Lower Duwamish Waterway Group

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

REMEDIAL DESIGN WORK PLAN FOR THE LOWER DUWAMISH WATERWAY UPPER REACH

FINAL

For submittal to

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

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ABBREVIATIONS

AC	activated carbon
AOC	Administrative Order on Consent
AOC2	Second Amendment to the Administrative Order on Consent
AOC3	Third Amendment to the Administrative Order on Consent
AOC4	Fourth Amendment to the Administrative Order on Consent
ARAR	applicable or relevant and appropriate requirement
BA	biological assessment
BMP	best management practice
BODR	Basis of Design Report
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cm	centimeter
COC	contaminant of concern
CQAP	Construction Quality Assurance Plan
CSI	Construction Specification Institute
CSM	conceptual site model
CSO	combined sewer overflow
DQO	data quality objective
E	east bank
EAA	early action area
EBDRP	Elliott Bay/Duwamish Restoration Program
Ecology	Washington State Department of Ecology
ENR	enhanced natural recovery
EPA	U.S. Environmental Protection Agency
FEMA	Federal Emergency Management Agency
FNC	federal navigation channel
FS	Feasibility Study
HASP	Health and Safety Plan
HEC-RAS	Hydrologic Engineering Center – River Analysis System
ICIAP	Institutional Controls Implementation and Assurance Plan
LDW	Lower Duwamish Waterway
LDWG	Lower Duwamish Waterway Group

LTMMP	Long-Term Maintenance and Monitoring Plan
MHHW	mean higher high water
MLLW	mean lower low water
MNR	monitored natural recovery
MTCA	Model Toxics Control Act
OSHA	Occupational Safety and Health Administration
PCB	polychlorinated biphenyl
PDI	pre-design investigation
PDIWP	Pre-Design Investigation Work Plan
propwash	propeller wash
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
RAL	remedial action level
RAO	remedial action objective
RAWP	Remedial Action Work Plan
RCRA	Resource Conservation and Recovery Act
RD	remedial design
RDWP	Remedial Design Work Plan
RI	remedial investigation
RM	river mile
RMC	residuals management cover
ROD	Record of Decision
SCO	sediment cleanup objective
SD	storm drain
SMA	sediment management area
SOW	statement of work
STM	sediment transport model
T-117	Terminal 117
USACE	U.S. Army Corps of Engineers
W	west bank
WQMP	Water Quality Monitoring Plan

1 Introduction

This Remedial Design Work Plan (RDWP) describes the process that will be used to design the remedy for the upper reach of the Lower Duwamish Waterway (LDW) Superfund Site in King County, Washington, as selected in the U.S. Environmental Protection Agency's (EPA's) November 2014 Record of Decision (ROD; EPA 2014). This RDWP was prepared on behalf of the City of Seattle, King County, the Port of Seattle, and The Boeing Company, collectively referred to as the Lower Duwamish Waterway Group (LDWG).

In December 2000, LDWG entered into an Administrative Order on Consent (AOC) for Remedial Investigation/Feasibility Study (RI/FS) with EPA and the Washington State Department of Ecology (Ecology) to conduct an RI/FS for the LDW. In September 2001, the LDW was formally added to the National Priorities List as a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA, or Superfund) site; in February 2002, Ecology listed the LDW as a cleanup site under the Washington Model Toxics Control Act (MTCA). EPA and Ecology have divided lead agency responsibility for addressing the site: EPA is responsible for administering the cleanup of the sediments in the waterway, and Ecology is responsible for controlling sources of pollution to the waterway. The RI was completed in 2010 (Windward 2010) and the FS was completed in 2012 (AECOM 2012). A ROD was issued by EPA in 2014 (EPA 2014).

Four amendments to the AOC have been signed. The first amendment resulted in the fishers study (completed in 2016). The second amendment (AOC2) involves an ongoing pilot study to assess the effectiveness of activated carbon (AC) amendments to sand layer placement as a remedial technology. The third amendment (AOC3) specified pre-design studies, including collecting baseline data following early actions but before implementation of the full remedial action, surveying waterway users to update information on uses of the waterway, and preparing a design strategy report (Integral and Windward 2019) to help EPA ensure that all remedial design (RD) data needs are addressed in the appropriate sequence. The fourth amendment (AOC4), being addressed through this RDWP, addresses the RD of the upper reach of the LDW (river mile [RM] 3.0 to RM 5.0).

1.1 Remedial Design Work Plan Objectives

The primary objective of this RDWP is to describe the process to develop detailed engineering designs for the selected remedy for the upper reach of the LDW, as set forth in the ROD and AOC4. Consistent with Section 5.3 of the AOC4 statement of work (SOW), this RDWP shall "include a proposed plan and schedule for implementing all RD activities for the LDW Upper Reach and identification and development of all RD supporting documents" (EPA 2018).

1.2 Remedial Design Work Plan Overview

This RDWP is organized as follows:

- **Section 1** introduces the RDWP; describes the site and selected remedy; discusses the general approach to remedial contracting, construction, maintenance, monitoring, and institutional controls; and describes RD project management.
- **Section 2** describes existing data.
- **Section 3** describes the engineering design process of the RD.
- **Section 4** describes additional activities that will support the RD process.
- **Section 5** presents the physical conceptual site model (CSM) for the upper reach, including expected outcomes of the remedial action.
- **Section 6** describes the RD deliverables.
- **Section 7** presents the RD project schedule.
- **Section 8** provides a list of references cited in this RDWP.
- **Appendix A** includes tables and figures extracted from the LDW Superfund ROD (November 2014) and a subsequent revisions memorandum (EPA 2015a).
- **Appendix B** provides a longitudinal cross section figure of the navigation channel excerpted from the Final Feasibility Study for the LDW.
- **Appendix C** is the Draft Pre-Design Investigation Work Plan (PDIWP).
- **Appendix D** provides the Quality Assurance Project Plan (QAPP) for pre-design surveys of the LDW upper reach.

1.3 Site Description

The Duwamish River originates at the confluence of the Green and Black rivers near Tukwila, Washington, and flows northwest for approximately 12 miles, splitting at the southern end of Harbor Island in Seattle, Washington to form the East and West Waterways, prior to discharging into Elliott Bay in Puget Sound (Figure 1-1). In the early years of the twentieth century, the last 6 miles of the Duwamish River were straightened and channelized into a commercial corridor for ship traffic, officially designated as the Lower Duwamish Waterway (LDW) and the East and West Waterways (located near the river mouth). The LDW spans 5 miles from the southern tip of Harbor Island to just upstream of the Turning Basin.

The upper reach of the LDW extends from a bridge on South 102nd Street at the southern end of the LDW (RM 5) to Duwamish Waterway Park (RM 3) (Figure 1-2). The upper reach includes the Turning Basin (RM 4.6 to RM 4.7) and a federal navigation channel (FNC), both of which are maintained by the U.S. Army Corps of Engineers (USACE). In this reach, the authorized navigation channel width is 150 feet and the authorized depth is -15 feet mean lower low water

(MLLW). The upper reach consists of 132 acres of intertidal and subtidal habitat. The average width of the upper reach is 540 feet.

Comprehensive descriptions of the LDW environmental and physical site characteristics are presented in the *Lower Duwamish Waterway Remedial Investigation Report* (Windward 2010), *Final Feasibility Study, Lower Duwamish Waterway* (AECOM 2012), and the ROD (EPA 2014).

1.4 Selected Remedy Summary

The selected remedy for the LDW is described in Section 13 of the ROD (EPA 2014). It addresses unacceptable human health risks associated with consumption of resident fish and shellfish, and with direct contact (skin contact and incidental ingestion of sediment) from net fishing, clamming, and beach play. It also addresses ecological risks to bottom-dwelling organisms (benthic invertebrates) and wildlife.

Remedial action levels (RALs) are contaminant concentrations that apply in sediment to specific locations and depths on a point-by-point basis (EPA 2014). Per the ROD, RALs are used to delineate areas that require active remediation. These RALs are dependent on the location, elevation type (i.e., intertidal vs. subtidal), Recovery Category, and depth interval in the sediment (e.g., 0 to 10 centimeters [cm]). In the intertidal areas, RALs apply to depth intervals of 0 to 10 cm and 0 to 45 cm. In the subtidal areas, RALs apply to depth intervals of 0 to 10 cm and 0 to 60 cm.[1] Shoal areas[2] within the FNC also have their own set of RALs. ROD Table 28 (included in Appendix A of this report) summarizes the RALs for each of the contaminants of concern (COCs). More information on RALs is presented in Section 2.2.1 of the PDIWP (Appendix C).

Based on RI/FS data, ROD Figure 18 (included in Appendix A of this report) shows the following remedial actions and estimated areas for the upper reach:

- Dredge or partially dredge and cap approximately 25 acres (19% of upper reach) of contaminated sediment.
- Place a thin layer (nominal 6 to 9 inches) of clean material, which may be combined with in situ treatment, on approximately 1.4 acres (1% of upper reach) of sediment in areas that meet the criteria for enhanced natural recovery (ENR).

[1] Subtidal RALs applicable to the 0- to 60-cm depth are dependent on Recovery Category designation and potential tug scour areas (see ROD Table 28 [included in Appendix A of this report] for additional details).
[2] Shoaled areas are defined as areas within the FNC with sediment accumulations above the authorized navigation depth.

- Apply location-specific cleanup technologies to approximately 0.2 acre (0.1% of upper reach) of contaminated sediment in the underpier area of Slip 6 and any other areas with structural or access restrictions (e.g., underpier areas and in the vicinity of dolphins/pilings, bulkheads, and riprapped or engineered banks). The underpier area of Slip 6 is assigned a cap on ROD Figure 18 (Appendix A).
- Implement monitored natural recovery (MNR) in approximately 88 acres of sediment:
  - **MNR Above Benthic Sediment Cleanup Objectives (SCOs):** Surface sediment contaminant concentrations are greater than benthic SCOs but below RALs in approximately 5.8 acres (4.4% of upper reach).
  - **MNR Below Benthic SCO:** Surface sediment contaminant concentrations are already below the benthic SCO in approximately 80 acres (61% of upper reach).

Early action areas (EAAs) comprise the remaining 19 acres (14%) in the upper reach and were identified for early cleanup actions during the RI phase to accelerate cleanup and hence reduce risks of exposure. The EAAs in the upper reach are detailed in Section 2.3.1.

The estimates of areas, volumes, and remedial construction time frame for the selected remedy are based on RI/FS data and analyses and other information included in the ROD (EPA 2014). These estimates will be refined during RD, based on area-specific pre-design investigations (PDIs), engineering analyses, updated Recovery Category assignments, and remedial technology assignment methodology identified on ROD Figures 19 through 23[3] (included in Appendix A of this report).

1.5 General Approach to Contracting, Construction, Operation, Maintenance, and Monitoring for the Upper Reach

This section briefly describes options for remedy construction procurement; construction; and operation, maintenance, and monitoring with details to be developed during RD. Contracting for implementing the upper reach remedial action will be undertaken by an entity to be determined, which is referred to as the “implementing entity” in this document.

1.5.1 Contracting

The implementing entity will establish contractor selection criteria. The implementing entity will also develop its preferred contracting approach, including number of contracts, breakdown of work between contracts (if multiple contracts are used), insurance and bonding requirements,

[3] ROD Figure 19 and Figure 20 (as revised in the ROD Errata Correction Memo [EPA 2015]) present design criteria flow diagrams to determine appropriate active cleanup technologies to be applied to intertidal and subtidal areas, respectively. ROD Figure 21 presents the design criteria flow diagram to apply MNR in areas that are not subject to active remediation. ROD Figures 22 and 23 list the RALs and applicable depth intervals for intertidal and subtidal areas, respectively.

and contract administration processes. The design to be developed under this RDWP is assumed to be implemented using a design-bid-build project delivery method; however, that approach may be reevaluated during or after the RD is completed. LDWG, or the implementing entity, will coordinate with EPA on any anticipated changes to the project delivery method.

1.5.2 Construction

Remedial construction of the upper reach will proceed following source control sufficiency determinations, as described further in Section 4.12. In-water construction activities will occur during fish windows designated for the LDW (generally from October through February) to protect threatened or endangered species under the Endangered Species Act. Remedial construction for the upper reach may span over multiple seasons, as defined by the fish windows.

The implementing entity will provide overall quality assurance (QA) of remedial action construction. The implementing entity will execute the Construction Quality Assurance Plan (CQAP), which will be developed during RD consistent with the requirements of AOC4 SOW Section 5.10(b) (EPA 2018). The CQAP will describe QA activities that the implementing entity will perform before, during, and after construction. These QA requirements will include construction administration, on-site inspection, environmental monitoring, sediment confirmatory sampling, and communication or coordination with EPA.

The selected construction contractor will be responsible for providing quality control of its work. The bid document specifications will identify pre-construction and construction submittals that must be prepared by the contractor, and contractor quality control requirements during construction. Anticipated pre-construction and construction submittals that the selected construction contractor will be required to prepare are described in Section 3.10.

1.5.3 Maintenance and Monitoring, and Institutional Controls

The purpose of the Long-Term Maintenance and Monitoring Plan (LTMMP) is to ascertain attainment of cleanup levels and compliance with applicable or relevant and appropriate requirements (ARARs), to protect the integrity of the remedial actions, and to aid in the evaluation of source control effectiveness. The final LTMMP will describe details of long-term monitoring and maintenance, including performance standards; sampling type, density, and frequency; interim benchmarks; and associated follow-up actions, as well as maintenance of remedy elements such as caps and ENR areas.

The LTMMP will be developed in accordance with *Guidance for Management of Superfund Remedies in Post Construction* (EPA 2017). The LTMMP will include both LDW-wide monitoring elements as well as elements specific to the remedy in the upper reach, such as specific monitoring requirements for caps, ENR, and MNR areas. It is expected that the LTMMP will be amended to include specific requirements for the middle and lower reaches following their construction. Per the AOC4 SOW (EPA 2018), the Preliminary (30%) RD shall develop an outline of the LTMMP and the Pre-Final (90%) RD shall develop an annotated outline. The LTMMP will remain as an annotated outline in the Final (100%) RD. The implementing entity will complete and implement the LTMMP after construction is completed.

An annotated outline of a Sediment Remedy Institutional Controls Implementation and Assurance Plan (Sediment Remedy ICIAP) will also be developed in conjunction with the LTMMP per AOC4 SOW (EPA 2018). The final Sediment Remedy ICIAP will identify the institutional controls necessary for the physical remedial actions. The Sediment Remedy ICIAP will include an evaluation of the most appropriate institutional, proprietary controls and location-specific use restrictions needed to ensure long-term effectiveness of the remedial action, consistent with Section 13.2.4 of the ROD (EPA 2014).

The Sediment Remedy ICIAP will be developed in accordance with *Institutional Controls: A Guide to Planning, Implementing, Maintaining, and Enforcing Institutional Controls at Contaminated Sites* (EPA 2012a) and *Institutional Controls: A Guide to Preparing Institutional Controls Implementation and Assurance Plans at Contaminated Sites* (EPA 2012b). For the protection of risks to human health from seafood consumption, EPA and Public Health Seattle-King County established a community-based Healthy Seafood Consumption Institutional Control Program for the LDW Superfund Site (*US EPA's Institutional Control Implementation and Assurance Plan [ICIAP] for Seafood Consumption at the Lower Duwamish Waterway [LDW] Superfund Site* [Public Health Seattle and King County 2019]*)*. To avoid redundancy, the Seafood Consumption ICIAP will refer to the Institutional Control Program for institutional controls related to human health risks from seafood consumption.

Like the LTMMP, the Sediment Remedy ICIAP annotated outline will be developed for the entire LDW and will provide additional detail related to the upper reach remedial actions. The Sediment Remedy ICIAP will be updated with information for the other reaches following design of those reaches.

Per AOC4 requirements, the Preliminary (30%) RD will prepare an outline of the Sediment Remedy ICIAP; Final (100%) RD will prepare an annotated outline of the Sediment Remedy ICIAP. The implementing entity will complete and implement the Sediment Remedy ICIAP after construction is completed.

1.6 Remedial Design Project Management

1.6.1 Agency Oversight and Stakeholder Process

EPA will provide oversight for the RD process; USACE is EPA's technical advisor. Ecology and LDW stakeholders will review RD progress and provide input in accordance with the review process established by EPA. In general, this process involves LDWG submitting draft deliverables to EPA, who obtains stakeholder input. LDWG will address EPA comments and will submit revised deliverables to EPA. Figure 1-3 provides a schematic of the agency oversight and stakeholder relationships.

1.6.2 Respondent Team Organization, Responsibilities, and Authorities

Anchor QEA, LLC (Anchor QEA) is coordinating activities for LDWG, managing the team of subcontractors, and leading the RD for the upper reach of the LDW. Windward Environmental is leading the pre-design investigation, database management, and development of monitoring plans. Bright Engineering is leading structural and civil engineering support activities, and Long Bay Enterprises is leading site access and real estate support. The key personnel list is provided in Table 1-1.

Table 1-1
Key Personnel

Title	Name	Firm Name
Project Manager	Tom Wang, PE	Anchor QEA
Project Engineer	John Laplante, PE	Anchor QEA
Remedial Sample Design Lead	Kathy Godtfredsen, PhD	Windward Environmental
Lead Geotechnical Engineer	Matt Woltman, PE, LEG	Anchor QEA
Lead Structural Engineer	Ade Bright, PE, SE	Bright Engineering
Field Lead	Susie McGroddy, PhD	Windward Environmental
Data Management Lead	Kim Goffman	Windward Environmental
Real Estate Lead	Cynthia Berne	Long Bay Enterprises

Other supporting contractors include: ECOSS, a Duwamish River community-based organization that will provide community engagement support and will advise LDWG on equity and social justice opportunities; TerraStat, which will provide statistical analysis support; and Stell Environmental Enterprises, which will provide archaeology support.

1.6.3 Communications

Monthly meetings will be held with EPA. Additional meetings will be scheduled at the request and discretion of EPA. In addition, as LDWG develops information during RD, EPA will present information and receive input through the Community Involvement process, which includes the Roundtable and potentially other public forums. The objective of the Roundtable forum is to discuss and identify ways to mitigate the potential impacts of the cleanup on affected communities, businesses, and waterway users. To address outreach activities during construction, a Community Outreach and Communications Plan will be prepared as part of the Pre-Final (90%) RD.

