectiveness with proper controls and long-term monitoring	Effective in managing risk	Moderate	Effective in preventing exposure to contaminated media. Does not provide favorable habitat.	No
Shoreline/Bank Excavation, Backfill and Habitat Restoration	Provides protectiveness and favorable habitat	Can be effective with appropriate institutional controls and routine monitoring	Moderate	Provides long-term effectiveness with proper controls and long-term monitoring	Effective in managing risk	Moderate	Effective in preventing exposure to contaminated media and provides favorable habitat	Yes
Enhanced Natural Recovery	Provides protectiveness	Can be effective with appropriate institutional controls and routine monitoring	Low	Provides long-term effectiveness with proper controls and long-term monitoring	Effective in managing risk	Easy	Effective in reducing exposure to contaminated media	Yes
Long-Term Monitoring	To be used in conjunction with all active remedial technologies. Effective and relatively low cost.							Yes

Notes:
LDW = Lower Duwamish Waterway
ROD = record of decision

Table 5. Cost Estimate Summary for Sediment Preferred Remedy (Partial Dredge and Cap with ENR)

Description	Quantity	Unit	Unit Cost ($)	Cost ($)	Comments
CAPITAL COSTS					
Direct Costs - Subtidal and Intertidal Sediment (Below MHHW)					
Pre-Construction, Mobilization, Site Preparation	10%			$ 127,000	Percent of total construction costs (10%). Includes bonds and insurance, mob/demob, health and safety, temporary facilities and controls.
Debris Removal and Disposal	1	LS	$ 325,000	$ 325,000.00	Based on the amount, size and type of obstructions uncovered during sheet pile wall installation. Lump sum cost estimated between $300,000 and $350,000. This includes 2-3 weeks of Derrick, barges, hammer and crew, tow to disposal site, and offload and tipping fees.
Dredging/Dewatering	1,585	CY	$ 77	$ 123,000	Mechanical dredging with hydraulic excavator; Enclosed Environmental bucket; RTK-GPS based bucket positioning. Includes dewatering. Cost based on recent project experience and professional judgement.
Excavation of Shoreface (Below MHHW)	375	CY	$ 66	$ 25,000	Excavation conducted from a barge. Approximately 13% of the shoreface volume is located below MHHW. Cost based on recent project experience and professional judgement.
Transport and Disposal					
Transportation to Subtitle D Facility	2,092	TON	$ 28	$ 58,000	Assume 10% swell and 1.5 ton/cy for sediment. Assume 80% of material consisting of debris transport to Subtitle D transfer facility in Seattle.
Sediment Disposal at Subtitle D Facility	2,092	TON	$ 54	$ 113,000	Assume 1.5 ton/cy for sediment. Assume 80% of material disposal at Subtitle D facility in WA.
Transportation to Subtitle C Facility	523	TON	$ 83	$ 43,000	Assume 10% swell and 1.5 ton/cy for sediment. Assume 20% of material transport to Subtitle C CWM landfill in Arlington, OR.
Sediment Disposal at Subtitle C Facility	523	TON	$ 398	$ 208,000	Assume 1.5 ton/cy for sediment. Assume 20% of material disposal at Subtitle C CWM landfill in Arlington, OR. Disposal estimate based on PCB >50 ppm.
Cap - Material Purchase, Delivery, and Placement	1,902	CY	$ 88	$ 168,000	Assume typical material ($30/cy) and equipment production rates. Cost based on recent project experience and professional judgement. Factor of 1.2 applied to account for consolidation.
ENR – Material Purchase, Delivery, and Placement	365	CY	$ 88	$ 32,000	Assume typical material ($30/cy) and equipment production rates. Cost based on recent project experience and professional judgement.
Shoreface Backfill - Material and Placement (Below MHHW)	585	TON	$ 44	$ 26,000	Unit cost based on recent project experience and professional judgement. Assume shoreface backfill material density of 1.3 ton/cy. Factor of 1.2 applied to account for compaction.
Turbidity Controls	1	LS	$ 110,000	$ 110,000	Cost based on recent project experience and professional judgement.
Confirmation of Placement - Bathymetric Survey	1	LS	$ 13,000	$ 13,000	Bathymetric survey of final surface. Cost based on recent project experience and professional judgement.
Shoreface – Topographic Survey	1	LS	$ 2,000	$ 2,000	Survey of final backfill placement grade. Estimate based on previous project experience. Total topo survey cost approximately $5,000. Lump sum cost based on 33% of shoreface area is located below MHHW.
Shoreface – Habitat Restoration	1	LS	$ 28,000	$ 28,000	Estimate from Grette for total shoreface – $75,000 (2018). Cost updated to 2021. Lump sum based on 33% of shoreface area is located below MHHW.
			Direct Cost (Subtotal):	**$ 1,401,000**	
			B&O Tax (1.5% Subtotal):	$ 21,000	
			Sales Tax (10.25% Subtotal):	$ 144,000	
			Total Direct Cost:	**$ 1,566,000**	

Table 5. Cost Estimate Summary for Sediment Preferred Remedy (Partial Dredge and Cap with ENR)

Description	Quantity	Unit	Unit Cost ($)	Cost ($)	Comments
CAPITAL COSTS					
Indirect Costs[a]					
Construction Management (10% of Direct Cost)[b]	--	--	--	$ 140,000	
Project Management (8% of Direct Cost)[c]	--	--	--	$ 112,000	
Remedial Design Report	1	LS	$ 70,000	$ 70,000	
Remedial Design Documents (30%, 90% and final)	--	--	--	--	
- Technical Specifications	1	LS	$ 38,000	$ 38,000	
- Drawings	1	LS	$ 65,000	$ 65,000	
Permitting	1	LS	$ 85,000	$ 85,000	
Construction Quality Assurance Plan	1	LS	$ 25,000	$ 25,000	
Health and Safety Plan	1	LS	$ 6,000	$ 6,000	
Long-Term Monitoring Plans	1	LS	$ 20,000	$ 20,000	
Agency Meetings/Negotiations	1	LS	$ 15,000	$ 15,000	
Water Quality Monitoring Plan	1	LS	$ 10,000	$ 10,000	
Biological Assessment	1	LS	$ 30,000	$ 30,000	
Institutional Controls	1	LS	$ 7,500	$ 8,000	
			Total Indirect Cost:	**$ 624,000**	
			Direct and Indirect Costs (Subtotal):	$ 2,190,000	
			Contingency (20%):	$ 438,000	
			TOTAL CAPITAL COSTS:	**$ 2,628,000**	

Description	Quantity	Units	Unit Cost	Cost	Description
LONG TERM MONITORING (LTM)					
Direct Periodic LTM	**Quantity**	**Units**	**Unit Cost**	**Cost**	**Description**
Waterway Cap, Bank and Habitat Monitoring	1	Event	$ 25,000	$ 25,000	
Reporting	1	Event	$ 20,000	$ 20,000	
Institutional Control Monitoring and Plan Updates	1	Event	$ 3,000	$ 3,000	Monitoring and review of institutional controls
			LTM Project Management (15%):	$ 7,000	
			Total Periodic LTM Cost:	$ 55,000	
			TOTAL LTM COST:	**$ 330,000**	Periodic monitoring for 30 years at year 5, 10, 15, 20, 25, and 30.
			TOTAL REMEDY COST (Actual Dollars, 30 years):	**$ 2,958,000**	

Notes:

The costs are Feasibility Study-level estimates based on existing information and are estimated to be within +50/-30% of actual costs.
The costs are in current dollars (2021). The estimate will need to be updated to account for inflation once the project is approved and the schedule is better defined.
ENR = enhanced natural recovery
MHHW = mean higher high water

[a]Indirect costs, with exception the of construction management and project management, are best on recent project experience and professional judgement.

[b]Construction management includes review and approval of contractor submittals, engineering during construction and design modifications if needed, construction inspection and oversight, testing and documentation of quality control/quality assurance, environmental monitoring during construction, and preparation of a construction completion report and record drawings.

[c]Project management includes all elements of project management including planning, meetings, reporting, regulatory oversight fees, and legal services.

Table 6. Evaluation of Preferred Remedial Action

	Selected Remedy
Remedial Technology	Partial Dredge and Cap and ENR, Shoreline/Bank Excavation/Backfill and Habitat Restoration
Footprint	Sediment Partial Dredge and Cap 0.29 acres (1,585 CY) ENR 0.25 acres (365 CY)
MTCA Alternative Threshold Criteria (WAC 173-340-360)	
Protect human health and the environment.	Alternative meets criteria.
Comply with cleanup standards. (WAC 173-340-700 through 173-340-760)	Alternative meets criteria.
Comply with applicable state and federal laws. (WAC 173-340-710)	Alternative meets criteria.
Provide for compliance monitoring. (WAC 173-340-410 and WAC 173-340-720 through 173-340-760)	Alternative meets criteria.
MTCA Selection Criteria WAC 173-340-360(2)(b)	
Use permanent solutions to the maximum extent practicable. (WAC 173-340-360(4))	Alternative meets criteria.
Provide a reasonable restoration time frame. (WAC 173-340-360(4))	Alternative meets criteria.
Consider public concerns. (WAC 173-340-600)	Alternative meets criteria.

Table 6. Evaluation of Preferred Remedial Action

	Selected Remedy	
MTCA Ranking Criteria	Description	
Protectiveness	Partial dredge and cap is the preferred remedy provided in the LDW ROD. Selection of ENR pending EPA pilot study.	
Permanence	Can be effective with appropriate institutional controls and routine monitoring. ENR can be implemented in areas of spudding. Remedy will provide net environmental benefit by improving benthic habitat.	
Effectiveness Over the Long Term	Provides long-term effectiveness with proper controls and long-term monitoring. ENR effective technology over long term. Final ENR requirements pending on EPA pilot study.	
Management of Short-Term Risk	Effective in managing risk.	
Technical and Administrative Implementability	Requires less technical and administrative support because of the smaller dredge and cap footprint than the ROD selected remedy. ENR requires completion of pilot study.	
Consideration of Public Concern	Effective in preventing exposure to contaminated media.	
Cost (total capital cost)	$	2,958,000
Retained	Yes	

Notes:
ENR = enhanced natural recovery
EPA = U.S. Environmental Protection Agency
LDW = Lower Duwamish Waterway
MTCA = Model Toxics Control Act
ROD = record of decision

Appendix A

Applicable ROD and ESD Excerpts

Table 1. Revised ROD Table 19 - Cleanup Levels for PCBs, Arsenic, cPAHs, and Dioxins/Furans in Sediment for Human Health and Ecological COCs (RAOs 1, 2 and 4) with updates for cPAH (in italics)