2 Existing Information Review

This section briefly summarizes site conditions in the upper reach that are relevant to developing the RD, references existing reports where additional information can be found, and reviews how this information will be used during the RD process. This section is based primarily on information developed for the LDW RI (Windward 2010) and FS (AECOM 2012), augmented with recent information in the following documents:

- *Technical Memorandum: Compilation of Existing Data* (Windward and Integral 2018)
- *Lower Duwamish Waterway Surface Sediment Data Report* (Windward 2019a)
- *Baseline Surface Water Data Collection and Chemical Analysis Data Repor*t (Windward 2019b)
- *Lower Duwamish Waterway Baseline Seep Data Report* (Windward 2018a)
- *Lower Duwamish Waterway Fish and Crab Data Report* (Windward 2018b)
- *Lower Duwamish Waterway Clam Data Report* (Windward 2019c)
- *Recovery Category Recommendations Report* (Integral et al. 2019)
- *Design Strategy Recommendations Report* (Integral and Windward 2019)
- *Draft Lower Duwamish Waterway Data Evaluation Report* (Windward 2018c)
- *Year 1 Monitoring Report, Enhanced Natural Recovery/Activated Carbon Pilot Study* (Wood et al. 2019)
- *Waterway User Survey and Assessment of In-Water Structures – Data Report* (Integral et al. 2018)

The chemical data in these reports were not collected for RD purposes.

2.1 Physical Conditions

The physical conditions of the LDW were described in the RI and FS. The sediment transport dynamics were evaluated in the sediment transport model (STM) as documented in *Lower Duwamish Waterway Sediment Transport Analysis Report* (Windward and QEA 2008) and *Lower Duwamish Waterway Sediment Transport Modeling Report* (QEA 2008). This section discusses the following physical site conditions in the upper reach:

- Geology and Hydrogeology
- Geomorphology
- Bathymetry
- Hydrodynamics and Sediment Transport
- Stratigraphy and Geotechnical Characteristics
- Infrastructure
- Banks
- Debris

2.1.1 Geology and Hydrogeology

The complex geology and hydrogeology of the Duwamish River basin are discussed in RI Section 2.5 and summarized in FS Section 2.1.3. The Duwamish River valley can be generally described as a glacial trough filled with alluvial deposits to a depth of as much as 200 feet below ground surface (FS Figure 2-3 [included in Appendix B of this report]). These deposits are underlain by either the bedrock unit or dense glacial deposits and non-glacial sedimentary deposits.

Within the LDW, native alluvium layers (consisting of sand, silt, gravel, and cobbles in the upper alluvium) are overlain by recently deposited organic sand and silt from upstream and lateral sources. The chemical characteristics of recently deposited sediment are discussed in Section 2.2 of this report. The physical properties of recently deposited sediment are summarized in RI Sections 2.5.4 and 2.5.5.

The groundwater system in the Duwamish River valley is described in RI Section 2.5.6. Native alluvium layers form the principal aquifer and groundwater pathway for the Duwamish River basin, and groundwater flow rates and gradients vary greatly. Groundwater flow near the LDW is generally toward the LDW; however, high tides cause temporary groundwater flow reversals close to the waterway. Areas subject to tidal influence are generally within 330 feet to 500 feet of the LDW bank (Booth and Herman 1998). Vertical flow gradients (both upward and downward) near the LDW develop from the complex interactions between groundwater, soil stratigraphy, infiltration of rainwater, and infiltration of tidally influenced LDW surface water (including higher density brackish water). Where downward gradients intersect with upward gradients, the interaction has the potential to cause shallower groundwater to flow toward the LDW and discharge as seeps in the intertidal zone (RI Section 2.5.6.1).

During RD, hydrogeology information will be used in the following ways:

- RD capping design will consider advection of groundwater through areas that will receive a cap, similar to previous analyses performed within the LDW for EAAs. The rate of advection will be determined based on available data on the groundwater aquifer in the Duwamish River basin.
- RD will use local hydrogeologic data to select inputs to slope stability analyses.

2.1.2 Geomorphology

As described in RI Section 2.2 and FS Section 2.1.3, the LDW historically was a naturally meandering estuary that was extensively modified over the past 100 years or longer to straighten the waterway for navigation purposes by dredging and filling. Tide flats and floodplains were filled to straighten the river channel and to create upland areas for development, resulting in the abandonment of almost 3.7 miles of the original meandering river bed. Current side slips in the LDW are remnants of these old river meanders.

The current configuration, established in the early 1900s, consists of the FNC and Turning Basin, off-channel intertidal benches and banks, slips, and numerous berthing areas along the banks. The FNC has been frequently dredged for navigational purposes. Material excavated during dredging events to straighten and deepen the FNC in the early 1900s was used to fill the old meanders and the lowlands to bring them up to elevations similar to those of the surrounding uplands. Subsequent filling of the lowlands for continued development resulted in a surficial layer of fill in the vicinity of the LDW. The current shoreline includes armored banks, unarmored banks, dock faces, and vertical bulkheads (Figure 2-1).

Information on the geomorphology of the upper reach will be used during RD in the following way:

- Bank erosion potential will be considered as part of recontamination evaluations and to inform the need to collect bank samples to characterize chemical concentrations on the bank.

2.1.3 Bathymetry

Approximately 55 acres of the upper reach are considered intertidal, with bed elevations between 11.3 feet MLLW (equivalent to mean higher high water [MHHW]) and -4 feet MLLW (Table 2-1). Approximately 76 acres of the upper reach are considered subtidal, with bed elevations below -4 feet MLLW. A 2019 bathymetric survey has been performed as part of RD for the upper reach, and thus these acreages will be updated once the new bathymetric data are available. These acreages are based on 2003 bathymetric survey elevations of the LDW as shown in Figure 2-2. Within the subtidal area of the upper reach, the FNC comprises 32 acres and is authorized to -15 feet MLLW.

Table 2-1
Overview of Areas Depicted in the ROD in the Upper Reach (RMs 3.0 to 5.0)

Area Designation	Upper Reach (Excluding EAAs) (acres)	EAAs (acres)[a]	Total (acres)
Total Area	**112**	**19**	**132**
Bathymetric Elevations[b]			
Intertidal	44	11	55
Subtidal	68	8	76
Areas of Interest for Site Use, Sediment Exposure, and Engineering Design (Areas May Overlap)			
Beach Play	23	0	23
Potential Clamming	37	11	48
Federal Navigation Channel	29	2.8	32
Berthing Areas	3.7	0	3.7
Under Pier	0.6	0	0.6
Recovery Categories[c]			
Category 1	32	N/A	
Category 2	11		
Category 3	61		
Not designated	9.6		
Total	112		
Preliminary Remedial Technology Assignments[d]			
Dredge	22	N/A	
Partial Dredge and Cap	2.9		
Cap	0.2		
ENR/in situ	1.4		
MNR > SCO	5.8		
MNR < SCO	80		
Total	112		

Notes:
Areas are rounded for presentation.
a. EAAs have been adjusted from the areas depicted in the ROD based on as-built reports for Boeing Plant 2 and Terminal 117.
b. Based on the 2003 bathymetric survey; will be adjusted during RD.
c. Recovery Category areas have been adjusted slightly from the *Recovery Category Recommendations Report* (Integral et al. 2019) to reflect EAA boundary adjustments described in note a. Recovery Category boundaries will be adjusted during RD based on criteria in the ROD. As noted in the ROD, the area of the LDW upstream of RM 4.75 (but not part of the EAAs) was not assigned to one of the three Recovery Categories because it is upstream of the area represented by the sediment transport model. This area is listed in the table as a Not Designated area equal to 9.6 acres.
d. Preliminary technology assignment areas have been adjusted slightly from the ROD to reflect EAA boundary adjustments described in note a. Remedial technology areas will be adjusted during RD based on criteria in the ROD.

Bathymetric information will be used in RD in the following ways:

- Evidence of scour will be evaluated using high-definition survey images (i.e., sun-illumination maps). This information will be used to evaluate whether refinements to Recovery Category designations are needed.
- The deepest historical dredging within the FNC will be evaluated using available historical dredging bathymetric records. This information will be considered in estimating the maximum potential vertical extent of contaminated sediment and selecting core intervals for analyses where vertical extent is to be determined in the PDI.
- Bathymetric information of current conditions is used to determine the appropriate RAL. The applicable RAL depends upon the bathymetric elevation of a remedial action area (see ROD Table 28; Figure 2 of the PDIWP [Appendix C]) as follows:
  - Intertidal areas (defined as above -4 feet MLLW) have different RALs and vertical points of compliance than subtidal areas.
  - The ROD defines "potential tug scour areas" as between -4 feet MLLW and -18 feet MLLW[4]; these areas have a subsurface RAL for polychlorinated biphenyls (PCBs) in Recovery Category 2/3 areas.
  - Shoaled areas of the FNC (i.e., areas shallower than the authorized FNC elevation of -15 feet MLLW) have RALs that apply to sediments above the authorized FNC elevation plus 2 feet of overdredge (i.e., sediment above -17 feet MLLW in the upper reach).
- The remedial technology selection and design will be informed by current condition bathymetric elevations as follows:
  - Material placement must leave sufficient clearance in the FNC and berthing areas for vessels and future maintenance dredging.
  - Dredging and capping will be designed to minimize changes in upper reach net habitat areas including the following: 1) the net aquatic area (i.e., the surface area below MHHW); and 2) the net areas of elevation bands of most value for habitat, such as lower intertidal and shallow subtidal elevation ranges.
- Slopes where active remediation is occurring will be evaluated for stability.

[4] Per Table 28 of ROD, the -18 feet MLLW applies south of the 1st Avenue South Bridge.

2.1.4 Hydrodynamics and Sediment Transport

The hydrodynamics and sediment transport of the LDW (summarized in RI Section 2.6 and FS Section 2.1.3) were modeled during development of the STM.

The upper reach is an estuary environment, with freshwater entering from the Green/Duwamish River system and saltwater originating from Puget Sound. The location of the interface between freshwater and marine layer flows, referred to as the saltwater wedge, is variable within the upper reach depending upon both river flow and tidal stage. During times of high river flow and low tide stages, the saltwater wedge does not enter the upper reach, whereas during low-flow conditions and high tide stages, the saltwater wedge can extend upstream of the upper reach. The upstream location or "toe" of the saltwater wedge is typically located between Slip 4 (RM 2.8) and the Turning Basin (RM 4.7).

River bottom velocities vary greatly within the upper reach depending upon the river flow rate and the presence or absence of the saltwater wedge at a given location and time. The saltwater wedge tends to reduce flow velocities near the river bottom because the less dense freshwater of the river will flow on top of the saltwater wedge; therefore, river bottom velocities are higher when the saltwater wedge is downstream of the upper reach. Additional detail on the hydrodynamics of the LDW is available in the recent University of Washington study (Horner-Devine et al. 2017), which suggests that the salt wedge can extend upstream of the Turning Basin (RM 4.7) higher than previously modeled, depending on tides and river discharge. Future sea level rise will affect the upstream extent of the salt wedge. The potential change to the upstream extent of the salt wedge does not change the physical conceptual site model (Section 5) and will not affect the remedial design; design criteria will be based on high flow and high-velocity events.

Based on the STM, approximately 220,000 metric tons of upstream sediment and 1,100 metric tons of sediment from lateral loads enter the LDW annually (Figure 2-3). Approximately 81,000 metric tons of the sediment is deposited between RM 4.0 and RM 4.9 where the water velocity is reduced due to the widening and deepening of the LDW (i.e., the Turning Basin and the FNC) compared to upstream. The STM values cited in the text are based on estimates developed during the RI/FS process, which included an uncertainty and sensitivity analysis. STM bounding runs conducted during that process included runs with upstream sediment inputs similar to the new, lower estimates for upstream loads produced by the U.S. Geological Survey (Senter et al. 2018).

A further assessment of the effects of differences in upstream inputs was conducted (*Effects of Changes in Estimated Upstream Sediment Load on Lower Duwamish Waterway Sediment Transport Modeling*; *Recovery Category Recommendations Report* - Appendix A [Integral et al. 2019]). Because the STM is calibrated to empirically measured sedimentation rates, the lower estimate of sediment load entering the LDW from upstream made by the U.S. Geological Survey resulted in only small changes to the STM-modeled sedimentation rates within most of the LDW. Therefore, consistent with the conclusions of the Appendix A memorandum (Integral et al. 2019), the STM sedimentation rate values from the RI/FS process have been retained for use in RD.

The STM scour depth is based on a 100-year high-flow event. Modeling analyses have shown that a 500-year high-flow event results in scour depths similar to the 100-year flow event because of morphological characteristics upstream of the LDW and flow regulation by the Howard Hanson Dam.

Hydrodynamics and sediment transport information will be used in RD in the following ways:

- Capping design will use predicted maximum river flow velocities generated by the hydrodynamic model to develop cap design criteria (along with other currents and wave conditions such as propeller wash [propwash] and wakes).
- The STM 100-year scour predictions and estimated net sedimentation rates were used to define Recovery Category areas, which inform the technology selection based on ROD Section 13.2.

2.1.5 Stratigraphy and Geotechnical Characteristics

As described in Section 2.1.1, the Duwamish River valley is generally a trough filled with alluvial deposits; the upper horizons of these have been dredged and filled in the current waterway configuration. The LDW is a net depositional environment, with organic-rich, soft, recent sediment deposited on native alluvium. The effects of contaminant releases, when present, are observable in these soft, recent sediments deposited in the LDW after industrial development. Therefore, the depth to the top of native alluvium represents the maximum potential vertical extent of contamination (see FS Figure 2-3 [included in Appendix B of this report]). This assumes no subsurface (i.e., groundwater) source of contamination, consistent with RI conclusions (e.g., RI Section 9.4.6 and *Quality Assurance Project Plan: Porewater Sampling of the Lower Duwamish Waterway* [Windward 2005]).

Limited geotechnical data characterizing the LDW sediments are summarized in FS Section 2.6.2. Sediment composition varies throughout the LDW, ranging from sand to mud (fine-grained silt and clay) with varying amounts of organic material, depending on the source of the sediments and the local current velocity. Silt with varying amounts of organic material is the dominant sediment type in much of the LDW main channel and in the slips. A mixture of silt and sand dominates the subsurface sediment upstream of the Turning Basin.

The stratigraphy and geotechnical properties of recent sediment (deposited after development of the LDW) will be used in the following ways:

- In the PDI, sediment cores in potential dredging areas will identify the thickness of sediment units below mudline. In potential dredging areas, the depth to the top of the native alluvium layer in previously collected cores or observed in the field will help to inform the vertical elevation to analyze core samples during PDI Phase II.
- In the PDI, for banks with known or suspected contaminated sediment, the thickness of soft sediment deposited over the existing riprap layer on armored banks will be evaluated to help define the potential extents and quantities of contaminated sediment overlying riprap-armored banks.
- The Basis of Design Report (BODR) will describe the geotechnical properties of the sediment layers to identify stable slope angles that can be achieved during dredging and capping remedial action.
- The compressibility and shear strength of soft sediment will be evaluated in PDI Phase II to develop specifications for placement activities (e.g., capping, ENR, residuals management cover [RMC]) to account for potential compaction or bearing strength failure of the substrate during placement.
- Bank caps will be designed to be statically stable and will be evaluated for seismic risk.
- Geotechnical properties such as density and shear strength will be used to evaluate the ease with which sediment can be dredged with standard equipment.

2.1.6 Infrastructure

Existing infrastructure located within the upper reach was described in the FS (Section 2.6), and additional information on in-water structures has been summarized in *Waterway User Survey and Assessment of In-Water Structures – Data Report* (Integral et al. 2018). As shown in Figure 2-4, infrastructure includes waterfront facility berthing, overwater structures (e.g., piers, docks, floats, bridges, flow diversion structures, covered boat slips), piling (e.g., erosion control structures, fendering, mooring piles), bridges, and utilities (e.g., underwater cables and pipe structures, overwater cables, storm drains [SDs], outfalls). Where outfalls or pipes with unknown origins are present in areas with active remediation or MNR to benthic SCO, additional information will be acquired and included in the RD documents. In addition, bank infrastructure includes armored banks and bulkheads (Figure 2-1). RD will take into account, and will not preclude, reasonably anticipated future land uses.

Infrastructure is assumed to remain intact during PDI. During RD, any changes to infrastructure will be tracked through coordination with waterway users (see Section 4.11). During RD, the location, condition, and type of infrastructure will be considered for the following purposes:

- Potential impacts to existing infrastructure from remedial actions will be evaluated (e.g., considering stability of structures and banks adjacent to dredging or capping areas).
- Protective setback distances from existing structures and other protective measures will be determined to prevent adverse impacts.
- Remedial technologies that can be effectively used adjacent to existing infrastructure will be determined through assessing constructability (e.g., considering equipment access constraints) and equipment capabilities during RD.
- Costs of protective measures versus demolition and replacing in-kind will be evaluated if appropriate. This is a standard practice of design, is an iterative process (beginning as early as the Preliminary [30%] RD step), and is incorporated into the next design draft after it is conducted.
- Potential impacts of remedial action on maintenance, repair, or replacement of existing infrastructure.

2.1.7 Banks

LDW upper reach banks are defined as the transition area from the LDW subtidal or intertidal bed to the upland areas above MHHW. The banks are typically delineated as starting at the toe, where the relatively flat waterway bed (which will vary in elevation) begins to steeply slope to the top of bank (i.e., area where the slope flattens in the upland and is located above MHHW). The toe of banks can significantly vary in elevation because banks may be adjacent to berthing or navigation areas (with toe of bank elevation controlled by navigation needs) or banks may be adjacent to intertidal mudflats.