COC	Cleanup Levels			Application Area and Depth			
	RAO 1: Human Seafood Consumption	**RAO 2: Human Direct Contact**	**RAO 4: Ecological (River Otter)**	**Basis for Cleanup Levels[a]**	**Spatial Scale of Application[b]**	**Spatial Compliance Measure**	**Compliance Depth[b]**
PCBs (µg/kg dw)	**2**	1,300	128	background (RAO 1) RBTC (RAO 2) RBTC (RAO 4)	LDW-wide	UCL95	0 – 10 cm
	NA	500	NA	RBTC	All Clamming Areas[c]	UCL95	0 – 45 cm
	NA	1,700	NA	RBTC	Individual Beaches[d]	UCL95	0 – 45 cm
Arsenic (mg/kg dw)	NA	7	NA	background	LDW-wide	UCL95	0 – 10 cm
	NA	7	NA	background	All Clamming Areas[c]	UCL95	0 – 45 cm
	NA	7	NA	background	Individual Beaches[d]	UCL95	0 – 45 cm
cPAH BaP-eq (µg/kg dw)[e]	NA	*2800*[f]	NA	RBTC	LDW-wide	UCL95	0 – 10 cm
	NA	*1100*[g]	NA	RBTC	All Clamming Areas	UCL95	0 – 45 cm
	NA	*590*[h]	NA	RBTC	Individual Beaches[d]	UCL95	0 – 45 cm
Dioxins/Furans (ng TEQ/kg dw)	**2**	37	NA	background (RAO 1) RBTC (RAO 2)	LDW-wide	UCL95	0 – 10 cm
	NA	13	NA	RBTC	All Clamming Areas[c]	UCL95	0 – 45 cm
	NA	28	NA	RBTC	Individual Beaches[d]	UCL95	0 – 45 cm

NOTE: where there are multiple cleanup levels for a cleanup area, the lowest cleanup level is shown in bold.

[a] Background – see Table 3 and Section 5.3.4.1, RBTC – Risk-based threshold concentration (based on 1 in 1,000,000 excess cancer risk or HQ of 1).

[b] Human-health direct contact cleanup levels (for PCBs, arsenic, cPAHs, and dioxins/furans) in intertidal areas, including beaches used for recreation and clamming.

[c] Clamming areas are identified in Figure 2 of the ESD.

[d] Beach play areas are identified in Figure 2 of the ESD.

[e] Change in terminology: cPAH µg TEQ/kg dw and cPAH BaP-eq are the same.

[f] Value increased by ESD from 380 to 2,800 µg/kg dw.

[g] Value increased by ESD from 150 to 1,100 µg/kg dw.

[h] Value increased by ESD from 90 to 590 µg /kg dw.

Table 3. Revised ROD Table 28 - Remedial Action Levels, ENR Upper Limits, and Areas and Depths of Application

			Intertidal Sediments (+11.3 ft MLLW to -4 ft MLLW)				**Subtidal Sediments (-4 ft MLLW and Deeper)**				
			Recovery Category 1 RALs, ENR ULs, and Application Depths		**Recovery Category 2 and 3 RALs, ENR ULs, and Application Depths**		**Recovery Category 1 RALs, ENR ULs, and Application Depths**		**Recovery Category 2 and 3 RALs, ENR ULs, and Application Depths**		**Shoaled Areas[a] in Federal Navigation Channel**
COC	**Units**	**Action Levels**	Top 10 cm (4 in)	Top 45 cm (1.5 ft)	Top 10 cm (4 in)	Top 45 cm (1.5 ft)	Top 10 cm (4 in)	Top 60 cm (2 ft)	Top 10 cm (4 in)	Top 60 cm (2 ft)[b]	Top to Authorized Navigation Depth Plus 2 ft
Human Health Based RALs											
PCBs (Total)	mg/kg OC	RAL	12	12	12	65	12	12	12	195	12
		UL[c] for ENR	--	--	36	97	--	--	36	195	--
Arsenic (Total)	mg/kg dw	RAL	57	28	57	28	57	57	57	--	57
		UL for ENR	--	--	171	42	--	--	171	--	--
cPAH BaP-eq[d]	µg/kg dw	RAL	*5,500*[e]	*5,900*[e]	*5,500*[e]	*5,900*[e]	*5,500*[e]	*5,500*[e]	*5,500*[e]	--	*5,500*
		UL[c] for ENR	--	--	*16,500*[e]	*8,850*[e]	--	--	*16,500*[e]	--	--
Dioxins/Furans	ng TEQ/kg dw	RAL	25	28	25	28	25	25	25	--	25
		UL[c] for ENR	--	--	75	42	--	--	75	--	--
Benthic Protection RALs											
39 SMS COCs[f]	Contaminant- specific	RAL	Benthic SCO	Benthic SCO	2x Benthic SCO	--	Benthic SCO	Benthic SCO	2x Benthic SCO	--	Benthic SCO
		UL[c] for ENR	--	--	3x RAL	--	--	--	3x RAL	--	--

Notes: This table reflects changes from the 2020 ESD to Table 28 in the ROD.