Bank conditions in the LDW have been characterized by Ecology (summarized in FS Section 2.6.3), and complemented by recent sampling by LDWG at Ecology's request. The upper reach includes 2.7 miles of armored banks, 1.6 miles of unarmored banks, 0.7 mile of dock faces, and 0.6 mile of vertical bulkheads (Figure 2-1). For RD purposes, armored banks are defined as bank areas that have an engineered surface armoring (e.g., riprap armoring, gabion armoring, bulkhead [sheetpile, concrete]) to prevent bank erosion. Banks that have no armoring or that consist of poorly placed or maintained armoring such that significant gaps in armoring exist (e.g., banks with intermittently exposed soil) will be considered to be unarmored banks. The RD will investigate upper reach bank areas during the Phase II PDI that are adjacent to active remedial action areas delineated through the PDI Phase I data evaluation. During Phase II PDI, the RD may need to investigate upper reach bank areas that have evidence of erosion (as identified through the PDI Phase I data evaluation) and that have evidence that the area may be a potential source. During the RD, bank information will be used in the following ways:

- Bank conditions (e.g., armored vs. unarmored) adjacent to active remedial action areas will be factored into RD. For example, dredging and capping design will need to account for existing armored and unarmored banks to maintain bank stability by considering appropriate construction offsets or bank redesign requirements.
- For applicable bank areas adjacent to active remedial action areas or that may be a potential source of contamination to LDW, banks will be evaluated for geotechnical stability and potential for erosion. Eroding banks adjacent to active remedial areas will be evaluated as potential sources. Eroding banks that are not source material and not above RALs will not be addressed by the RD. The source evaluation will consider chemistry data (historical and PDI data), bank physical conditions (e.g., visible erosion, oversteepening or undercutting), and the presence and condition of bank armoring, in coordination with EPA and Ecology (see Section 4.12).
- If a bank area is contiguous to an area of sediment RAL exceedances and/or is identified as a potential source, additional coordination with EPA and Ecology will be required during the Preliminary (30%) and Intermediate (60%) RD stages to inform the sediment and bank remedial design plan, in conjunction with potential upland cleanup actions.[5] Following PDI Phase I data evaluation, additional bank characterization may be required in bank areas. Bank areas with RAL exceedances below MHHW will be part of the RD plan; bank contamination above MHHW will be identified as potential sources.
- Sedimentation on bank riprap armor occurs mostly from natural river processes, including ongoing deposition and/or scour during various flow events, and may also have contribution from lateral discharges and suspended sediments from vessel propwash. In remedial action areas, the thickness of soft sediment over existing riprap used to armor banks will be evaluated to help define the potential extents and quantities of contaminated sediment overlying riprap-armored banks in PDI Phase II, using jet-probing or coring as appropriate.

[5] In accordance with the *Memorandum of Agreement* (MOA; EPA and Ecology 2014), EPA and Ecology will coordinate before initiating active in-waterway cleanup to ensure that sources have been sufficiently controlled. In addition, the MOA states as follows:
- EPA intends to provide Ecology with the baseline monitoring data and remedial design data required by the ROD for the area targeted for active in-waterway sediment remediation activities at least six months prior to the anticipated date that a source control sufficiency evaluation and recommendation is needed.
- Ecology will coordinate with EPA in preparing source control sufficiency evaluations for areas targeted for active in-waterway sediment cleanup activities and will submit associated recommendations to EPA for its concurrence.

- To inform RD (such as volume calculations, excavation, backfilling, and armoring design), topographic surveys will be performed on bank areas that are determined to require active remedial action or other actions that may be needed to support remedial activities (e.g., habitat mitigation, site access or staging areas, potential source locations if applicable). The PDI Phase I (and potentially Phase II) Data Evaluation Report will identify bank topographic characterization needs in coordination with EPA and will identify appropriate topographic data collection methods.

2.1.8 Debris

The presence of debris within the LDW was discussed in FS Section 2.6.1.3. Debris is common in industrial waterways such as the LDW, deposited over decades of waterway use. Submerged and emergent debris will impact the implementation of remedial technologies. For example, larger debris (larger than 1 meter in size) or significant quantities of debris can reduce mechanical dredging production rates and increase dredge residuals.

As with many industrial waterways, much of the debris in the LDW is likely to be beneath the mudline and may or may not be visible or detectable at the surface. While it is not possible or necessary to fully inventory all debris, efforts are made in RD to identify observable large debris, and the specifications will require the contractor to be prepared to manage debris in any location. Identifying debris during RD will be accomplished using the following methods:

- The bathymetric survey will be used to identify potential near-surface debris. Debris on the order of a meter in size can typically be seen in high-resolution bathymetric surveys.
- Visual debris surveys of intertidal areas will be conducted at low tide in active remediation areas during PDI (Phase II).
- Focused debris surveys (e.g., side scan sonar, diver inspection survey) may be conducted (if determined to be needed) in dredging and capping areas during PDI (Phase II or III). Site history will be reviewed to identify areas with potential subsurface obstructions (e.g., pile stubs).

Debris will be factored into the RD and remedial action in the following ways:

- The quantity, type, and size of observed debris will inform remedial equipment selection or design details.
- To the extent available, debris characterization information will be included in the bid document plans and specifications to inform the selected contractor about site conditions and guide the contractor’s selection of construction equipment.

- The contractor's Remedial Action Work Plan (RAWP) will develop an approach to remove and manage debris encountered during construction, with the expectation that debris may be encountered anywhere and equipment shall be capable of managing it.

2.1.9 Dredged Areas in the LDW Upper Reach

Maintenance dredging has been performed in the FNC and in select berth/marina areas within the upper reach. PDIWP Map 17 depicts locations where dredging events since 1992 have been completed.

2.2 Sediment Chemistry Information

Existing sediment chemistry data have been summarized in the RI, FS, and in recent RD relevant data reports listed in Section 2. In addition, an evaluation of existing chemistry data is included in the PDIWP (Appendix C).

Additional sediment chemistry data will be collected in PDI Phases I and II (and Phase III if needed). Sediment chemistry data are the key part of RD, as discussed further in Section 3, and will be used for the following purposes:

- Establishing horizontal extents of contamination (i.e., areas exceeding RALs; Section 3.3)
- Evaluating contaminant trends in the surface sediment and shallow subsurface sediment as a line of evidence to evaluate Recovery Category designations (Section 3.4)
- Applying remedial technologies (i.e., delineating areas exceeding technology-specific upper limit concentrations such as those for ENR; Section 3.5)
- Establishing vertical extents of contamination (i.e., the depth of RAL exceedances) in dredging areas (Section 3.7.1)
- Developing dredge prisms (Section 3.7.1)
- Performing predictive modeling to assess long-term sediment cap effectiveness (Section 3.7.2)

2.3 Previous and Ongoing Remedial Investigations and Actions

This section describes how lessons learned from previous and ongoing investigations and actions will be considered during RD, focusing on early actions in the LDW, the ENR/AC pilot study being performed under AOC2, and upland contaminated sites along the LDW shoreline. During RD, previous actions and existing remedies within the upper reach will be considered to ensure that implementation does not compromise the integrity of completed or ongoing studies or remedial actions.

2.3.1 Early Action Areas

Six EAA remedial actions have been performed in the LDW, including from south to north: Norfolk EAA, Boeing Plant 2 EAA, Jorgensen Forge EAA, Terminal 117 (T-117) EAA, Slip 4 EAA, and Duwamish/Diagonal EAA. As shown on Figure 2-5, four of these EAAs are located within the upper reach (Norfolk EAA, Boeing Plant 2 EAA, Jorgensen Forge EAA, and T-117 EAA), and the lessons learned from these early actions will be integrated into the RD. In addition to providing locations of the EAAs, Figure 2-5 also provides known locations of Resource Conservation and Recovery Act (RCRA) and MTCA cleanup sites adjacent to the boundary of the upper reach of the LDW.

The EAAs were implemented by different entities using different remedial technologies. The following sections summarize each EAA.

2.3.1.1 Norfolk

The Norfolk EAA is located next to the Boeing Developmental Center, upstream of the Turning Basin at RM 4.9 east bank (E). It was identified as a cleanup area by the Elliott Bay/Duwamish Restoration Program (EBDRP) because of sediment contamination associated with a City of Seattle SD and King County combined sewer overflow (CSO). In 1999, King County dredged 1 acre of contaminated sediment and backfilled the area with clean material. Monitoring post-construction continued annually through 2004.[6] Long-term monitoring was completed in 2004.

In addition, in 2003, Boeing removed sediment from the LDW offshore of the Boeing Developmental Center south outfall (Boeing South), adjacent to the Norfolk EAA, as part of Ecology's Voluntary Cleanup Program (Ecology and Leidos 2018).

2.3.1.2 Jorgensen Forge

Jorgensen Forge is a steel and aluminum forging and distribution facility located south (upstream) of Boeing Plant 2 at RM 3.7E. Originally developed in 1942 by the Navy, the property has had several owners over 70 years. Earle M. Jorgensen (previous owner and operator of the facility until 1992) conducted removal of 1.6 acres of contaminated bank and sediments in the Jorgensen Forge EAA followed by backfilling with clean material in 2014. Additional remedial investigations and studies (i.e., Supplemental Engineering Evaluation/Cost Analysis) are ongoing. Jorgensen Forge is also the name of an upland site being investigated under an MTCA Administrative Order.

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[6] Closure reports and post-closure monitoring reports (through 5 years post-construction) can be found on the King County Wastewater Treatment Division's Sediment Management website available at: https://www.kingcounty.gov/services/environment/wastewater/sediment-management/projects/Norfolk.aspx.

2.3.1.3 Boeing Plant 2

Boeing Plant 2 is located on the east side of the LDW (RM 2.9E to RM 3.6E). Boeing built Plant 2 along the LDW in the late 1930s to manufacture military aircraft for the U.S. Government. Boeing remediated by dredging and backfilling with clean material over 18 acres of contaminated sediment between 2012 and 2015 and restored nearly 1 mile of fish and wildlife habitat in 2013.[7] Long-term monitoring of the Boeing Plant 2 EAA is ongoing. Boeing Plant 2 is also an upland cleanup site with previously performed and planned remedial actions.

2.3.1.4 Terminal 117

T-117 is a former asphalt shingle manufacturing facility located in Seattle's South Park neighborhood on the river's west bank (RM 3.6 west bank [W]). From 2012 to 2015, the Port of Seattle and City of Seattle remediated by dredging and backfilling with clean material for 1.4 acres of contaminated sediment from the bank and mudflat. Upland excavation was also a component of the cleanup.[8] Long-term monitoring of the T-117 EAA is ongoing.

2.3.1.5 Slip 4

Slip 4 is a 6.4-acre navigational slip on the east side of the river just downstream of the upper reach (RM 2.8W). For many years, nearby industries used Slip 4 as a berthing area for vessels and for various industrial activities, and SDs and emergency sewer overflows[9] were historically routed into the water here. Between October 2011 and February 2012, the City of Seattle removed contaminated sediment, capped with clean material, and restored wildlife and fish habitat.[10] Long-term monitoring of the Slip 4 EAA is ongoing.

2.3.1.6 Duwamish/Diagonal

The Duwamish/Diagonal EAA is located on the river's east bank, a half-mile south of Harbor Island and downstream of the upper reach (RM 0.4E to RM 0.6E). It was identified as a cleanup area by EBDRP because of sediment contamination associated with City of Seattle SDs and CSOs, a King County CSO, and a former sewage treatment plant outfall. Between 2003 and 2004, King County implemented a cleanup, restoring 7 acres of habitat for salmon and other species by removing contaminated sediment and capping remaining contamination. In addition, a clean

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[7] Additional information on the Boeing Plant 2 cleanup can be found on the EPA's website available at: https://www.epa.gov/hwcorrectiveactionsites/hazardous-waste-cleanup-boeing-plant-2-tukwila-washington.

[8] Project documents and construction summaries can be found on the T-117 cleanup page available at: http://www.t117.com/.

[9] In contrast to a CSO, an emergency sewer overflow is an overflow point that only relieves the system if there is a mechanical failure and rarely or never discharges.

[10] Additional project information can be found in the *Slip 4 Early Action Area Removal Action Completion Report* (Integral 2012).

sand layer was added over 4 acres in 2005 to address dredge residuals. The remediation area and a perimeter area were monitored post-construction annually through 2010.[11]

2.3.2 Enhanced Natural Recovery/Activated Carbon Pilot Study

In 2015, LDWG initiated the ENR/AC pilot study to determine whether ENR material amended with AC can be successfully applied to reduce the bioavailability of PCBs in contaminated sediments in the LDW. The study was designed to compare the effectiveness of ENR with added AC compared to ENR without added AC in three areas in the LDW (intertidal plot, subtidal plot, and scour plot), as shown in Figure 2-5. Project construction was completed in January 2017 (Amec et al. 2018), and monitoring results for post-construction and Year 1 have been generated to date (Wood et al. 2019). One of the three plots, the intertidal plot, is within the upper reach at RM 3.9E.

The Year 2 and 3 pilot study monitoring results will be available in late 2019 and late 2020, respectively. Pilot study results will inform the selection of technology assignments and the potential in situ treatment design, consistent with the ROD (Section 13.2.1.2). The pilot study plots are anticipated to become part of site-wide monitoring after pilot study monitoring is completed. If additional work is needed after the pilot study is completed, RD will address the pilot study areas.

2.3.3 Lessons Learned

The lessons learned from the EAAs and the ENR/AC pilot study (construction only) are summarized based on project documentation and discussions with personnel involved in the work (Table 2-2). The Removal Action Completion Reports for Jorgensen Forge and Slip 4 (Anchor QEA 2016; Integral 2012) both contained well-organized lessons learned sections. For the other EAAs (Norfolk, Boeing Plant 2, T-117, and Duwamish/Diagonal), key lessons learned were culled from pertinent sections of construction reports. Lessons learned from the ENR/AC pilot study construction activities can be found in the Pilot Study Construction Completion Report (Amec et al. 2018).

To be useful in the context of this RDWP, the lessons learned for the EAAs and other similar sediment remediation projects in the LDW have been distilled into common themes that are considered applicable to future cleanup in the LDW (Table 2-2). These lessons learned are also similar to experiences at other sediment cleanup sites located outside of the LDW (i.e., Puget Sound and national sediment remediation projects). Key lessons learned from the EAAs and other similar sediment remediation projects will be incorporated into the RD.

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[11] Additional information can be found on King County Wastewater Treatment Division's Sediment Management website available at: https://kingcounty.gov/services/environment/wastewater/sediment-management/projects/DuDi.aspx.

Table 2-2
Summary of Early Action Areas, ENR/AC Pilot, and Other Sediment Remediation Site Lessons Learned

Topic	Lesson Learned	Recommendations for Consideration
Communications	Early and frequent communication between the implementing entity, EPA, the contractor, the community, Tribes, and property owners and tenants is critical to project success.	The EAAs report a number of successes in early and continuing communications. Core recommendations include the following: • Engage stakeholders during all project stages. • Develop communications plans. • Understand community concerns. • Perform frequent outreach. • Provide multiple outlets of communication. • Hold structured meetings (e.g., during construction). • Have identified contacts for issues that arise. • Perform early coordination to plan for construction challenges.
Affected Users and Site Access	Negotiations for site access, business disruption, alternative facilities, and Tribal fishing disruption are costly, complex, and time consuming, and the requirements must be integrated into the RD.	• Initiate access negotiations early (e.g., after 60% design). • Include access costs in cost estimate.
Design Specification Approach; Measurement and Payment Approach	Contractors can identify project efficiencies to improve project outcomes.	• Develop performance specifications; avoid prescriptive means and methods that limit flexibility. • Include provisions for contractor's value engineering proposals.
	Measurement and payment approaches affect project incentives.	• Develop a measurement and payment scheme with incentives that align with project goals.
	Transloading and transportation can be key production rate and cost drivers.	• Allow for contractor flexibility in selecting and implementing transloading and transportation options. Recognize that rail capacity has a large impact on production rates and is influenced by outside factors (e.g., competing projects, infrastructure limitations).
	Dredging and placement tolerances can affect production rates.	• Provide reasonable tolerances (e.g., overdredging and overplacement allowances) considering both production rates and material (disposal or purchase) costs.
	Actual quantities may differ from design quantities.	• Develop measurement and payment approaches that consider uncertainty (e.g., unit costs, contingency items).

Topic	Lesson Learned	Recommendations for Consideration
Dredging and Excavation	Dredge residuals are intrinsic to dredging and may be observed within and around the perimeter of the dredging area. Dredge residuals concentrations can be transient. Residuals management cover (RMC) has effectively managed dredge residuals in the LDW and on other sediment remediation sites.	• Develop a dredge residuals management plan that uses BMPs during dredging, post-dredge sampling, and targeted contingency actions (e.g., RMC, contingency redredging) to achieve defined performance goals.
	Debris in industrial waterways is common. Debris in the LDW is likely to be beneath the mudline and may or may not express itself at the surface. Debris can have significant impacts on production rates, equipment effectiveness, and sediment resuspension.	• Clearly identify in specifications that the contractor shall expect significant debris (observable and buried) during construction. • Plan equipment and removal means and methods to remove a wide variety of debris. • Use reasonable methods to identify large observable debris during RD.
	Both environmental and digging buckets are necessary to achieve both production rate and environmental dredging objectives.	• Allow the contractor to use a digging bucket as necessary for rock, debris, and consolidated sediment.
	BMPs will require modification over time.	• Plan to adaptively manage BMPs during the duration of the project.
	Work near structures has additional uncertainties and risks.	• Require structural surveys. • Plan for contingencies.
	Subsurface conditions are uncertain, particularly in banks.	• Plan for contingencies, particularly in bank areas.
	Dredge return water management has been successful in the LDW using a variety of approaches.	• Manage water with BMPs and engineering controls and return water to LDW. This approach successfully meets all water quality requirements without costly upland treatment and discharge.
	High-resolution progress surveys improve feedback and dredging accuracy.	• Require multi-beam progress surveys.
RAWP and Other Pre-Construction Submittals	Development and approval can take months to finalize.	• Award contract several months before the opening of the in-water work window.
Construction Sequencing and Phasing	The short in-water work window in the LDW compresses project schedule.	• Plan for the potential need for night work by coordinating with EPA and the neighboring community. • Allow flexibility to optimize efficiency and appropriate dredging season stop points.

Topic	Lesson Learned	Recommendations for Consideration
Water Quality	Water quality criteria exceedances (e.g., turbidity at a compliance distance) can occur during dredging and during placement of capping/ENR material.	• Turbidity is the primary water quality driver, not COCs. • Develop clear communications and response protocols with EPA. • Develop an adaptive approach using BMPs that minimize releases during dredging. • Develop appropriate response actions to address turbidity water quality criteria during clean material placement. • Consider fixed monitoring stations. • Recognize that the saltwater wedge affects turbidity.
Material Placement	The placement of granular activated carbon requires additional QC and handling steps.	• Specifications should provide clear requirements on handling of granular activated carbon (e.g., pre-wetting procedures).
	Additional material needs to be placed to meet minimum design thicknesses for caps and ENR.	• Provide reasonable overplacement allowances to meet design criteria. • Consider the average thickness that will be placed to meet minimum thicknesses.
	Cap and ENR thickness measurements have uncertainty and can vary depending on the measurement approach.	• Establish accurate surveying and positioning control prior to conducting placement. • Use several methods of determining cap thickness, such as surveys, tracking quantities, "bucket maps," and coring/probing. • Anticipate subgrade settlement below placed material. • Timely measurement and acceptance of placed thickness is essential to avoid construction delays.
Compliance Sampling	The compliance sampling approach can affect construction.	• Carefully develop a compliance sampling approach that can evaluate the appropriate project goals and limits down time
	Some backfill types cannot be sampled.	• Develop contingencies for sampling coarse material.
	Ongoing site processes (e.g., sedimentation and resuspension) affect long-term monitoring results.	• Long-term monitoring should consider site processes.

2.4 Existing Habitat Conditions in Upper Reach

RI Section 2.8 and FS Section 2.1.5 summarize the habitat types in the entire LDW. The natural habitat types in the LDW include intertidal mudflats, tidal marshes, and subtidal areas. Intertidal marshes contain marsh soils (generally fine-textured and nutrient-rich), supporting grasses, sedges, rushes, and various other plants. For example, the Hamm Creek and Turning Basin restoration areas are both small intertidal marshes within the upper reach.

Intertidal mudflats are generally defined as the gently sloping areas from MLLW up to the edge of intertidal marsh vegetation (Blomberg et al. 1988). Intertidal mudflats are unvegetated intertidal areas with sand or mud substrate, representing the majority of intertidal area within the upper reach. Intertidal mudflats serve as sources of nutrients for primary producers and provide food and habitat for benthic invertebrates, fish, shorebirds, and aquatic mammals. Intertidal mudflats also attenuate boat wakes for upslope tidal marshes (Battelle 2001). Approximately 48 acres of the upper reach were identified in the ROD as potential clamming areas based on bathymetric elevations (shallower than -4 feet MLLW) and considering substrate and salinity conditions. Potential clamming areas are a subset of the intertidal areas.

Several habitat restoration projects have been performed (or are currently planned for construction) within the upper reach; these include the following (Figure 2-6):

- The Boeing Plant 2 South Site habitat project between RM 3.3 and RM 3.6 includes 1.2 acres of restored marsh habitat, 0.95 acre of restored riparian habitat, and 0.69 acre of restored intertidal habitat.
- The T-117 future habitat site is located between RM 3.5 and RM 3.7 and will include restoration of upland, shoreline, and intertidal habitat.
- The Hamm Creek habitat area is located at RM 4.3W, where 1 acre of emergent salt marsh, 2 acres of freshwater wetlands, and nearly 2,000 feet of the Hamm Creek streambed have been restored.
- The Muckleshoot Tribe habitat area at Kenco Marine is located near the Turning Basin at RM 4.6W.
- At the Turning Basin (RM 4.7W), multiple restoration projects from 1996 through 2007 have included derelict vessel removal, fill removal, creosote-treated piling and derelict structure removal, fill and large woody debris placement, and riparian and emergent plantings, resulting in an addition of 5 acres of restored intertidal habitat (Seaport Planning Group 2009).

During RD, the upper reach habitat conditions will be considered in the following ways:

- Existing upper reach habitat areas will be identified to help ensure that the RD restores the site to pre-construction bed elevations to the extent practicable.
- Existing and post-construction upper reach habitat areas will be summarized in the BODR as part of Endangered Species Act consultation and Section 404(b)(1) evaluations. The summary will identify existing habitat areas (divided into established elevation bands); proposed post-construction habitat areas (divided into established elevation bands); substrate materials for caps, ENR, or placement of backfill materials in any identified habitat areas; and locations where loss of aquatic habitat is unavoidable (e.g., capping around infrastructure) and how those losses are offset in other locations. Should habitat mitigation be necessary for ARAR compliance, mitigation requirements will be assessed in the Preliminary (30%) to Intermediate (60%) RD stages and finalized in the Pre-Final (90%) RD.

2.5 Waterway Usage in Upper Reach

The RD will consider location-specific waterway usage so that the remedy minimizes interference with existing site uses during remedial construction, and it informs the RD to accommodate existing and future uses post-construction. This section describes important current and reasonably anticipated future land use of the upper reach.

2.5.1 Tribal Use and Treaty Rights

As described in the ROD (Section 3), the LDW is one of the locations of the Muckleshoot Tribe's commercial, ceremonial, and subsistence fishery for salmon, as part of its Usual and Accustomed fishing area. The Suquamish Tribe actively manages aquatic resources north of the Spokane Street Bridge, just north of the LDW study area. The Tribes, as sovereign nations, have engaged in government-to-government consultations with EPA on the cleanup process and decisions. The Tribes have also broadly and actively participated in meetings determining the course of the cleanup to date. EPA plans to continue to consult with the Muckleshoot and Suquamish Tribes throughout design, construction, and long-term monitoring of the remedy, including any potential modifications to the remedy. In addition, although not a federally recognized Tribe, the Duwamish Tribe uses Herring's House Park (located north of the upper reach) and other parks along the Duwamish River for cultural gatherings.

Tribal consultation will occur during the design and construction process at a schedule determined by EPA and could include topics such as commercial fishing, shoreline use, access points, cultural activities, or other tribal interests. Tribal use within the LDW was considered during the development of the ROD, and Tribal use will be considered during RD by maintaining aquatic area with beneficial water depths for fisheries (e.g., shallow subtidal). Close coordination will be maintained with the Muckleshoot and Suquamish Tribes during RD and construction, and agreements for any needed fishery disruption will be negotiated prior to construction. Tribal input will be sought by EPA during RD, and Affected Tribes will be consulted as per Section 106 of the National Historic Preservation Act.

2.5.2 Beach Play and Tribal Clamming Areas

The upper reach contains three potential beach play areas, designated in the RI/FS as Beaches 5C, 7, and 8, encompassing 23 acres of the upper reach. In addition, the upper reach contains 48 acres (including EAAs; Table 2-1) where the intertidal sediments are suitable for clam habitat and could support clamming, including Tribal clam harvest. Beach play and Tribal clamming were considered in the RI/FS/ROD process in the development of cleanup levels and RALs.

2.5.3 Public Access Points

Potential public access locations are important to consider during RD in order to maintain public safety and to minimize the impacts of construction on the public. The ROD identifies four potential public access points from the shoreline within the upper reach (Figure 2-6). Duwamish Waterway Park is situated at RM 3.0W and includes public beach access. A public walking path near RM 4.0W could potentially offer public access to the LDW. Finally, two potential public access points were identified in the Turning Basin, one near the end of the Green River Trail at RM 4.7W and the other near the pedestrian bridge at RM 4.9W. In addition to these access points, the T-117 restoration project includes a planned public access point and boat launch. The EPA's Roundtable forum may identify other potential public access issues that could be considered when developing RD details.

Construction of enhanced public access is beyond the scope of this remediation project; however, should other entities plan enhanced public access, those plans could be considered in RD to avoid conflicts between the public access design completed by others and the RD. EPA will use the Roundtable forum to coordinate public input on the Preliminary (30%) and Intermediate (60%) RD; impacts and safety concerns identified in EPA comments based on public input will be addressed in the next iteration of design. In addition to EPA's Roundtable forum, a Community Outreach and Communications Plan will be developed during Pre-Final (90%) and Final (100%) RD phases so that potential public access closures are effectively communicated to the public during construction.

2.5.4 Waterway Users

LDWG contacted waterway users in 2018 as part of pre-design activities, as summarized in *Water User Survey and Assessment of In-Water Structures – Data Report* (Integral et al. 2018). Waterway users were divided into three categories: waterway-dependent users, recreational use businesses and associations, and owners of residential and waterfront properties without water-dependent facilities. Waterway-dependent users include waterfront property owners and their tenants that are supported by bank infrastructure (e.g., docks, piers, wharves, berthing areas) and operators of commercial tug, barge, and cargo vessels. Berthing areas comprise approximately 3.7 acres within the upper reach (see Table 2-1).

Recreational use businesses and associations include businesses that support recreational boating (e.g., marinas) and owners of recreational areas (i.e., municipal park owners). Owners of residential and waterfront properties without water-dependent facilities include all property owners and tenants without apparent water-dependent facilities and those who own residential properties (with or without minor waterfront structures such as docks and piers).

Discussions with waterway users are important for identifying the current and reasonably anticipated future land uses, assessing waterfront infrastructure and banks near remediation areas, and identifying changes during RD and potential sources of disruption during construction. During RDWP development and RD, LDWG will conduct additional outreach to coordinate with water-dependent users on the RD approach, construction sequencing planning, and planned future construction activities.

The completed design will be compatible with current and reasonably anticipated future land uses. The design will maintain water depths in berthing areas and avoid damaging existing waterfront infrastructure such as overwater structures, armored banks, and utilities. For example, the top of the cap or ENR layer must be below the berthing maintenance depth after cap or ENR placement (ROD Figure 20) and incorporate allowable overdredge depths (i.e., 2 feet) that are typically specified for maintenance dredging projects. Approximate berthing maintenance depths are documented in the FS. Unlike the FNC, berthing area maintenance elevations are not formally defined, but based on operational needs and identified in USACE dredging permits.

As noted earlier, during Pre-Final (90%) and Final (100%) RD phases, a Community Outreach and Communications Plan will be developed that includes communication with waterway users.

2.5.5 Federal Navigation Channel

The FNC supports water-dependent industry along the LDW. As discussed in Section 2.1.3, the ROD incorporated evaluation and remedial action for shoaled areas (i.e., areas with bed elevations shallower than the authorized depth) if sediment concentrations are above the RALs at depths up to 2 feet below the authorized depth.[12] Sample intervals will be determined in the PDI QAPP.

In addition, the ROD requires appropriate post-construction clearances for placement activities (i.e., a 2-foot buffer between the authorized depth and the top of an ENR layer, and a 4-foot buffer between authorized depth and the top of a cap). Furthermore, the ROD requires a 10-foot horizontal buffer outside of the FNC for placement activities to account for equipment tolerances, and the potential for material to slough into the channel (ROD Section 13.2.1.1). The considerations for RD technologies in the FNC are discussed in Section 3.7.

2.6 Data Gaps Identification

The PDIWP provides a conceptual sampling plan based on the data types summarized in Appendix B of the *Design Strategy Recommendations* Report (Integral and Windward 2019). In addition, the PDIWP identifies data quality objectives (DQOs) for the Phase I and II investigations (Section 4.1).

The following bullets summarize the data that are anticipated to be collected during the PDI (PDIWP Section 3.4):

- Site-wide bathymetric survey data to support the potential refinement of Recovery Category areas, potential vessel scour areas, and applicable RALs; this survey was conducted in April and May 2019, and the results will be provided as an appendix to the PDI QAPP
- Sediment chemistry data to delineate RAL exceedances, as noted earlier, and to determine the following:
  - Required dredge elevations in dredging areas, partial dredging and capping, and partial dredging and ENR areas
  - Refined area boundaries of MNR to benthic SCO
- Possible collection of toxicity test data in areas where active remediation is anticipated if only benthic RAL exceedances exist in the particular area

[12] The ROD indicates that "where contaminant concentrations exceed RALs only at depths below the top 2 ft, cleanup may be deferred if USACE determines it is not currently an impediment to navigation, but must be dredged in the future if USACE determines that the area has become an impediment to navigation." USACE will be provided the opportunity to comment on design documents as determined by EPA.

- Focused topographic survey data in bank areas with adjacent remedial action areas that have dredging or capping remedies
- Area-specific sediment geotechnical properties including geologic characterization, sediment index, and sediment strength and consolidation properties to achieve the following:
  - Determine sediment stability and stable dredge cut side-slope requirements.
  - Characterize sediment dredgability.
  - Support sediment consolidation assessment for cap design.
  - Support selection of dredge equipment.
  - Support design of sediment handling, transport, dewatering, treatment systems, and disposal requirements.
- Specialized surveys as appropriate for debris characterization
- Sediment transport and erosion/scour/disturbance process information (such as bathymetry and engineering analyses) to support the following:
  - Delineation of MNR/ENR areas
  - Design of ENR/in situ treatment (depending on results of ENR/AC pilot study)
  - Cap design
  - Outfall scour protection

3 Engineering Design Process

3.1 Design Objectives

This RDWP has been developed to support the preparation of a design that is constructable, environmentally protective, effective, and consistent with the ROD requirements. Sequencing the data collection that informs RD is important to ensure that appropriate data for RD are collected at the applicable phase of RD, and that the RD will be conducted so that design elements may be refined as new information becomes available.

When possible, the design will specify performance requirements instead of prescribing the means and methods of the remedial construction. Performance-based specifications describe the performance criteria that the contractor is required to meet during construction, which allows for the contractor to develop project-specific means and methods that take advantage of contractor creativity and expertise. The contractor will propose the specific means and methods in their RAWP, subject to approval by the Engineer and EPA. This approach also allows for adaptive management that can incorporate real-time lessons during construction rather than rigid prescriptive specifications. However, prescriptive method specifications will be used for those design elements that cannot be flexible (e.g., minimum cap layer thickness, sequencing and access constraints, etc.) and will also be used to set project-wide minimum requirements for communications, environmental protection, and health and safety.

3.2 Design Process

This section discusses the general design process phases for RD and how PDI data will be used in design. Figure 3-1 graphically depicts the progression of the RD process and how the various PDI and RD phases interrelate with one another.

3.2.1 Pre-Design Investigation Phases

The PDIWP (Appendix C) details the phased approach that will be used for the PDI. The first phase of sampling is generally focused on defining the horizontal extent of RAL exceedances by targeting surface sediment (0 to 10 cm) and shallow subsurface sediment (0 to 45 cm in intertidal areas and 0 to 60 cm in subtidal areas).

The Phase I PDI data will be used to define initial remediation areas, identify any additional data gaps in the horizontal extents of contamination, help identify areas for subsurface investigation (e.g., the depth of contaminated sediment in dredging areas) in both open water and under overwater structures, and help define investigation needs at adjacent bank areas.

The Phase II PDI will focus on addressing additional horizontal extent data gaps identified in Phase I, refining horizontal extents of required remediation areas, collecting subsurface data to define vertical extents of required dredging, and collecting engineering data (e.g., geotechnical, structural conditions, thickness of contaminated sediment overlying riprap-armored banks) to inform RD.

Phase III PDI will be conducted, if necessary, to address any data gaps that remain following the Phase II PDI.

PDI Data Evaluation Reports will present the investigation results, in addition to refining the RAL exceedance areas (Section 3.3), revising Recovery Category designations (Section 3.4), and refining the preliminary technology assignments (Section 3.5).

3.2.2 Remedial Design Phases

RD is generally defined as those activities to be undertaken to develop construction plans and specifications, general provisions, special requirements, and other technical documentation necessary to solicit bids for construction of the remedial action. The RD also includes identification of the required documentation to be provided by the construction contractor, subject to approval by EPA, during the pre-construction and construction phases, and annotated outlines, conceptual plans, or initial drafts of certain documents to be finalized after construction.

The Preliminary (30%) RD will incorporate data from the Phase I and II PDIs. Key deliverables of the Preliminary (30%) RD package will include a draft BODR, preliminary plans (i.e., drawings), and an outline of the contract specifications.

The Intermediate (60%) RD package will incorporate EPA input on the Preliminary (30%) RD and advance the preliminary design concepts presented therein. Coordination with EPA and resource agencies will continue during Intermediate (60%) RD to ensure that the design is compliant with ARARs, and that approvals can be obtained in advance of the planned construction period.

The Pre-Final (90%) RD package will incorporate EPA input on the Intermediate (60%) RD, incorporate any data obtained during a Phase III PDI (if needed), and will be a near-final package including a CQAP and Water Quality Monitoring Plan (WQMP).

The Final (100%) RD package will incorporate EPA comments on the Pre-Final (90%) design submittal and include final versions of all supporting design deliverables. The remediation construction implementing entity will determine the requirements of the final bid document plans and specifications as noted in Section 1.5.1.

Outreach and coordination with waterway users and other stakeholders will take place before field sampling events, as detailed in the PDI QAPP. The components of each RD deliverable are discussed in detail in Section 6.

3.2.3 Design Process Sequencing

The following bullets provide a summary of the design process sequence to delineate remedial action areas, select remedial technologies, and delineate sediment management areas (SMAs; defined in Section 3.6) consistent with the RD phases and Figure 3-1:

- Collect 2019 bathymetry data
- Phase I PDI
  - Develop sun-illumination maps (i.e., map with shading to enhance the appearance of bathymetric features).
  - Adjust Recovery Category area designations where appropriate based on new bathymetry (i.e., sun-illumination maps).
  - Collect Phase I PDI data.
  - Evaluate RAL exceedances.
  - Adjust Recovery Category area designations where appropriate based on Phase I PDI data.
  - Preliminarily delineate remedial action areas.
  - Preliminarily assign remedial technologies.
  - Identify data gaps for Phase II PDI.
- Phase II PDI
  - Collect Phase II data including horizontal delineation data gaps identified in Phase I, vertical extent data, bank characterization data, and engineering data.
- Preliminary (30%) RD
  - Refine remedial action areas.
  - Select remedial technology[13] (i.e., dredge, partial dredge and cap, cap, ENR, ENR/AC, MNR).
  - Identify data gaps for Phase III PDI.
- Intermediate (60%) RD
  - Delineate SMAs considering common adjacent remedial technologies, site physical characteristics, constructability, and other engineering factors as appropriate.
  - Design remedial actions (e.g., horizontal and vertical limits for dredging; cap thickness and erosion protection; ENR; treatment; dredging or capping construction offsets from existing infrastructure).
  - Identify any remaining data gaps for RD.
  - Collect Phase III PDI data, if any further data gaps are identified.

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[13] It is expected that remedial technology assignment at the Preliminary (30%) RD will be roughly 90% complete, but remedial technologies in particular areas may be refined as design is further developed.

- Pre-Final (90%) RD
  - Refine SMAs and RDs, if any, based on Phase III PDI.
- Final (100%) RD
  - Finalize RD.

The following sections provide additional details for several key design components of the RD process.

3.2.4 Design Quality Control

RD submittals to EPA will be reviewed using the design team's internal quality control processes, and they will also be reviewed by LDWG, EPA, and other stakeholders including affected users. Analytical data are collected using EPA-approved QAPPs and validated to ensure the data are of suitable quality to make RD decisions.

Other internal quality control processes occur prior to submittals to EPA. Engineering designs are peer-reviewed internally by senior engineers, calculations are cross-checked, and experienced construction managers thoroughly evaluate implementation plans to ensure constructable designs. Constructability and value engineering reviews will be performed during the 60% design phase to gauge equipment and material availability, construction cost escalation, contractor concerns, and other risk factors that may impact implementation of the remedy.