-- not applicable

[a] Shoaled areas are those areas in federal navigation channel with sediment accumulation above the authorized depth including a 2 ft over-dredge depth that USACE uses to maintain the channel for navigation purposes. The authorized channel depths are (1) from RM 0 to 2 (from Harbor Island to the First Avenue South Bridge), 30 ft below MLLW, (2) from RM 2 to RM 2.8 (from the First Avenue South Bridge to Slip 4), 20 ft below MLLW, and (3) from RM 2.8 to 4.7 (Slip 4 to the Upper Turning Basin), 15 ft below MLLW. For shoaled areas, the compliance intervals will be determined during Remedial Design, these are typically 2-4 ft core intervals. For areas in the channel that are not shoaled, Recovery Categories 1 or 2 & 3 RALs apply as indicated in the other subtidal columns.

[b] Applied only in potential vessel scour areas. These are defined as subtidal areas (below -4 ft MLLW) that are above -24 ft MLLW north of the 1st Ave South Bridge, and above -18 ft MLLW south of the 1st Ave South Bridge (see Figure 17 in the ROD).

[c] The ENR UL is the highest concentration that would allow for application of ENR in the areas described. For areas with no ENR limit listed, ENR is not a currently designated technology (see Section 13.2.1.2 for further discussion).

[d] Change in terminology: cPAH µg TEQ/kg dw and cPAH BaP-eq are the same

[e] Intertidal RAL modified by ESD, based on beach play RBTC at $1x10^{-5}$. The RAL of 5,500 µg/kg dw for subtidal and intertidal 0-10 cm sediments is to address hotspots. As in the ROD, the Upper Limits for ENR, where applicable, are 1.5 times the 0-45 cm RAL (in intertidal areas) and 3 times the 0-10 cm RAL (in subtidal and intertidal areas).

[f] There are 41 SMS COCs, but total PCBs and arsenic ENR ULs are based upon human health based RALs only (see Table 20 in the ROD).