3.3 Remedial Action Area Designation

The ROD provides criteria for identifying remedial action areas by comparing the surface sediment and shallow subsurface sediment concentrations to the RALs. The RALs are listed in ROD Table 28 (included in Appendix A of this report) and can vary for different Recovery Category areas, intertidal and subtidal areas, and in shoaled areas of the FNC. The RAL exceedance areas will be delineated using existing data and PDI data and will be adjusted as necessary should the Recovery Categories be modified.

Geostatistical methods or a combination of methods (e.g., inverse distance weighting, kriging, Thiessen polygons) will be used, along with practical engineering considerations, to delineate the remedial action areas. The delineation method will be described in the BODR.

Bank areas will be designated for remedial action based on the RALs identified in Table 28 of the ROD. Bank areas will be evaluated using the following general approach:

- Bank areas will be visually inspected during Phase I PDI to assess their general conditions (e.g., armored condition, stability).
- Phase I PDI results and coordination with MTCA site managers will inform which bank areas may exceed RALs and will be sampled during Phase II PDI.

- Armored banks in good condition will not be sampled below the armor layer; sediment overlying the armor layer may be sampled on banks adjacent to active remediation areas.

3.4 Recovery Category Finalization

The FS developed Recovery Categories that define where remedial technologies can be used. Generally, Recovery Category 1 designates areas where only dredging and/or capping are applicable; Recovery Categories 2 and 3 designate areas where MNR, ENR, dredging, and capping are all applicable.

The Recovery Category area boundaries depicted in the ROD Table 23 (included in Appendix A of this report) summarize the criteria used to assign final Recovery Categories. The recent *Recovery Category Recommendations Report* (Integral et al. 2019) evaluated the Recovery Category designations in the ROD based on the waterway user survey and new chemistry data and recommended minor revisions. Within the upper reach, two locations were modified: Boyer Towing at RM 2.3W, and Waste Management transload property at RM 2.8E. Both locations were modified from Category 3 to Category 2 based on site use (vessel berthing). The Phase I and Phase II PDI Data Evaluation Reports will review, and potentially revise, the Recovery Category designations using new bathymetric survey and PDI chemistry data. These final Recovery Category boundaries will then be used in RD.

3.5 Remedial Technologies Assignments

A remedial technology or technologies will be assigned to each remedial action area. Preliminary remedial technology assignments presented in the ROD will be refined during RD based on PDI data and engineering judgment. The remedial technologies will be assigned based on ROD criteria summarized in ROD Tables 27 and 28 and Figures 19 through 23 (included in Appendix A of this report). The technology assignment criteria in the ROD include the following:

- RAL exceedance and magnitude of exceedance (i.e., upper limit for ENR)
- Recovery Category
- Bathymetric elevation (intertidal, subtidal, and bathymetric elevation compared to future maintenance dredging)
- FNC and berthing area maintenance dredging requirements (e.g., horizontal and vertical tolerances compared to maintenance dredge depths)
- Access constraints and the presence of structures

The remedial technology assignments will also consider equipment tolerances, structure protection offsets, constructability, proximity to outfalls, debris, and the conditions in adjacent areas.

The Phase I and Phase II PDI Data Evaluation Reports will review, and potentially revise, the remedial technology assignments using new bathymetric survey and PDI chemistry data and using the revised Recovery Category delineations described in Section 3.4. This step is necessary in order to collect the appropriate data for the next phase of PDI (such as vertical extent in dredge areas or lateral extent of ENR areas.) The technology assignments will continue to be revised in the RD submittals.

3.6 Sediment Management Areas Designation

Once the upper reach remedial action areas are delineated and remedial technologies are assigned to each remedial action area, the upper reach will be divided into SMAs in the Preliminary (30%) RD (where appropriate). SMAs represent discrete areas within the site in which different remedial technologies may be implemented or where unique constructability issues may exist. SMAs are discrete areas within the larger site that can be managed differently from one another using the applied technology and monitoring, but are considered part of the larger site. SMAs provide a method for referencing individual remedial action areas in the bid documents, and a method for overlaying constructability considerations in the assignment of remedial technologies to an SMA. SMA designations will rely on engineering judgment.

In many cases, a remedial action area boundary will naturally form a discrete unit that will become its own SMA. In other cases, a contiguous remedial action area may be split into two or more SMAs based on physical constraints or use of multiple remedial technologies. Some of the considerations for delineating SMAs will include the following:

- **Sediment stability.** SMA delineation will consider sediment stability, including scour potential, proximity to berthing areas and outfalls, and the location of steeper slopes (e.g., banks and adjacent to FNC). Uncertainty in Recovery Category boundaries, when developing SMA delineation, will be addressed by considering Recovery Category designations in adjacent areas.
- **Structures and offsets.** Underpier areas that require remediation will be evaluated to assess whether it makes sense to delineate them as separate SMAs. In addition, SMA delineation will consider structural offsets needed to protect overwater structures, engineered slopes, and utilities.
- **Site physical conditions.** The SMA delineation will consider site physical conditions, such as the FNC, berthing areas, intertidal areas, habitat areas, bathymetric elevations shallower than -10 feet MLLW, and areas identified as habitat for compliance with the Endangered Species Act and Section 404 of the Clean Water Act.
- **Constructability.** SMA delineations may be influenced based on constructability considerations, such as equipment access, presence of piling and debris, and location of structures.

The SMA delineations may be refined throughout the design process as the RD progresses in each area. The transition between each SMA and adjacent areas (e.g., other SMAs or EAAs) will be designed to provide a constructable and stable transition. Some SMAs may extend past the upper reach boundaries.

3.7 Remedial Technologies Design Considerations

3.7.1 Dredging

For areas where dredging is the selected remedial technology, dredging design will be guided by the *USACE Technical Guidelines for Environmental Dredging of Contaminated Sediments* (Palermo et al. 2008) and engineering professional judgment based on past sediment remediation designs. The dredging design will consider lessons learned from EAAs and other cleanup sites discussed in Section 2.3.3.

The first step in the dredging design process will be to define the horizontal and vertical extents of dredging based on PDI data, then calculate resulting dredge areas and volumes. The dredge areas and volumes will be refined throughout RD considering constructability and protection of infrastructure and utility areas. The extent of the dredge areas will be presented on design drawings.

As identified in the ROD (Section 13.2.1.1), if 1 foot or less of contaminated sediment would remain at concentrations greater than the human health RALs or the benthic SCO after dredging to sufficient depth to accommodate a cap, all contaminated sediments will be dredged. If more than 1 foot of contamination would remain after dredging to sufficient depth to accommodate a cap, sediments will be partially dredged and capped.

Following the initial definition of the dredge areas and volumes, different types of dredging equipment and material transport systems will be evaluated based on project requirements, site conditions, and implementation efficiencies. Factors influencing the selection of the types of dredging equipment to be used include but are not limited to the following:

- Water depth to accommodate equipment draft
- Mobilization and site access constraints
- Dredge cut thickness
- Presence of debris
- Sediment type and physical or geotechnical characteristics
- Production rates and schedule requirements
- Dredged material transport methods
- Availability and locations of potential transload facilities
- Environmental monitoring requirements

Identification of anticipated dredging equipment types (e.g., mechanical versus hydraulic dredging) will occur as early in the design process as practicable to allow for progress on dependent design processes (i.e., material handling, transloading, and transport). The selected remediation contractor will select and identify its dredging equipment and construction means and methods in the contractor's RAWP. However, the RD may specify general types of dredging equipment (e.g., mechanical versus hydraulic dredging) to be used for specific site conditions in order to reduce construction uncertainties.

Throughout the design process, dredge area boundaries may need to be refined based on concurrent design activities. Where dredging occurs near the bank and structures, the dredge design will evaluate the stability of both the existing bank side slopes and the new side slopes that will result from dredging. In addition, identification of cultural resources, critical habitats, and utilities may require modifications to the design dredge prism. A slope setback may be required in areas where the design dredge prism may undermine the toe of the slope or existing structures to prevent undermining or reducing the stability of slopes and structures. An alternate remedial action may be required to manage the remaining contaminated sediment that cannot be removed. The extent of any necessary slope setbacks or structural offsets and how remaining contaminated sediment will be managed will be presented on the design drawings.

The Preliminary (30%) RD will develop an overall dredging strategy and preliminary dredging plans showing the horizontal and vertical limits of dredging based on the results of PDI data. The Preliminary (30%) RD will also include a list of the relevant technical specifications governing dredging.

The Intermediate (60%), Pre-Final (90%), and Final (100%) RD phases will refine dredging plans based on additional data collection after the PDI phases, siting of marine access points and materials transport, and results of infrastructure information not available at the Preliminary (30%) RD phase. In addition, subsequent phases of RD will evaluate and identify anticipated dredge equipment types and methods based on the required dredge extents and site conditions, building from the Preliminary (30%) RD. The specifications outlined during the Preliminary (30%) RD will be further developed and finalized during subsequent RD phases, and in response to EPA comments.

3.7.1.1 Dredging Design Factors for Federal Navigation Channel and Shoaled Areas

Shoaled areas are defined in the ROD as areas in the FNC with sediment accumulation above the FNC authorized depth (-15 feet MLLW in the upper reach). As described in the ROD (Section 13.2.1.1), shoaled areas in the FNC will be dredged as the remedial action if contaminant concentrations exceed RALs at any elevation above the maintenance depth (i.e., 2 feet below the authorized depth, or -17 feet MLLW). The RD will consider the USACE's FNC authorized navigation and maintenance depths, over-dredge requirements and lateral offsets from the channel as required by the ROD, and whether the post-dredge surface may exceed

RALs. A Z-layer sample (collected from cores during PDI) will predict the post-dredge surface concentration. When dredging is required within and to the edge of the FNC, the dredge prism will extend an additional 10 feet (lateral) outside of the FNC.

Partial dredging plus capping design within the FNC and shoaled areas will also factor in any follow-on capping such that all post-remedy surfaces in these areas will be maintained at or below the ROD-mandated FNC authorized depth offsets.

3.7.1.2 Dredging Design Factors for Areas Outside the Federal Navigation Channel

Outside the FNC, the dredge design will consider navigation depths that are maintained by private or public entities (called berthing areas in the ROD, but could include slips, entrance channels, or restoration areas).

Dredging may be required in some areas that would otherwise be designated for capping if institutional controls required to prevent damage to a cap (such as deed restrictions) are not compatible with the current or reasonably anticipated future use of that area.

The dredge design and required follow-on material placement activities (e.g., capping, backfill, or RMC) would be designed to avoid the loss of aquatic habitat and preserve an appropriate range of habitat elevations in the intertidal zone. Habitat design considerations are discussed further in Section 3.8.

3.7.1.3 Dredging Design Factors for Infrastructure and Slope Areas

The RD will incorporate design factors when dredging adjacent to existing infrastructure, utilities, and slopes. During the 30% and 60% design phases, the RD will identify areas where dredging is impractical based on the operational characteristics of the dredging equipment and equipment access constraints. In addition, dredging may need to be offset from existing slopes and structures to prevent adverse impacts to stability. Dredging offsets and slopes for protecting existing structures and utilities will be developed during the 30% and 60% design phases and will consider factors such as the type of utility (e.g., power, drainage, communications) or type and condition of existing structures.

In locations where standard dredging equipment cannot remove the material due to obstructions, or where offsets for structural stability prevent removal, alternate remedial technologies will be evaluated in coordination with EPA during the 30% and 60% design phases (e.g., underpier areas and in the vicinity of dolphins/piling, bulkheads, and riprapped or engineered banks).

Debris and abandoned pilings will be removed or replaced from remedial action areas in the upper reach as necessary or as required by EPA to implement the remedy. In some circumstances, removal in the vicinity of certain infrastructure will require structural and/or geotechnical engineering assessments of the infrastructure; in such cases, alternate means for sediment removal will be evaluated on a case-by-case basis. Potential obstructions may include but are not necessarily limited to the following:

- Structures (e.g., bridge abutments, wing walls, bulkheads, mooring dolphins) whose structural stability may be adversely impacted by dredging
- Low clearance structures (such as bridges and piers)
- Armored banks
- Other physical obstacles within the waterway that cannot be removed (e.g., concrete cribs, very large boulders, bedrock, stormwater outfalls)
- Buried utilities or utility crossings

3.7.1.4 Sediment Resuspension Management During Dredging

Dredging activities will result in resuspended sediment. Some causes of resuspension include disturbance of the bed by dredging buckets (mechanical dredging) or hydraulic cutterheads (hydraulic dredging), loss of sediment from dredging buckets as the bucket is raised or lowered through the water column, propwash disturbance from dredging equipment and attendant vessels (e.g., tugboats), sediment spillage or discharge from haul barges, debris preventing bucket closure, and disturbance from dredge or barge anchoring. Areas with high debris density will experience higher sediment resuspension during removal (USACE 2008).

The RD will evaluate potential methods to reduce sediment resuspension during dredging activities (e.g., best management practices [BMPs] for operational controls, specialized dredging equipment such as an environmental bucket). A range of BMPs to reduce sediment resuspension will be evaluated and described in the BODR. The feasibility and effectiveness of various BMPs is dependent upon project- and site-specific considerations, including the following:

- Water quality compliance criteria
- Water depth
- Waterway velocities and flow
- Vessel traffic frequency
- Waterway constraints for installing or anchoring resuspension barriers (e.g., navigation, Tribal Usual and Accustomed fishing)
- Waterway elevation variability
- Dredging equipment and methods
- Geotechnical properties of dredge material
- Waterway access

A WQMP will be developed (see Section 6.2.3) during RD to provide a mechanism to assess water quality during in-water remedial actions, evaluate the overall effectiveness of the control approach, and inform contingency actions to address potential water quality criteria exceedances.

3.7.1.5 In-Water Dredged Material Transport

The design for dredged material in-water transport is directly linked with the dredging methods and dredged material handling, dewatering, and water treatment. The anticipated dredged material in-water transport design will be based on the dredge equipment type selection during RD. Dredged material in-water transport methods and performance requirements will be identified and finalized in combination with dredge equipment type and anticipated dewatering processes. Minimum performance requirements for in-water transport (e.g., spill prevention, barge loading, U.S. Coast Guard requirements, barge seaworthiness) will be included as performance specifications.

Performance requirements will also include a Vessel Management Plan, developed at the Pre-Final (90%) RD phase, that will be finalized by the selected remediation contractor. The Vessel Management Plan will include information about anticipated vessel operations necessary to complete the remedial actions such as types of vessels, access points, and vessel frequency.

3.7.1.6 Dredged Material Handling, Dewatering, and Water Treatment

Dredging operations will require material handling, potential dewatering, and potential water treatment to prepare the dredged sediment and debris for disposal at an off-site landfill. The design and location of the material handling processes will be informed by the removal technology, transport constraints, requirements of the disposal facility, and the upland transport method used to transport the material to the disposal facility.

Design for material handling, potential dewatering, and potential water treatment activities will consider the following elements:

- Space and area available along the river for material transloading, temporary stockpiling, potential dewatering, and potential water treatment
- Availability and capacity of commercial transload facilities
- Amount and type of debris to be processed
- Dredging volumes
- Dredging production rates
- Dredged material physical characteristics
- Results of sediment treatment study work (if necessary) to be performed in support of these operations (e.g., leachate testing and ex situ stabilization)
- Amount of water to be treated, if necessary

- Water discharge requirements (e.g., barge discharge, transload facility discharge)
- Transport and offloading methods from the in-water work area to transload facility and then to disposal facility

The Preliminary (30%) RD will evaluate potential locations for commercial transload facilities and water treatment operations (if needed) as discussed in Section 4.5. The Preliminary (30%) RD will also assess the potential need and property availability for constructing a new, dedicated upper reach transload facility. The actual location of a transload facility will be finalized in the contractor's RAWP due to the dependency on contractor means and methods, the available space (which could change over time), and the disposal facility's dredged material acceptance criteria. Design plans and specifications will be developed to identify performance requirements for material transloading, handling, potential dewatering, potential water treatment, and discharge that are compatible with site constraints and comply with ARARs and EPA requirements.

3.7.1.7 Upland Dredged Material Transport and Disposal

Building on the results from the dredge material handling, dewatering, and water treatment evaluation, upland transportation and disposal processes will be evaluated and potential transloading and disposal facility locations and transport methods will be preliminarily identified. The operational constraints imposed by available sediment transload, available rail and/or truck transport capacity, and disposal facilities may affect dredging production rates, in-water transportation design, waterway access, rail or truck transload design, and potential sediment dewatering and water treatment design. The potential locations for the transload and disposal facilities will be evaluated during Intermediate (60%), Pre-Final (90%), and Final (100%) RD so that results may be factored into the design reports and construction bid documents. Trucking and rail transport requirements (e.g., lined and covered truck beds or containers), haul route requirements (e.g., routes, dust control), and disposal facility requirements (e.g., documenting facility permits and approvals) will be evaluated throughout RD and presented in the BODR.

3.7.1.8 Dredge Residuals Management

Dredge residuals refer to the contaminated sediments found at the post-dredge surface, either within or adjacent to the dredging area, as depicted in Figure 3-2. Generated residuals refers to contaminated sediments that have been disturbed or resuspended by the dredging equipment but not captured and therefore settled back to the sediment bed; they tend to be relatively thin deposits (e.g., less than a couple of inches thick). Missed inventory (i.e., undisturbed residuals) refers to contaminated sediments that have been uncovered but not removed. The primary causes of missed inventory are incomplete characterization, resulting in inaccurate remediation designs, and incomplete dredging due to technical and logistical limitations (e.g., structural setbacks) (USACE 2009).

The RD will develop a multiple-pronged strategy that anticipates dredge residuals and establishes a phased approach to proactively plan for and respond to them. LDWG will work with EPA to determine how to discern residuals from missed inventory and what concentration thresholds will be considered acceptable as residuals. Dredge residuals will be managed by specifying appropriate dredging performance standards in the specifications, developing a dredge residuals monitoring approach and decision framework in the CQAP, and including appropriate dredge residuals response requirements in the plans and specifications.

The three general management approaches for dredge residuals are anticipated to include contingency redredging, RMC, and MNR. Contingency redredging can be conducted to attempt to reduce contaminant concentrations at the surface, but this approach has often been inefficient with little reduction in residual concentrations (USACE 2008). Typically, contingency redredging is used to target only high-concentration dredge residuals.