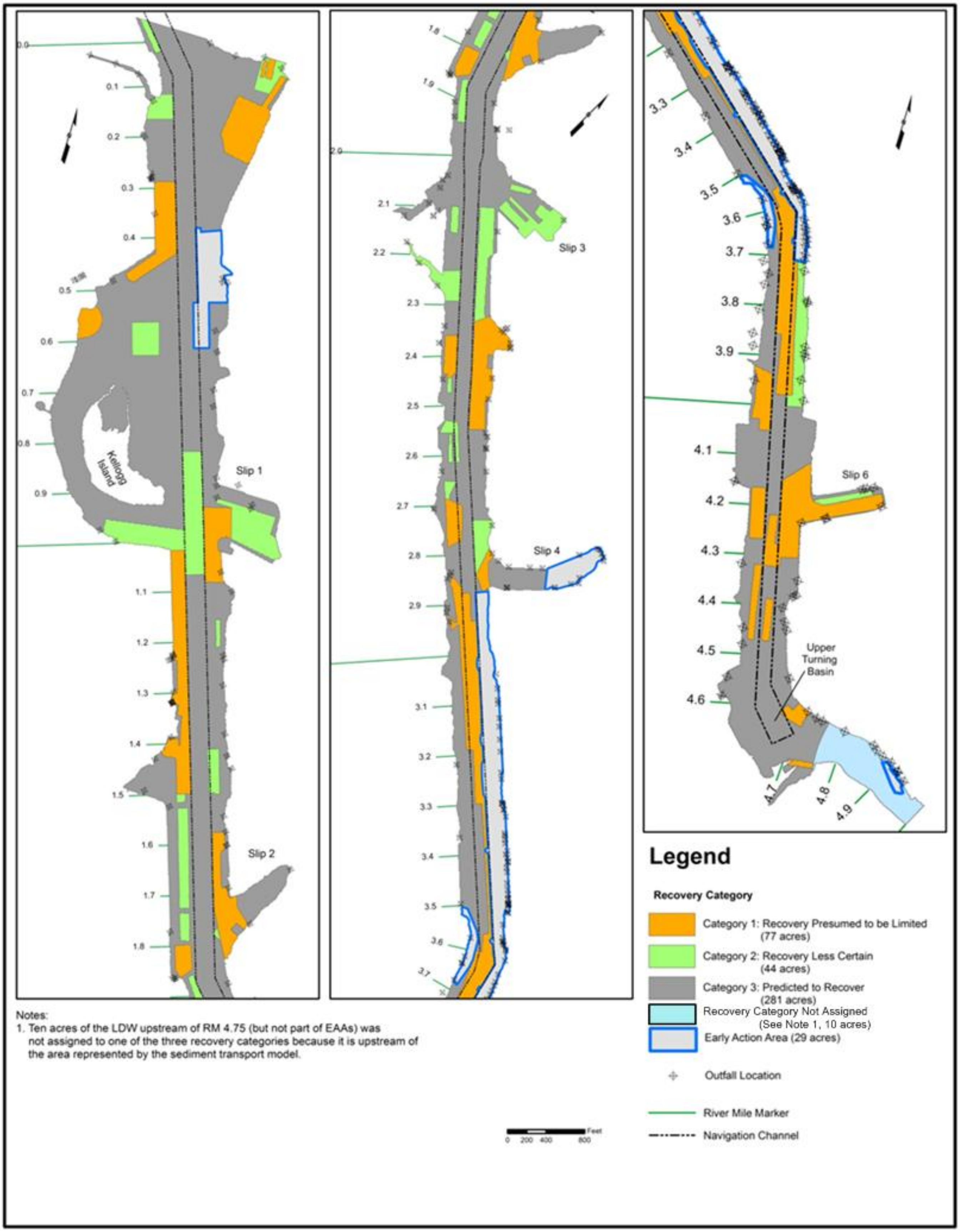


Figure 12. Recovery Category Areas

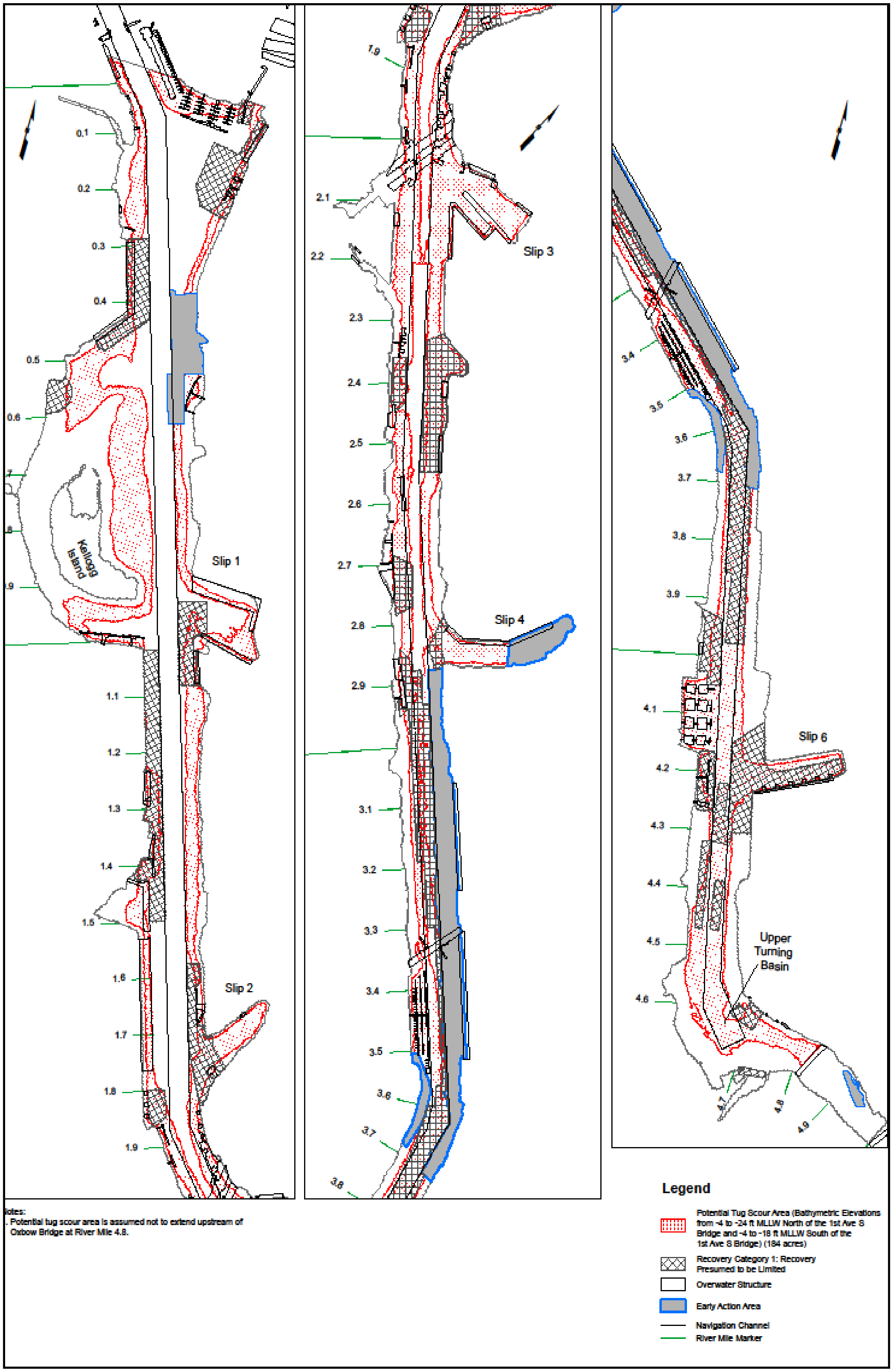


Figure 17. Recovery Category 1 and Potential Tug Scour Areas in LDW

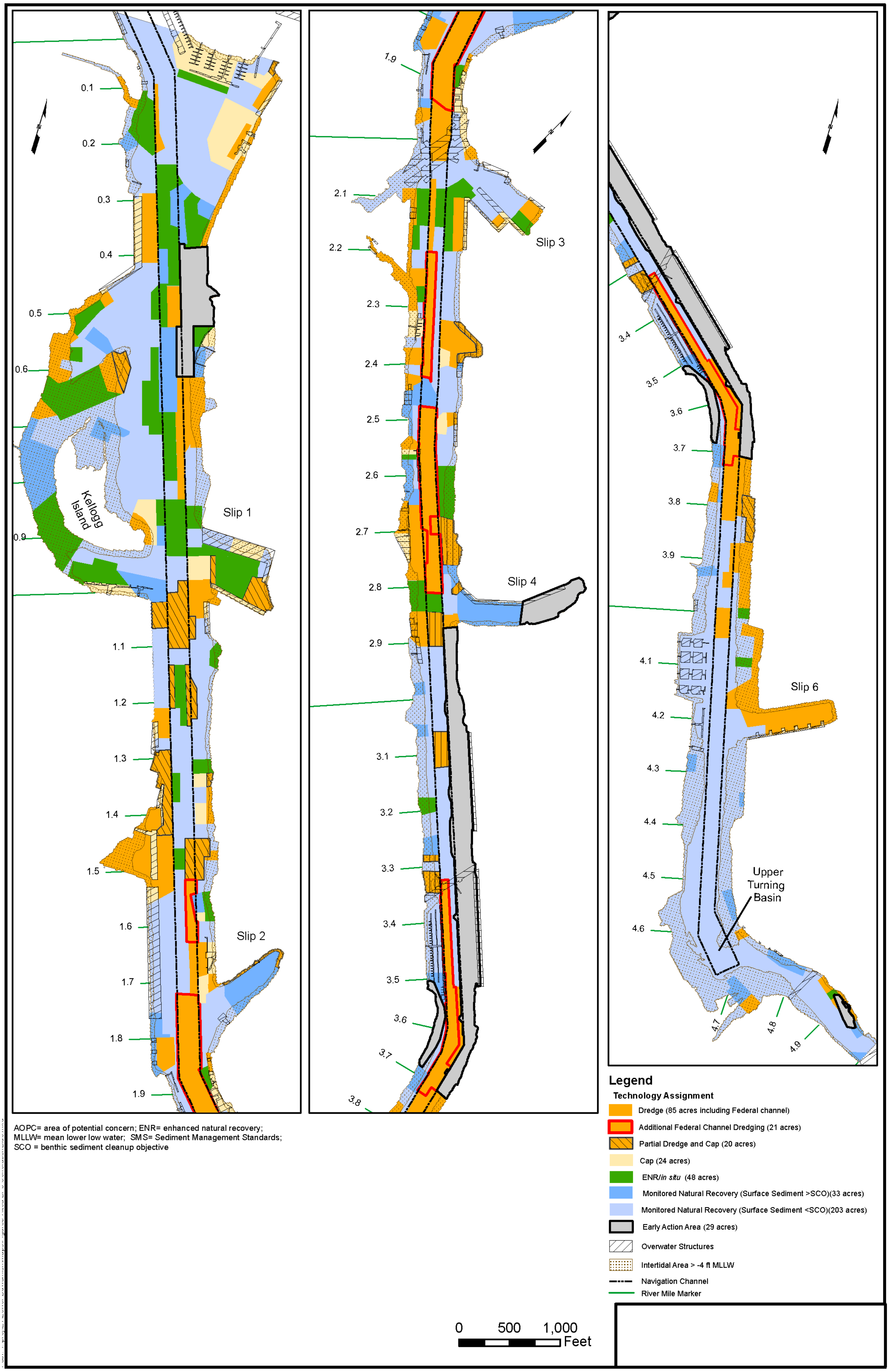
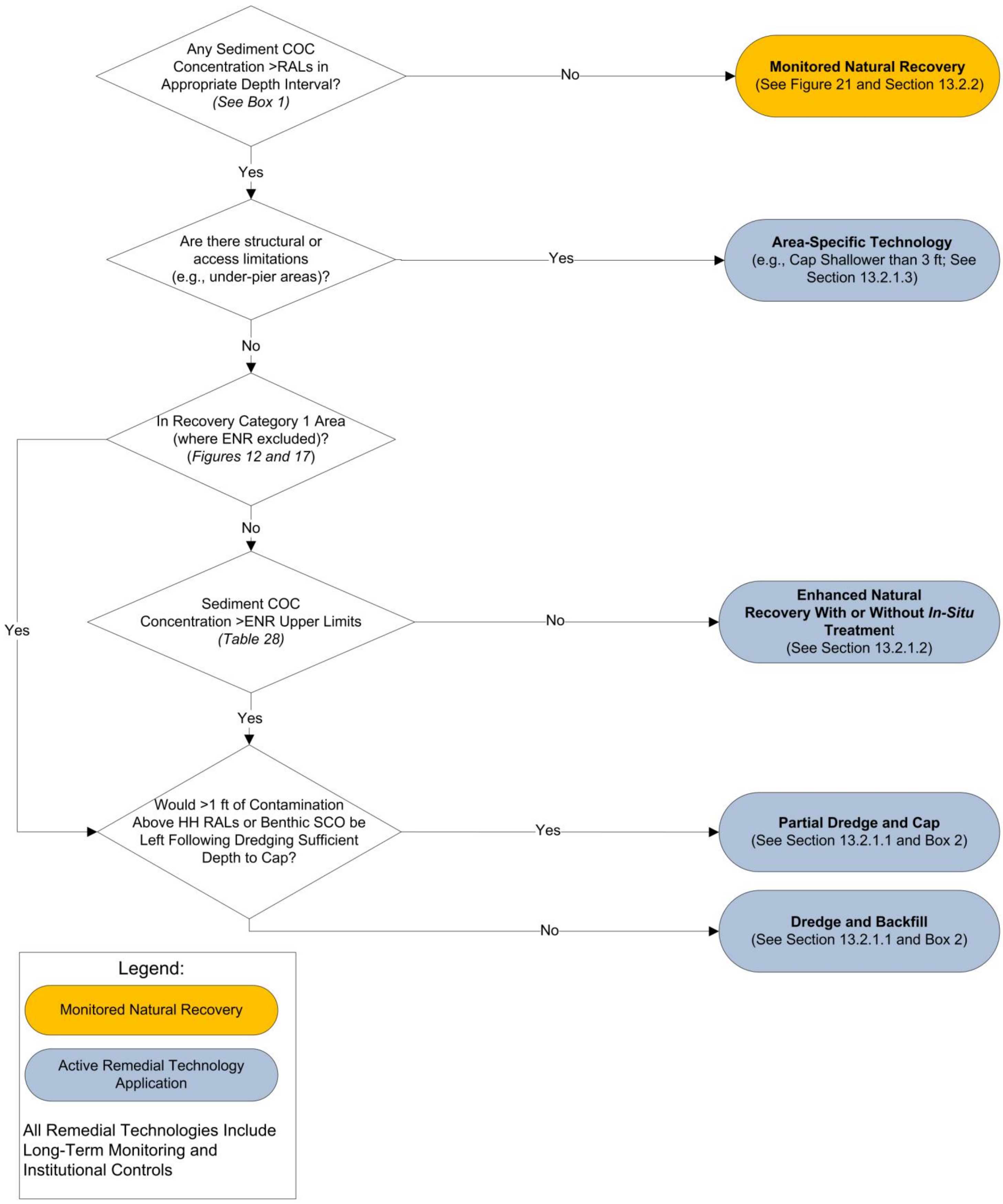