The second management strategy is to place clean sand RMC. This approach provides greater certainty in achieving dredge residuals performance criteria (USACE 2008) and RMC is regularly used to manage thin deposits of generated residuals. Placing RMC has a similar purpose as placing an ENR layer to accelerate the natural recovery process and is described further in the next section.

After required dredging is completed, and in areas where the residuals concentration is sufficiently high (as determined by post-dredge compliance testing), RMC may be used to address dredge residuals. The RMC is typically a relatively thin layer (e.g., nominally 6 to 12 inches) of clean sand as determined during RD. The RD will include the following RMC design components:

- Materials specifications
- Potential material source identification
- Estimates of surficial post-dredge residual contaminant concentrations
- RMC thicknesses
- RMC horizontal extents
- RMC placement methods

Finally, dredge residual layers tend to be thin and have low density, and therefore are amenable to MNR. Exceedances due to dredge residuals also tend to be transient, so project goals may be met by MNR alone in some dredge residual areas.

3.7.1.9 Post-Dredge Backfilling

Backfilling dredged areas with clean material may be necessary in some areas to restore pre-dredge elevations for habitat purposes. Backfill can also serve a residuals management function. The RD will include design of backfilling integrated, as appropriate, with the design for habitat replacement and reconstruction (see Section 3.8). The backfilling design will include the following:

- Materials specifications
- Potential material source identification
- Estimates of surficial post-dredge residual contaminant concentrations
- Backfill thicknesses
- Backfill horizontal extents
- Backfill placement methods

3.7.2 Capping

The RD for cap areas will consider the physical, chemical, hydrodynamic, and hydrogeological properties of cap areas. These factors include bathymetry, existing infrastructure and obstructions, groundwater advection, bioturbation, intertidal site use, and potential erosive forces, such as current velocities, propwash, and wave or wake action.

Caps will be designed to isolate and stabilize existing sediments in general accordance with the *Assessment and Remediation of Contaminated Sediment Program Guidance for In Situ Subaqueous Capping of Contaminated Sediments* (Palermo et al. 1998). The guidance document recommends a generalized approach to designing an in situ cap, including considerations of the following specific design components:

- Assessment of the potential contaminant mobility from the sediment into the water column, and design of a cap component to prevent breakthrough within a given design life
- Assessment of bioturbation potential of local burrowing benthic organisms; design a cap component to physically isolate them from contaminated sediment
- Assessment of cap design in intertidal areas where potential clamming may occur
- Evaluation of construction and placement methods, and identification of performance objectives and monitoring methods for cap placement and long-term assessment
- Identification of candidate capping materials that are physically and chemically compatible
- Assessment of the operational considerations and determination of restrictions or additional protective measures (e.g., institutional controls) needed to ensure cap integrity
- Evaluation of the long-term effects of sea level rise and climate change on cap integrity

In addition, the following design consideration will also be evaluated:

- Assessment of intertidal seeps and preferential groundwater flows that affect groundwater velocities and cap construction in intertidal areas

Cap modeling performed during RD will determine the cap thickness, cap material types, and material gradation. The cap will be designed to resist the following erosive forces, as applicable:

- **Hydrodynamic flows:** The caps will withstand scour from high-flow events. Caps near outfalls will be designed to withstand currents associated with the outfall flows, including surface flows at low tide.
- **Propwash and wakes:** The cap design will assess the potential forces from propwash and vessel-generated wakes. Representative recreational and commercial vessels will be selected for evaluation during RD; the selected design criteria vessel(s) will be identified in the BODR.
- **Wind-generated waves:** The effects of wind-generated waves will also be evaluated during the cap design, although the wind-generated wave impacts are expected to be minor relative to the other erosional forces in the upper reach. The capping design consists of several steps that are integrated with the other major design components. The first step in the capping design is to identify the areal extent of capping that can be used as described in Sections 3.3, 3.4, and 3.5. Identification of critical habitats and utilities may require modifications to the extent of capping. The areal extent of capping will be used to quantify capping areas and cap material volumes. ROD Figures 19 and 20 (included in Appendix A of this RDWP) identify where capping may be used.

The materials at the top of the cap (i.e., cap surface) will be sized to resist erosive forces, and available material sources will be considered in developing cap material specifications. Once cap material volumes and material specifications have been developed, a combination of performance and method specifications will be developed to specify means and methods for cap material transport, handling, and placement.

The Preliminary (30%) RD will develop preliminary capping plans (i.e., drawings) showing the horizontal limits of capping. The Preliminary (30%) RD will also include a list of the relevant technical specifications related to capping.

The Intermediate (60%), Pre-Final (90%), and Final (100%) RD phases will refine capping plans, siting of marine access points and capping materials transport, and results of infrastructure information not available at the Preliminary (30%) RD phase. Prospective sources of cap material and methods for transporting the material will be identified. The specifications outlined during the Preliminary (30%) RD will be further developed and finalized during subsequent RD phases, and in response to EPA comments.

3.7.2.1 Capping Design Factors for Federal Navigation Channel

Capping design within the FNC will consider final post-remedy surface elevations, such that they are maintained at or below the ROD-mandated authorized depth offsets. In order to avoid potential damage to a cap during federal maintenance dredging, the top of any cap will be at least 4 feet below the FNC-authorized depth as required by the ROD and as noted in comments from the USACE (2013). In addition, use of RMC to address dredge residuals contamination may be necessary and would need to be accounted for in the dredging design.

3.7.2.2 Capping Design Factors for Intertidal Areas and Areas Outside Federal Navigation Channel

For areas outside the FNC where navigation depths are maintained by private or public entities (called berthing areas in the ROD, but could include slips or entrance channels), any capping remedial action will have a top surface at a minimum of 2 feet below the operating depth as determined during RD.

Material placement (e.g., capping, backfill, or RMC) would be designed to avoid the loss of aquatic habitat and preserve an appropriate range of habitat elevations in the intertidal zone. This includes cap thickness and material selection design considerations within Tribal clamming areas in the intertidal zone. Habitat design considerations are discussed further in Section 3.8.

3.7.2.3 Capping Design Factors for Infrastructure and Slope Areas

The RD will incorporate cap design factors when capping adjacent to or under existing infrastructure, utilities, and slopes. The RD will identify areas where capping may be impractical based on the operational characteristics of the capping equipment and the presence of permanent structures or obstructions that could potentially interfere with capping activities.

Besides the potential impact to water depths, capping can also have adverse impacts to structure and slope stability due to the added weight of the cap. Similar to dredging, cap placement offsets may be necessary to prevent impacts to the stability of existing structures, slopes, and utilities. The cap design will consider factors such as the type and condition of existing structures and slopes, and the geotechnical conditions of areas of stability concern. The extent of any necessary slope setbacks or structural offsets and how remaining contaminated sediment will be managed will be presented on the design drawings.

In locations where standard capping equipment cannot place capping material due to obstructions, alternate methods for placing cap materials will be evaluated. The design will consider applying location-specific capping technologies to areas with structural or access constraints (e.g., underpier areas and in the vicinity of dolphins/piling, bulkheads, and riprapped or engineered banks).

Potential obstructions are similar for capping and dredging equipment and may include but are not necessarily limited to the following:

- Structures (e.g., bridge abutments, wing walls, bulkheads, mooring dolphins) whose structural integrity may be adversely impacted by capping
- Low clearance structures (such as bridges and piers)
- Other physical obstacles within the waterway that cannot be removed prior to capping (e.g., concrete cribs, very large boulders, bedrock, stormwater outfalls)
- Buried utilities or utility crossings

3.7.2.4 Sediment Resuspension Management During Capping

Capping activities will result in turbidity impacts. Most of this turbidity will be from fines contained in the clean cap material as it descends through the water while being placed; however, some resuspension of the bed sediment may occur depending upon the contractor's cap placement method. Sediment resuspension during capping may also result from propwash disturbance from capping equipment and attendant vessels (e.g., tugboats), clean material spillage from haul barges, and disturbance of the bed from capping equipment or barge spudding/anchoring.

Disturbance of the existing bed sediments during capping is commonly managed by specifying limits on the initial lift thickness of the cap material, to avoid bearing capacity failure of the sediments, as well as requiring placement techniques that spread the cap material.

Turbidity from clean fines in the capping material can be reduced to an extent by limiting the fines content in the materials specification. However, some fines are always present and the need to evenly spread the capping material will result in the resuspension of the clean fines.

Many of the other resuspension mechanisms mentioned above can be limited through BMPs, such as avoiding spudding or propwash (as practical) in cap placement areas.

Capping operations have been used extensively in the Pacific Northwest and nationally to isolate contaminated sediment. Lessons learned from many previous sediment remediation projects indicate that special equipment or barriers are not necessary to ensure protectiveness during clean cap placement operations. The BODR will identify proven BMPs typically required during capping operations that the contractor will be required to follow in order to limit sediment resuspension in addition to performance specifications.

3.7.3 Enhanced Natural Recovery

ENR entails placing a thin layer (nominally 6 to 9 inches thick) of clean material to accelerate natural recovery processes. ENR is not applicable in Recovery Category 1 areas. In Recovery Category 2 and 3 areas, ENR may be selected for intertidal and subtidal areas based on COC concentrations and the potential for sediment scour, as indicated in ROD Table 28 and on ROD Figure 17 (included in Appendix A of this report).

The RD will design ENR thickness considering material type, placement tolerances, and protectiveness. Habitat-compatible ENR material specifications will be developed during RD for habitat areas as discussed in Section 3.8. The ENR may include in situ treatment using AC or other amendments as discussed in Section 3.7.5.

3.7.3.1 Enhanced Natural Recovery Design Factors for Federal Navigation Channel

The ENR design within the FNC will consider final post-remedy surface elevations, such that they are maintained at or below the ROD-mandated authorized depth offsets. The top of any ENR layer will be below the FNC-authorized depth.

3.7.3.2 Enhanced Natural Recovery Design Factors for Areas Outside Federal Navigation Channel

For areas outside the FNC where navigation depths are maintained by private or public entities (called berthing areas in the ROD, but could include slips, entrance channels), any ENR remedial action will have a top surface below the operating depth as determined during RD.

The ENR design will consider factors such as the type and condition of existing slopes and banks, and the geotechnical conditions of areas of stability concern, to determine effectiveness and stability of ENR materials in these areas.

3.7.3.3 Sediment Resuspension Management During Enhanced Natural Recovery Placement

ENR placement will result in resuspended sediment similar to capping placement as described in Section 3.7.2.4. The BODR will identify BMPs that the contractor will be required to follow to limit potential sediment resuspension during ENR placement operations.

3.7.4 Monitored Natural Recovery

MNR will be applied in all areas below the benthic RALs but above the benthic SCO (remedial action objective [RAO] cleanup level) that are not remediated through capping, dredging, or ENR. For all areas where MNR is applied, compliance monitoring of surface sediments (top 10 cm) will be implemented to evaluate whether the RAO 3 cleanup levels (benthic SCO criteria) are being achieved in a reasonable time frame or are not met within 10 years after remediation.

During RD, a decision framework will be developed in compliance monitoring to identify potential contingency measures if RAO 3 is not met in a reasonable restoration time frame. In contrast, MNR below benthic SCO areas will be monitored as part of the site-wide monitoring program to track progress toward achieving RAOs 1 and 2.

3.7.5 In Situ Treatment

ENR with in situ treatment may be used as a remedial technology depending on the results of the ongoing ENR/AC pilot study. Following completion of the pilot study, EPA will consider, in coordination with the State and Tribes, the use of in situ treatment with ENR (i.e., the ENR sand layer may be amended with AC or other sequestering agents to reduce the bioavailability of organic contaminants such as PCBs). The effectiveness and potential impacts of using in situ treatment or amendment technologies, as well as the areas best suited for these technologies, will be defined during RD considering the findings from the ENR/AC pilot study (see Section 2.3.2) and PDI results.

EPA may consider the use of in situ treatment in some of the Recovery Category 1 areas where it can be demonstrated that ENR with in situ treatment will maintain its stability and effectiveness in these areas over time. EPA may also consider ENR with in situ treatment in areas with COC concentrations up to the benthic cleanup screening level if it can be demonstrated that it will maintain its effectiveness over time.

The ENR/AC pilot study report may identify additional data that could be useful for designing in situ treatment using AC. This report is anticipated to be available during RD.

3.8 Habitat Design Considerations

To meet the substantive requirements of the Endangered Species Act and Section 404 of the Clean Water Act, sensitive species and their habitat will be identified within the active remediation areas as part of a biological assessment. The biological assessment (BA) will be prepared as a Pre-Final (90%) RD submittal and will evaluate potential impacts associated with the remedial actions.

A goal of the RD is to reestablish habitats impacted by the remedial activities, which may include restoring intertidal area elevations and substrate (i.e., restore dredged areas to pre-dredge elevations with suitable backfill). The RD will include an evaluation of pre-construction and proposed post-construction habitat areas and substrates, which will be considered in the Endangered Species Act consultation and Section 404(b)(1) evaluations. Materials used for caps, ENR, and backfill placement will be evaluated to assess habitat suitability in consultation with EPA. During RD, details and specifications will be developed for habitat elements for the reestablishment of targeted habitats.

EPA will use the information in the BA and the RD to conduct their Endangered Species Act consultation.

3.9 Other Design Considerations

3.9.1 Climate Change

Climate change impacts potentially affecting the greater Puget Sound region and relevant to the LDW include sea level rise; changes in precipitation patterns; and overall hydrological changes. Climate change adaptation generally focuses on evaluating the system's vulnerability to climate change and implementing adaptation measures, when warranted, to ensure the remedy continues to prevent human or environmental exposure to contaminants of concern (EPA 2015b).

Sea Level Rise

Climate change is expected to continue to increase sea levels over the next few hundred years (CIG/UW 2017). Anticipating an increase in mean sea level will correspond to a likewise increase in design water levels at the site; however, not all components of the RD are anticipated to be affected by an increase in design water levels. For example, dredging will not be impacted by the increase in water depth, and caps and ENR layers are designed for constant or tidal immersion. The design of engineered components of the remedy (e.g., shoreline caps) will need to incorporate potential long-term impacts from climate change by including erosion-resistance aspects (i.e., increasing elevations of anticipated shoreline stabilization; Webb and Schuchardt 2017).

Hydrodynamics

Increases in design water levels may result in a change (e.g., decrease) to bottom currents due to river/tidal currents and propwash velocities. These changes in bottom currents will be considered in the RD for engineered caps. In addition to rises in sea level, the increase of flooding in low-lying areas, higher tides, increased storm intensity and frequency, and heavier precipitation events could change LDW flow velocities and/or the frequency of high-flow events; however, ongoing water management practices at the Howard Hanson Dam effectively control peak river flows (USACE 2014; Brettmann 2017). The *Adaptation Strategies for Resilient Cleanup Remedies* (Ecology 2017) identifies potential vulnerabilities for sediment cleanup sites, such as the increased risk for scour, erosion, and habitat loss; the compromise of overwater structures; and the effect on remedy integrity and performance (e.g., caps, ENR).

Additional modeling of climate change on future hydrodynamics is not necessary for RD. First, propwash velocities tend to control cap design because they are much higher than velocities due to river flows. Second, ongoing water management practices at the Howard Hanson Dam effectively control most peak river flows in the Duwamish River (USACE 2014). Sea level rise will be considered external to the hydrodynamic model for similar reasons.

Sediment Load

Uncertainties in estimates of sediment load were evaluated as part of the RI/FS process. Climate change impacts and land use changes of upstream areas in the Duwamish watershed may affect the relative and total sediment contributions to the Duwamish Waterway. Past modeling addressed uncertainty in upstream sediment loads by using bounding assumptions 50% greater or 50% less than the estimated average upstream sediment load. These results will be considered in RD. No further modeling of these effects on sediment loads is planned due to the infeasibility of predicting changes to sediment load that have many contributory factors (e.g., upland development, agricultural practices, erosion, dam operations, stormwater discharges).

Design Approach

The RD will be developed using existing model results and design parameters based on existing environmental conditions and analyses (e.g., using the existing results from previous hydrologic and STM model runs, existing tidal ranges, etc.). The Intermediate (60%) and Pre-Final (90%) RD will evaluate potential impacts on the design from climate change and include revised design and long-term monitoring elements as appropriate to improve the resiliency of the remedy. The LTMMP outline will identify any expected measures for climate change adaptation, such as defining events that may trigger additional monitoring elements (e.g., 100-year high-flow events could trigger surveys or inspections in some locations).

3.9.2 Green Remediation

The RD will assess and specify greener construction activities to the extent practicable (e.g., during dredging, sediment handling, transportation, and disposal) consistent with EPA Region 10's *Clean and Green Policy* (EPA 2009a) and the *Superfund Green Remediation Strategy* (EPA 2010). The BODR will identify guidance documents that will be reviewed to inform the RD (e.g., ASTM E2876-13, *Standard Guide for Integrating Sustainable Objectives*, ASTM E2893, *Standard Guide for Greener Cleanups*). Additional guidance documents (if used) will be identified in the BODR. The core elements identified in these EPA documents include the following:

- Use energy conservation/efficiency approaches (including Energy Star equipment) and electric construction equipment where applicable.
- Use cleaner fuels (e.g., low-sulfur fuel or biodiesel), diesel emission controls and retrofits, and emission reduction strategies.
- Use water conservation/efficiency approaches (including Water Sense products).
- Use reused/recycled materials within regulatory requirements.
- Minimize transportation of materials and use rail rather than truck transport to the extent practicable.
- Protect land and ecosystems near the site.

Anticipated remedial construction activities will be evaluated to identify potential opportunities to implement the remedy consistent with the goals of the Green Remediation Strategy. Construction approaches that can be specified to address multiple goals will be highlighted.

3.10 Pre-Construction and Construction Submittals

Final (100%) RD will identify pre-construction and construction submittals that the selected construction contractor will be required to prepare. These pre-construction and construction submittals are delivered by the contractor.

The primary pre-construction submittal will be the construction contractor's RAWP. The RAWP will describe construction details. For example, the construction contractor will be responsible for identifying and securing specific transload facility locations and staging areas, listing equipment types and numbers to be used during construction, identifying haul routes, and listing import material sources. The contractor will also be responsible for developing and implementing the Vessel Management Plan, coordinating with Tribal fishing activities, and developing detailed construction schedules.

The contractor's RAWP is anticipated to address the following minimum construction elements that will be defined during RD:

- Contractor's Organization and Communication Plan
- Contractor's Health and Safety Plan (including community health and safety)
- Contractor's Construction Quality Control Plan
- Construction schedule and work hours
- Construction sequencing
- Location of transload and disposal facilities
- Staging areas and site preparation
- Engineering controls for all active remedial actions (e.g., dredging, capping, ENR, treatment)
- Environmental controls and BMPs
- Dredging and material placement operations (i.e., capping, ENR, in situ treatment, RMC)
- Dredge materials handling, potential dewatering, potential water treatment, and discharge operations
- Material transload, transportation, and disposal operations
- Vessel Management Plan

Additional anticipated pre-construction submittals often include the following:

- Insurance and bonding
- Disposal facility certifications
- Contractor's surveyor licensing/certifications
- Example contract administration forms (e.g., progress payments, change notifications, value engineering proposal requests, requests for information)

4 Remedial Design Support Activities

This section describes activities that will be conducted throughout the upper reach to support the RD process, as outlined in Section 3. These activities will provide the information needed to complete RD and to comply with ARARs. Results will be incorporated into the design and documented in the BODR. The deliverables associated with the design support activities are included under each effort and are summarized in Section 6.

4.1 Pre-Design Investigation Activities

RD will follow a phased approach that allows sufficient time for data gathering, engineering analyses, and EPA review at key project milestones. Field investigations that are needed to support the upper reach RD are detailed in the PDIWP (Appendix C). PDI will be conducted at the initial stage of the RD to address DQOs outlined in Appendix C and at a minimum will include the following:

- Sediment quality characterization to determine preliminary remedial action areas and technology assignment
- Geotechnical studies to inform dredge and cap design and work around existing infrastructure
- Physical and geophysical surveys, bathymetric/topographic surveys, and infrastructure condition surveys to inform remediation technology selection; geometric design of dredging, capping, and ENR; construction offsets and no-work area location; slope stability; and habitat conditions and considerations

The PDIWP (Appendix C) describes in detail the conceptual sampling plan (i.e., general principles applied for the sampling decision) and proposed data collection efforts for the two PDI phases to support RD. If any data gaps remain following the Phase II PDI, the Preliminary (30%) RD documents, or in EPA's review of those documents, a Phase III PDI sampling event will be conducted. A summary of the phased PDI studies, results, and preliminary remedial action areas and technology assignments will be presented in PDI Data Evaluation Reports (see Section 6.1.4).

An updated bathymetric survey was initiated in May 2019, in accordance with the EPA-approved *Quality Assurance Project Plan: Pre-Design Surveys of the Lower Duwamish Waterway Upper Reach* (Appendix D), in advance of the Phase I PDI. The updated bathymetry will inform potential refinements to Recovery Category assignments.

4.2 Base Mapping

A base map of the upper reach is necessary to support RD because it is the basis for developing plans, identifying property lines, establishing potential access points (e.g., public roadways, haul routes), determining constraints due to structure presence (e.g., bridges, underwater clearance), and identifying utility locations. Detailed maps of the site are available and will be supplemented as needed during RD. Base mapping activities that will supplement existing mapping will be obtained from the following additional field surveys:

- Bathymetric and topographic surveys
- Structure and debris surveys (as-builts where available; structure dimensions from surveying; and condition assessments from visual inspection)
- Utilities (private locate, utility owner, National Oceanic and Atmospheric Administration maps as sources)
- Habitat delineation

In addition to field surveys, mapping conducted by others may be acquired and used to aid in the RD, such as aerial photography, adjacent infrastructure, property boundary maps, and historical landmarks.

All supporting mapping information obtained will be merged into the base map using the tidal reference datum of MLLW (the average of the lower low-water height of each daily epoch), for the Final (100%) RD process. The compiled base map of the entire upper reach will be prepared during Preliminary (30%) RD.

4.3 Hydrodynamic Information

Existing hydrodynamic modeling information will inform cap design stability criteria and cap material specifications to protect the cap against both predicted velocities up to the 100-year discharge event and vessel-induced scour forces (e.g., propeller scour, vessel wakes). The hydrodynamic model's predicted velocities and flow directions will also be used to assess sediment resuspension impacts during dredging and select appropriate types of sediment resuspension BMPs if needed.

The anticipated range of climate change effects on hydrology, peak river flow velocities, sea level, and bathymetry will be incorporated into the RD analyses as discussed in Section 3.9.1.

4.4 Zero-Rise Evaluation

A zero-rise evaluation may need to be conducted to ensure that the RD complies with federal and state floodplain management ARARs, depending on the specifics of the RD. Section 60.3(d)(3) of the National Flood Insurance Program and King County Code Section 21A.24.240 (zero-rise flood fringe) stipulate that any development or alterations to the floodplain shall not increase the base flood elevation or energy grade line elevation during the occurrence of the 100-year flood discharge. Per the Federal Emergency Management Agency (FEMA) Region 10 guidance document *Procedures for "No-Rise" Certification for Proposed Developments in the Regulatory Floodway* (FEMA 2013), a "no-rise" certification may need to be obtained for the upper reach remedial action based on hydraulic analyses.

If a zero-rise evaluation is required, the USACE's Hydrologic Engineering Center – River Analysis System (HEC-RAS) hydraulic model would be used to evaluate the effect of the remedial action on the 100-year flood elevation. This model would be used to estimate the pre-construction and post-construction flood stage elevations in the upper reach and upstream and downstream of it. HEC-RAS is the FEMA-accepted modeling tool used for determining the base flood elevations reported in FEMA Flood Insurance Studies. The existing HEC-RAS floodplain model developed by FEMA for the Duwamish River would be used directly to represent pre-construction conditions and would be modified at the site location to represent post-construction conditions.

The zero-rise analysis may need to be conducted to demonstrate that the remedial action does not result in unacceptable flood rise in the Lower Green/Duwamish River during the 100-year return interval flood event. Results from the zero-rise analysis will be documented in the BODR.

4.5 Transload Facility Requirements

A transload facility is a specified location where dredged material will be offloaded from one mode of transportation (in-water, such as barges) and loaded onto another mode (upland, such as trucks or rail) for upland transport and off-site landfill disposal. The transload facility typically serves the following purposes: dredged material temporary stockpile; rehandling operations; ex situ treatment (if applicable); dewatering and water treatment (if applicable); equipment laydown for temporary storage; water-based equipment mooring and adjacent upland staging; and decontamination area (including wheel wash for haul trucks and related equipment).

Commercial transload facilities have been previously set up at existing facilities to support dredging and capping projects within the LDW and have been used by some of the EAA projects. The current infrastructure, condition, and capacity of these existing commercial facilities will be evaluated during RD.

Existing transload facilities may have production rate limitations, and they can also be used by multiple projects at the same time. LDWG may decide to assess the feasibility of establishing one or more dedicated transload facilities for the upper reach remedial actions, which would necessitate additional ARARs evaluations (for substantive compliance and/or permitting requirements). Results from the assessments will be documented in the BODR.

4.6 Potential Water Quality Impacts

Potential water quality impacts due to sediment resuspension associated with dredging and other remedial actions (in-water work) are expected to be temporary and located at or close to the point of disturbance. Water quality monitoring has been conducted during the construction of the EAAs and many similar regional sediment remediation projects. The most common water quality issue observed has been occasional exceedances of turbidity criteria, either during dredging or placement of clean cap/ENR material. As discussed in Section 3.7, a range of BMPs will be evaluated and summarized in the BODR to minimize and reduce the degree of resuspension.

4.7 Dredged Material Treatment

Two regional Subtitle D landfills (Waste Management, Inc., located at Columbia Ridge, Oregon, and Allied Waste, Inc., located at Roosevelt, Washington) are permitted to accept "wet" sediment (i.e., containing free liquid) generated from mechanical dredging, thereby avoiding the need to stabilize or dewater mechanically dredged materials prior to transport. Hydraulically dredged sediment would need to be dewatered prior to transport to landfills. However, the overall need for treatment studies will be assessed when preparing the Phase II PDI Data Evaluation Reports that will inform dredging, dewatering, water management, transportation, and disposal design. LDWG may decide to assess specific dredged material treatments if PDI data evaluation suggests there may be value in treating the dredged material, but treatment studies are not anticipated at this time.

The selected remediation contractor may also propose to conduct treatment studies during pre-construction to inform their construction means and methods for elements such as sediment dewatering or water treatment.

No dredged material treatment studies are anticipated to be needed to complete RD. If specific dredged material treatment studies are determined to be necessary, a QAPP addendum for treatment studies would be developed for the Phase III PDI and summarized in the Phase III PDI Data Evaluation Report. Findings from these studies and how they will be incorporated into RD will be described in the 60% BODR.

4.8 Waste Characterization

The PDIWP (Appendix C) summarizes the characterization of potential waste material (i.e., dredged material) to provide preliminary data about whether the waste material meets both regulatory requirements and bulk chemistry and leachate concentration requirements for disposal at specific commercial landfill facilities. Waste characterization data are anticipated to be collected as part of Phase II or Phase III PDI and summarized in the Phase II or Phase III PDI Data Evaluation Report.

4.9 Clean Material Source Identification

Locally available sources of aggregate material (e.g., commercial sand and gravel quarries) that can supply materials for capping (e.g., sand, gravel, armor rock) and ENR (e.g., sand) will be identified during RD. The contractor will ultimately select appropriate material suppliers that can meet the design quantities, gradations, and chemical quality criteria established for each material type during RD.

Monitoring results from the ENR/AC pilot study will inform and describe the effectiveness of using AC as an in situ treatment with ENR. AC is also a common amendment for cap designs. If the AC amendment is included as a component of the RD for ENR or as a cap amendment, AC vendors that can meet the design quantities and other prescriptive criteria established for AC will also be identified during RD.

The BODR will present the results from the supplier research and material source identification.

4.10 Archaeological, Cultural, and Historic Surveys

The LDW and vicinity encompasses cultural resources including archaeological sites, districts, historic buildings and structures, objects, traditional fishing locations, and areas of cultural or spiritual significance. Consistent with Section 106 of the National Historic Preservation Act of 1966, and to comply with historical and archaeological preservation requirements, any cultural resources in the vicinity of the upper reach potentially impacted by remedy implementation (e.g., upland areas used for staging) and included or eligible for inclusion in the National Register of Historic Places will be assessed to determine whether remediation plans need to accommodate cultural resources. Confirmation of this assessment will be documented in the BODR.

An Inadvertent Discovery Plan will be prepared, including specifications to ensure protection of historical Native American artifacts and cultural and archaeological resources. Confirmation of Section 106 compliance will be conducted during the Preliminary (30%) RD. The Inadvertent Discovery Plan will be drafted at the Pre-Final (90%) RD phase and finalized during the Final (100%) RD.

4.11 Tracking Changes in the Upper Reach During Design

Bank or in-water construction activities (e.g., permitted maintenance dredging) within the limits of the upper reach may take place during the anticipated RD duration. Upper reach construction activities could modify existing conditions. Therefore, any planned or completed construction activities within the upper reach from 2019 (representing the upper reach RD notice to proceed) through anticipated RD completion in 2023 (see Section 7) will be tracked and summarized in the BODR. Construction activities will be documented by tracking USACE permits and through communications with water-dependent users (see Section 2.5).

In addition, the 2018 waterway user survey (Integral et al. 2018), plus findings from the Phase I PDI (in terms of horizontal delineation of extents of contamination and remedial technologies assignments), should help to identify remaining data gaps needed to support the design (e.g., assessing waterfront infrastructure and banks near remediation areas, identifying potential sources of disruption during construction).

Should non-remediation-related construction take place between RD and remedial construction, the implementing entity will review the changed conditions and revise the Drawings and Specifications as necessary.

4.12 Source Control Integration

Remedial construction of the upper reach will proceed following source control sufficiency determinations. Ecology has identified 24 source control areas for the LDW as part of their source control strategy (Ecology 2016) for the LDW sediment remedy. Nine of these source control areas (10 through 14 and 21 through 24) drain to the upper reach, and sufficiency recommendations will be developed for each of these areas by Ecology (although areas may be bundled in documentation). EPA is expected to complete the sufficiency determinations by Final (100%) RD for the upper reach. Ecology may consult on source control evaluations with the LDW Source Control Workgroup (currently consisting of representatives from Ecology, King County, the City of Seattle, the Port of Seattle, Puget Sound Clean Air Agency, Washington State Department of Transportation, and EPA; see ROD Section 13.2.7).[14]

Ongoing coordination between Ecology, EPA, and LDWG (during RD) and the implementing entity (during contracting and remedial action) will be necessary to ensure that the RD details (e.g., areas targeted for active in-waterway sediment remediation activities) pertaining to source control activities are provided to Ecology in a timely manner, through routine check-ins and at critical RD milestones. The following proposed milestones represent anticipated coordination check-ins during RD, which may be modified at the direction of EPA:

- Following the PDI Phase I data evaluation, when approximate active remedial action areas are delineated
- Following Preliminary (30%) RD, when remedial action area boundaries, bank remediation footprints, and technology assignments are nearly complete
- Following Pre-Final (90%) RD, when remediation contracting schedules are being planned to accommodate the source control sufficiency determinations that precede remedial construction

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[14] Information on the current status of source control efforts can be found on Ecology's website available at: https://ecology.wa.gov/Spills-Cleanup/Contamination-cleanup/Cleanup-sites/Toxic-cleanup-sites/Lower-Duwamish-Waterway/Source-control.

4.13 Site Access

Site access must be considered throughout RD (e.g., for PDI field sampling, RD geotechnical work, and in planning for equipment and materials staging, shore access during construction). In addition, proprietary controls may be necessary to protect the remedy. Depending on the owner and the nature and duration of the access, written agreements or other legal documentation (e.g., leases, easements, deed restrictions) may be required.

Waterway and adjacent property ownership is shown in Figure 4-1. The upper reach of the waterway consists mostly of public-owned aquatic land (the Port of Seattle and the State of Washington) but includes some submerged portions of adjacent upland parcels. Access agreements are not needed for sampling or transient access to Port- or State-owned portions of the LDW Superfund Site, and it is anticipated that access for RD purposes to waterway and upland properties owned by LDWG parties will be readily approved. Access agreements may be required by private owners of waterway or adjacent property. During RD, properties where access agreements are needed will be identified.

During the PDI, sampling will occur in active berths, in underpier areas, and in the vicinity of dolphins/pilings, bulkheads, and riprapped or engineered banks. LDWG will proactively coordinate with property owners to provide notification or obtain access agreements, as necessary, based on specific access needs.

Property acquisition, leases, and/or easements may be needed for remedial activities that disrupt businesses or for off-site staging areas that may be required for the contractor's material and equipment staging. Coordination with property owners or lessees will be needed during RD to accommodate construction near infrastructure and in underpier areas. Construction equipment selection will account for access constraints for vessels transiting the LDW.

As stated in Section 6, site access will be discussed in the BODR, access and easement requirements will be included in the Preliminary (30%) RD, a Draft Permitting and Site Access Plan will be included in the Pre-Final (90%) RD, and a Final Permitting and Site Access Plan will be included in the Final (100%) RD. Proprietary controls will be evaluated in the ICIAP outline submitted as part of the 90% and 100% RD submittals.

4.14 Documenting Substantive Compliance with Applicable or Relevant and Appropriate Requirements

ARARs are legally applicable or relevant and appropriate substantive 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 under federal law. ARARs for the remedial action are presented in Table 26 of the ROD (included in Appendix A of this report). Sections 3 and 4 describe key design elements that will be used to comply with anticipated

ARARs. The RDWP does not list all potential design needs; 30% design must be developed to help identify applicable ARARs and assess whether there are data gaps and additional design elements needed to comply with those ARARs. The BODR will include descriptions of how substantive compliance with ARARs will be achieved and documented.

4.15 Permitting

Federal, state, and local permits are not required for CERCLA response actions that are completely conducted on site, provided that the response action is performed in compliance with the substantive requirements of all ARARs (EPA 1992a). During RD, EPA and LDWG will determine if there are any permits required for remedial action outside of the ARARs listed in Table 26 of the ROD (included in Appendix A of this report). In addition, permitting for any necessary off-site work (e.g., landfill permits for creating a new project-specific landfill, building permits for transload structures that are not considered to be on site) will be identified and discussed in the BODR.

If any material is to be removed from the site for transloading, treatment, and/or disposal at pre-existing facilities, the compliance status of these facilities will be confirmed before beginning the removal action by contacting the appropriate EPA regional Off-Site Rule coordinator.

A Draft Permitting and Site Access Plan will be included in the Pre-Final (90%) RD, and a Final Permitting and Site Access Plan will be included in the Final (100%) RD.

5 Upper Reach Physical Conceptual Site Model and Expected Outcomes from Remedial Action

The objectives of cleanup in the LDW are to meet the following four RAOs presented in Section 8 of the ROD:

- **RAO 1:** Reduce risks associated with the consumption of contaminated resident LDW fish and shellfish by adults and children with the highest potential exposure to protect human health.
- **RAO 2:** Reduce risks from direct contact (skin contact and incidental ingestion) to contaminated sediments during net fishing, clamming, and beach play to protect human health.
- **RAO 3:** Reduce to protective levels risks to benthic invertebrates from exposure to contaminated sediments.
- **RAO 4:** Reduce to protective levels risks to crabs, fish, birds, and mammals from exposure to contaminated sediment, surface water, and prey.

To meet these objectives, EPA selected a remedy that uses a variety of remedial technologies targeted to different areas of the waterway (e.g., dredging, partial dredging and capping, capping, ENR, MNR to benthic SCO, and MNR below benthic SCO). The predicted outcomes of the selected remedy are summarized in ROD Section 13.4. This section describes the physical CSM for the upper reach and includes physical impacts from implementing remedial actions in order to conceptually discuss the expected outcomes from remediation. This physical CSM, as shown on Figure 5-1, was also informed by the lessons learned from the remediation of the EAAs (Section 2.3.3).

The physical CSM is intrinsic to the RI/FS process, the selected remedy, and the approach to RD for the remedial technologies described in Section 3.7. The RD process takes into consideration the physical CSM when conducting engineering evaluations, establishing design criteria, and developing monitoring plans. For example, the physical CSM factors into residuals management design, water quality monitoring planning, source control sufficiency determination, dredging and material placement design, CQAP development of during construction monitoring, and long-term monitoring to assess MNR effectiveness.