Figure 18. Selected Remedy



Box 1. Intertidal Sediments (+11.3 ft MLLW to -4 ft MLLW)

Remedial Action Levels (RALs) and Depth Interval to Which They Apply

Contaminant	Units	Recovery Category 1 Areas: 4 in (10 cm) depth interval	Recovery Category 1 Areas: 1.5 ft (45 cm) depth interval	Recovery Category 2 and 3 Areas: 4 in (10 cm) depth interval	Recovery Category 2 and 3 Areas: 1.5 ft (45 cm) depth interval	Risk Reduction Associated with RALs
PCBs (Total)	mg/kg-OC	12	12	12	65	Human Health [a,b,c,e]
cPAH	µg TEQ/kg-dw	1000	900	1000	900	
Dioxins/Furans	ng TEQ/kg-dw	25	28	25	28	
Arsenic (Total)	mg/kg-dw	57	28	57	28	
39 SMS COCs	Varies by COC	SCO (see Table 27)	--	2xSCO (see Table 27)	--	Ecological [d,e]

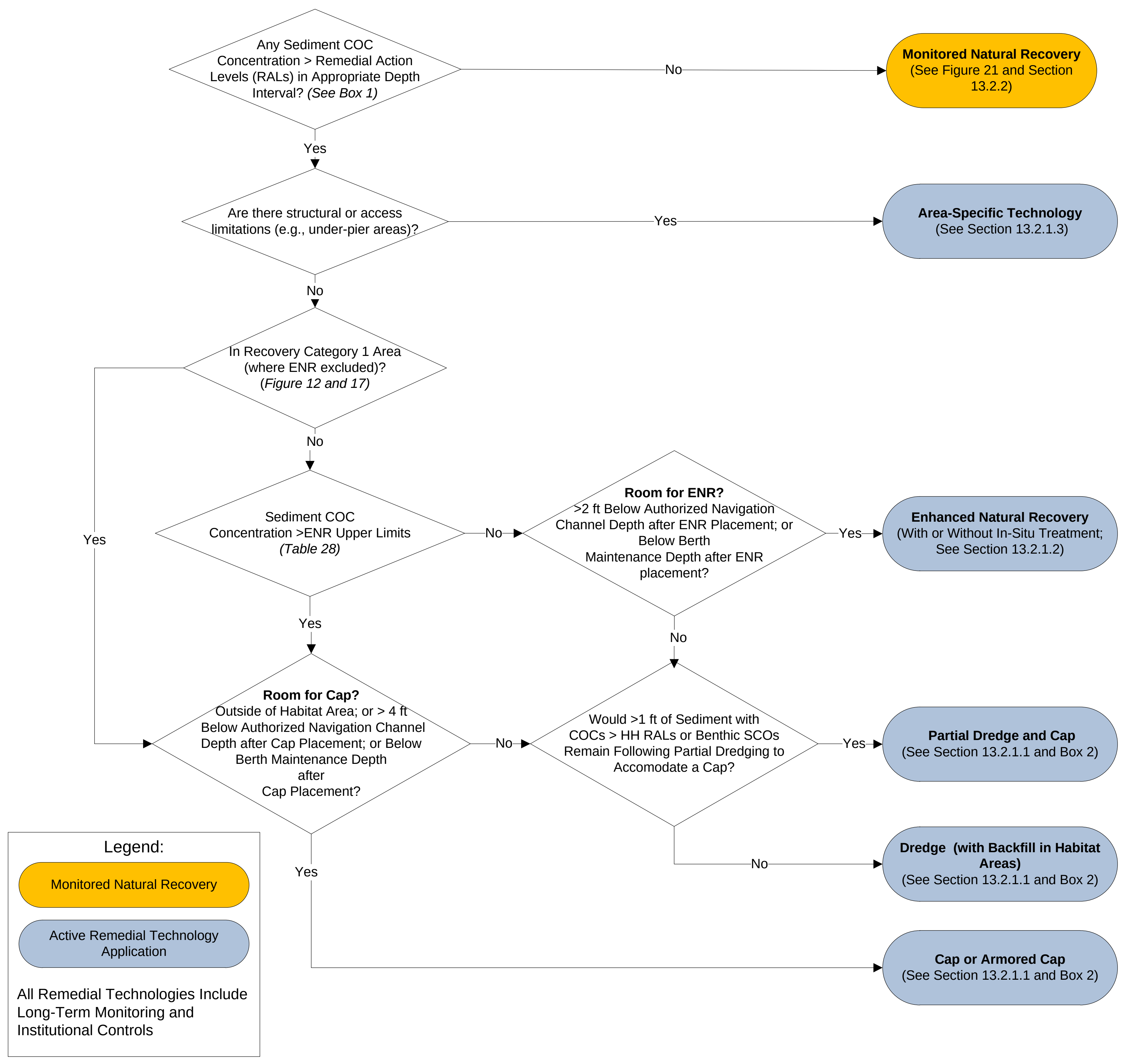
Notes:

1. The average concentrations in depth Interval (e.g., vertically composited samples) are compared to RALs.
2. Human Health RALs and RAO 3 RALs must be met immediately following construction.

[a] RAO 1 - Human health seafood consumption
[b] RAO 2 - Human health direct contact includes beach play, clamming, and netfishing
[c] RAO 4 - Ecological protection for river otter (addressed by meeting human health PCB RAL)
[d] RAO 3 - Ecological protection of benthic community
[e] There are 41 SMS COCs, but PCB and arsenic are principally RAO 1 COCs. SMS also lists toxicity test-out criteria using bioassays. Test-out is not allowed for PCBs or arsenic.

Box 2. Habitat Areas
Elevations of intertidal habitat areas are assumed to be unaffected by addition of 6-9" of suitable materials (i.e., ENR)
Cap,dredge and backfill,or partial dredge and cap to pre-construction grade; finish with suitable habitat layer
In clam habitat areas (Figure 6), caps will generally include 4 ft of suitable clean material Including a minimum 45 cm clam habitat layer

Figure 19. Intertidal Areas – Remedial Technology Applications



Box 1. Subtidal Sediments (-4 ft MLLW and Deeper)

Remedial Action Levels (RALs) and Depth Interval for Application of RAL

Contaminant	Units	Recovery Category 1 Areas		Recovery Category 2 and 3 Areas		Shoaled Areas of the Federal Channel	Risk Reduction Associated with RALs
		4 in (10 cm) depth interval	2 ft (60 cm) depth interval	4 in (10 cm) depth interval	2 ft (60 cm) depth interval-applied only at potential tug scour areas; See *Footnote 2* and Figure 16	See *Footnote 3*. To a depth of 2 ft below the authorized depth for waterway reach[f]	
PCBs (Total)	mg/kg-OC	12	12	12	195	12	Human Health [a,b,c]
cPAH	µg TEQ/kg-dw	1000	1000	1000	--	1000	
Dioxins/Furans	ng TEQ/kg-dw	25	25	25	--	25	
Arsenic (Total)	mg/kg-dw	57	57	57	--	57	
39 SMS COCs	Varies by COC	SCO (see Table 27)	SCO	2xSCO (see Table 27)	--	SCO (see Table 27)	Ecological [d,e]

Notes

1. The average concentrations in depth interval (e.g., vertically composited samples) are compared to RALs.
2. Potential Tug Scour Areas are Subtidal Elevations Potentially Susceptible to Propellor Wash (North of the 1st Avenue South bridge located at approximately RM 2 in Water Depths from -4 to -24 ft MLLW, and South of the 1st Avenue S Bridge, in Water Depths from -4 to -18 ft MLLW).
3. Shoaled areas are those areas in federal navigation channel with sediment accumulation above the authorized depth including a 2 ft over-dredge depth; see Table 28. For areas in the navigation channel that are not shoaled, Recovery Categories 1 or 2 & 3 RALs apply. Authorized depths are: (1) from RM 0 to 2, 30 ft below MLLW (from Harbor Island to the First Avenue South Bridge); (2) from RM 2 to RM 2.8, 20 ft below MLLW (from the First Avenue South Bridge to Slip 4); and (3) from 15 ft below MLLW from RM 2.8 to 4.7 (Slip 4 to the Upper Turning Basin).
4. Human Health RALs (and RAO 3 PRGs (Benthic SCOs) in Category 1 areas) must be met immediately following construction.

[a] RAO 1 - Human health seafood consumption
[b] RAO 2 - Human health direct contact includes beach play, clamming, and netfishing
[c] RAO 4 - Ecological protection for river otter (addressed by meeting human health PCB RAL)
[d] RAO 3 - Ecological protection of benthic community
[e] There are 41 SMS COCs, but PCB and arsenic are principally RAO 1 COCs. SMS Also lists toxicity test-out criteria using bioassays. Test-out is not allowed for PCBs or arsenic.
[f] Depth intervals to determine compliance will be determined during Remedial Design.
[g] Caps were assumed to be 3 ft for cost estimating purposes; cap thicknesses will be evaluated by EPA during Remedial Design in accordance with EPA and USACE (1998)

Box 2. Habitat Areas (see Section 13.2.1.1)
Elevations of intertidal habitat areas are assumed to be unaffected by addition of 6-9" materials (i.e., ENR)
Cap, dredge and backfill, or partial dredge and cap to pre-construction grade; finish with suitable habitat layer.

Revised Figure 20. Subtidal Areas – Remedial Technology Application