5.1 Sediment Sources

As discussed in Section 2.1.4 and illustrated on Figure 5-1, 99% of sediment entering the upper reach originates from the upstream Duwamish/Green River system, with more than one-third of it depositing in the upper reach. As a general trend, concentrations in the upper reach will approach upstream sediment concentrations over time. Studies by Ecology (data received from Ecology by Windward [Ecology 2009]), the USACE (2009a, 2009b), the U.S. Geological Survey

(Conn and Black 2014; Conn et al. 2015; Conn et al. 2018), and King County (data received from King County by Windward [King County 2016a]) have been conducted to characterize upstream suspended solids that enter the LDW. The Data Evaluation Report (Windward 2018c) provides a summary of these data including estimates of contaminant concentrations on suspended solids.

Lateral sources, including bank erosion, a CSO, SDs, and creeks (North and South forks of Hamm Creek) are secondary sources of sediment into the upper reach. Source tracing samples by Seattle, King County, and other entities have been conducted to characterize drainage solids that enter the LDW. The Data Evaluation Report (Windward 2018c) provides a summary of these data including estimates of SD and CSO contaminant concentrations on solids for the LDW as a whole.

5.2 Sediment Transport

In addition to sediment transported from the Green River into the upper reach, other sediment transport mechanisms include sediment scour and resuspension caused by high-flow events and vessel maneuvering, as discussed in Section 2.1.4 (Figure 5-1). Both of these causes are ongoing and affect the long-term concentrations that will be observed in the upper reach. Lateral discharges from outfalls can also have localized impacts on receiving sediments near the outfalls.

Episodic high-flow events (e.g., greater than a 2-year event) can result in increased bottom velocities and bed resuspension. The saltwater wedge, where present, tends to reduce flow velocities near the river bottom because the freshwater river flow will flow on top of the saltwater wedge; therefore, river bottom velocities are higher when the saltwater wedge is absent. Potential scour areas in the upper reach from Green River high-flow events were identified based on STM predictions, and more are located in the FNC than in higher elevation areas of the waterway. Sediment resuspended during a high-flow event is likely to be carried downstream and redeposited in an area with lower velocities. Most areas in the upper reach that are predicted to scour during a high-flow event are still net depositional on annual time scales.

Propwash from maneuvering vessels is the other primary cause of potential resuspension in the upper reach (Figure 5-1). The FS analysis found evidence for propwash impact from maneuvering vessels near berthing areas, and minor resuspension/mixing from transiting vessels in the FNC (FS Section 2.3.1.1). The location of propwash scour on the sediment bed depends on the vessel characteristics, bathymetry, sediment characteristics, configuration of the docks, and the docking procedures used during vessel maneuvering. Propwash forces are sensitive to the water depth below the prop, the amount of throttle used during maneuvering, and the duration that the prop is activated in a given location. Compared to high-flow scour, most material that has been resuspended by propwash is likely to redeposit in a nearby location due to the much smaller footprint that can be impacted by propwash and the rapid drop-off of propwash velocities at increasing distances from the vessel's propeller.

5.3 Remedial Action Effects on the Physical Conceptual Site Model

Project experience in the EAAs (Section 2.3.1) and in other cleanup sites similar to the LDW can provide insight into the expected outcomes from remedial actions. This section and Figure 5-1 briefly describe and depict the effect a remedial action has on the physical CSM and the conceptual expected outcome from using different remedial technologies during and following construction.

5.3.1 Dredging

Dredging removes sediment contaminated above applicable RALs from the waterway to the maximum extent practicable. Furthermore, the process of dredging generates resuspended sediments (i.e., dredge residuals) that are intrinsic to environmental dredging projects (USACE 2008).

Most resuspended sediment from dredging is expected to settle near the dredging area and have approximately the average concentration of the dredged material. Dredge residual deposits tend to be thin (e.g., less than a couple of inches thick) with low density, high water content, and very low strength, and are therefore difficult to redredge.

In the short term, dredging impacts the physical CSM because it results in additional resuspension of contaminated sediments, which can cause a short-term increase in observed surface sediment concentrations within and adjacent to the dredging area. An RMC layer may be placed on recently dredged areas as an engineering control to stabilize and reduce concentrations in the biologically active zone (Figure 5-1).

The potential impact from dredging is considered a short-term effect and negligible with respect to long-term expected outcomes. As observed during EAA construction, any increases in sediment concentrations in and adjacent to dredging areas are expected to be gone within 1 year to a few years following construction.

5.3.2 Capping

Capping isolates contaminated sediment from surface exposure. Cap placement is expected to create turbidity in the water column during placement activities. However, this turbidity will be transient and associated with the clean cap material, so these impacts do not impact the physical CSM for contaminated sediment movement. Cap materials will have lower concentrations than the incoming upstream sediment. Therefore, following construction, surface sediment concentrations in capping areas are expected to increase toward surrounding surface concentrations over time.

5.3.3 Enhanced Natural Recovery

ENR consists of a thin layer of material placement, which may mix with underlying sediment and/or newly deposited sediment over time. ENR placement is expected to create turbidity in the water column during placement activities. However, this turbidity will be transient and associated with the clean ENR material, so it does not impact the physical CSM for contaminated sediment movement. ENR materials will have lower concentrations than the incoming upstream sediment. Therefore, following construction, sediment concentrations in ENR areas are expected to increase toward surrounding surface concentrations over time.

5.3.4 Monitored Natural Recovery

MNR is applied to areas with relatively low initial surface sediment concentrations and/or low scour potential. MNR areas may be impacted in the short term by releases from adjacent areas, either during dredging or placing clean material. Over the long term, MNR is driven by sediment deposition and transport processes described in Section 5.2.

5.4 Anticipated Short-Term and Long-Term Post-Remediation Outcomes

The expected conceptual outcomes to the upper reach of the remedial technologies described in Section 5.3 are described in this section. Nevertheless, there is uncertainty associated with accurately predicting immediate post-remediation surface concentrations for the overall upper reach due to numerous variables (e.g., sequencing of work, contractor's equipment selection and construction means and methods, natural events such as high flows, and anthropogenic influences such as vessel propwash that occur during construction).

As previously observed on the LDW EAAs,[15] and assuming upper reach sources are sufficiently controlled, the expected outcome of remediation in the overall upper reach is that surface sediment concentrations will equilibrate toward the surrounding sediment concentrations. In the long term, as more remediation and source control occur, the sediment concentrations will continue to decrease toward the incoming upstream sediment concentration. However, specific areas within the upper reach are anticipated to behave differently in the short term immediately following construction, depending upon the remedial technology implemented, as described in the following sections.

[15] For example, *Duwamish Diagonal Sediment Remediation Project: 2011 and 2012 Monitoring Report* (King County 2016b) and *Post-Construction Surface Sediment Monitoring Report—Year 3 Duwamish Sediment Other Area and Southwest Bank Corrective Measure and Habitat Project Boeing Plant 2, Seattle/Tukwila, Washington* (Wood 2018).

5.4.1 Enhanced Natural Recovery, Capping, and Backfill Placement Areas

The surface sediments are expected to be at or below cleanup levels immediately post-placement in ENR, capping, and backfill areas because the material used for those remedial technologies will be tested to ensure it meets specified chemical concentration criteria prior to placement. For a short time after placement, the surface sediments in these areas will equilibrate to reflect a combination of placed material and depositional sediments composed of surrounding sediments and upstream and localized lateral inputs. In the long term, the surface sediment concentrations are anticipated to equilibrate to upstream sediment concentrations as incoming upstream sediment is deposited in the area through natural sedimentation processes.

5.4.2 Dredged Areas

After required dredging has been completed to design depths that account for ROD requirements, confirmation samples will be collected in dredge areas to assess whether remaining sediments exceed RALs. Results from the confirmatory sampling program, which will be developed as part of the CQAP, will be used to determine whether required backfilling or capping, additional dredging ("redredging"), or other contingency action (e.g., placing RMC) is needed, as described in the next sections. Contingency actions and a decision process will be developed in the CQAP.

5.4.2.1 Dredged Areas with Surface Concentrations Below Remedial Action Levels

If the post-dredging confirmation samples indicate surface (0- to 10-cm [i.e., the compliance depth]) sediment concentrations are below the RALs and the benthic cleanup levels (benthic SCO), no further dredging is required by the ROD, and backfill material, if required for elevation reasons (e.g., habitat areas), can then be placed. These areas will be incorporated into long-term monitoring plans to assess progress toward compliance with cleanup levels.

5.4.2.2 Dredged Areas with Surface Concentrations Above Remedial Action Levels

If the post-dredging confirmation samples indicate surface sediment concentrations above RALs, benthic cleanup levels, or both, contingency action will be required. For dredging areas requiring a cap or backfill, Section 5.4.1 describes the anticipated short-term and long-term post-remediation outcomes.

5.4.3 Areas Adjacent to Dredging

Dredge residuals from nearby dredging activities may be transported outside of the dredging area and then settle on the adjacent surface, causing the surface sediment concentrations in these areas to be higher than pre-dredge conditions. Confirmation samples will be collected in adjacent areas to assess the need for contingency actions.

6 Remedial Design Deliverables

This section describes the deliverables to be prepared for the RD in accordance with AOC4 SOW (EPA 2018).

6.1 Pre-Remedial Design Deliverables

6.1.1 Pre-Design Investigation Quality Assurance Project Plans

The PDI QAPPs address sample collection, analysis, and data handling. The QAPPs will include a field sampling plan, maps with sampling locations, sampling location placement rationale, and an explanation of DQOs, QA and quality control (QC), and chain-of-custody procedures for any treatment studies, design, compliance, and monitoring samples. The QAPPs will address disposal of Investigation Derived Waste in accordance with *Guide to Management of Investigation-Derived Wastes* (EPA 1992b).

A QAPP and QAPP addenda will be submitted to EPA for each field sampling effort in accordance with *EPA Requirements for Quality Assurance Project Plans* (EPA 2006), *Guidance for Quality Assurance Project Plans* (EPA 2002), and *Uniform Federal Policy for Quality Assurance Project Plans* (EPA 2005). PDI QAPP addenda will be developed and submitted 30 days after submittal of the draft PDI Data Evaluation Report.

6.1.2 Pre-Design Investigation Health and Safety Plan

The PDI Health and Safety Plan (HASP) will describe all activities to be performed to protect on-site personnel and others transiting the area or living or working nearby from physical, chemical, and all other hazards posed by the work. HASPs will be developed in accordance with EPA's Emergency Responder Health and Safety and Occupational Safety and Health Administration (OSHA) requirements under 29 C.F.R. §§ 1910 and 1926. EPA will not approve the HASP but will review it to ensure that all necessary elements are included and that the plan provides for the protection of human health and the environment.

6.1.3 Pre-Design Investigation Data

Data collected during the PDI will be submitted to EPA.

6.1.4 Pre-Design Investigation Data Evaluation Report

The PDI Data Evaluation Reports will include the following:

- Summary of the investigations performed
- Summary of investigation results
- Narrative interpretation of data and results, with supporting figures and tables, including updated graphics (similar to ROD Figure 18 [included in Appendix A of this report] or more detailed) of specific remedial technologies and details of how the decision trees in the ROD were applied (Figure 19 and corrected Figure 20 [included in Appendix A of this report])
- Results of statistical and modeling analyses, as needed
- Photographs documenting the work conducted
- Conclusions and recommendations for RD, including design parameters and criteria, and identification of any remaining data gaps needed to support the design

6.2 Remedial Design Deliverables

Design deliverables will be prepared and submitted to EPA at the Preliminary (30%), Intermediate (60%), Pre-Final (90%), and Final (100%) RD stages. Table 6-1 illustrates the timing of the development of various design deliverables in relation to the overall design process. The following subsections present the information and documents that will be submitted as part of the design deliverables in accordance with AOC4 SOW (EPA 2018).

6.2.1 Preliminary (30%) Remedial Design

The key deliverable of the Preliminary (30%) RD is the BODR. The draft BODR will document the design process outlined in Sections 3 and 4 of this document. The primary purpose of the BODR is to identify and establish design criteria for major elements of construction, present the technical requirements of the design elements, and document how they apply to the overall remedial action. The BODR will describe the analyses conducted to select the design approach, including a summary and detailed justification of design assumptions, restrictions, and objectives to be used in the design of the selected remedy, and supporting calculations.

The draft BODR will be submitted as part of the Preliminary (30%) RD and updated in subsequent RD submittals. The BODR will include the following:

- Designation of remedial action areas based on a Recovery Category evaluation and contaminant concentrations compared to RALs
- Designation of SMAs considering location-specific conditions (e.g., structural considerations, geotechnical considerations, site use, habitat, etc.)

- Narrative basis of design for selection of remedial technologies for SMAs (e.g., dredge, cap, ENR, and MNR), including supporting technical evaluations
- Permitting, site access, and easement requirements
- Preliminary construction sequence, scheduling, and cost estimate
- Anticipated long-term maintenance and monitoring approaches, including any expected measures for climate change adaption
- Evaluation of institutional control requirements for caps
- Archaeological monitoring and discovery
- Transportation and disposal approaches
- Scheduling and coordination of work under AOC4 SOW with other in-water work or navigation or development projects on the bank and intertidal or subtidal areas, if they may substantively affect RD or construction in the upper reach
- Green and sustainable remediation evaluation and implementation approach, in accordance with *Principles for Greener Cleanups* (EPA 2009b)
- Approach to implementation and assurance of institutional controls,[16] in accordance with *Recommended Evaluation of Institutional Controls: Supplement to the "Comprehensive Five-Year Review Guidance"* (EPA 2011); *Institutional Controls: A Guide to Planning, Implementing, Maintaining, and Enforcing Institutional Controls at Contaminated Sites* (EPA 2012a); and *Institutional Controls: A Guide to Preparing Institutional Controls Implementation and Assurance Plans at Contaminated Sites* (EPA 2012b)
- Geotechnical basis of design (e.g., stable construction slope angles)
- Sediment excavation prism design and verification
- Capping design criteria
- ENR design criteria
- Descriptions of the analyses conducted to select the design approach, including a summary and detailed justification of design assumptions, restrictions, and objectives that will be used in the design of the selected remedy
- Essential supporting calculations (at least one) for each significant or unique design calculation, such as cap thickness or propwash modeling
- General design elements for remedial technologies, such as:
  - Identification of candidate transloading locations, anticipated transport methods, and permitted upland off-site landfill facilities
  - Identification of potential import material sources
- Anticipated dredging and material placement equipment types

[16] These do not include fish consumption advisory institutional controls, which are currently being developed under an agreement between EPA and Seattle-King County Public Health.

- Requirements during construction such as any needed controls and monitoring to comply with ARARs and minimize impacts (in accordance with Section 13.2.5 and Section 13.2.8 of the ROD)
- Contracting strategy to procure the remediation contractor

Table 6-1
Remedial Design Elements

Document	Element	Description	Preliminary (30%) Remedial Design	Intermediate (60%) Remedial Design	Pre-Final (90%) Remedial Design	Final (100%) Remedial Design
BODR Text and/or Appendices	Basis of Design for Remedial Technologies (dredging, capping, ENR, MNR>SCO)	Development of design criteria for technology areas, including the development dredging prisms, capping thicknesses, material grain sizes, material transport and transload, and other criteria.	Draft	Draft Final	Final	
	Transload Facility Criteria	Identification of candidate transloading location.	Draft	Draft Final	Final	
	Green and Sustainable Remediation Evaluation and Implementation Approach	Green and sustainable remediation calculations and implementation approach.	Draft	Draft Final	Final	
	Engineer's Construction Project Schedule	Engineer's project schedule for remedial action construction.			Draft Schedule	Final Schedule
	Engineer's Capital and Operation and Maintenance Cost Estimate	Cost estimate for post-construction operations, maintenance, and monitoring.			Draft Cost Estimate	Final Cost Estimate
	ARAR Compliance Evaluation	Descriptions of how compliance with ARARs will be achieved and documented.	Draft Evaluation	Final Evaluation		
	Habitat Area Identification	Identification of sensitive species and their habitat areas within the upper reach to facilitate the Biological Assessment and comply with the Endangered Species Act and Section 404 of the Clean Water Act.			Draft Identification	Final Identification
Drawings	Drawings	RD drawing package.	30% Drawings plus a list of all drawings for subsequent submittals	60% Drawings plus a list of all drawings for subsequent submittals	90% Drawings	100% Drawings
Specifications	Specifications	RD specification package.	Outline	Revised Outline	90% Specification Package	100% Specification Package
	Emergency Response Plan Specification	Procedures to be followed in the event of an accident or emergency during remedial construction. Requirements will be defined in the Specifications; the Emergency Response Plan itself will be a component of the contractor's RAWP.	Outline	Revised Outline	90% Specification	100% Specification
	Vessel Management Plan Requirements	Anticipated vessel operations necessary to complete the remedial action such as types of vessels, access points, and vessel frequency. The Vessel Management Plan itself will be an element of the contractor's RAWP.			90% Specification of Required Elements	100% Specification of Required Elements
LTMMP Outline	LTMMP Outline	Post-construction long-term operations, maintenance, and monitoring elements, including any expected measures for climate change adaptation.	Draft Outline and Description	Revised Outline and Description	Annotated Outline and Description	Annotated Outline and Description
Sediment Remedy ICIAP Outline	Sediment Remedy ICIAP Outline	Evaluation of the most appropriate institutional, proprietary controls and location-specific use restrictions needed to ensure long-term effectiveness of the remedy.	Draft Outline and Description	Revised Outline and Description	Annotated Outline and Description	Annotated Outline and Description

Document	Element	Description	Preliminary (30%) Remedial Design	Intermediate (60%) Remedial Design	Pre-Final (90%) Remedial Design	Final (100%) Remedial Design
CQAP	CQAP	Descriptions of activities that will be implemented to ensure the remedial action construction satisfies all plans, specifications, and related requirements, including quality objectives.	Summary Table	Revised Summary Table	Draft Plan	Final Plan
WQMP	WQMP	Plan for collecting and responding to water quality data during construction.			Draft Plan	Final Plan
QAPP and HASP	Addenda to QAPP and HASP. Provided as appendices to CQAP and WQMP.	QAPP and HASP for remedial action construction oversight and monitoring activities. The contractor will prepare a separate RAWP and contractor HASP per specifications.			Draft Plan	Final Plan
Archeological Discovery Plan	Archeological Discovery Plan	Documentation of districts, sites, buildings, structures, or objects included or eligible for inclusion in the National Register of Historic Places that are potentially impacted by remedy implementation. Specifications for an archaeological discovery plan to ensure protection of Native American artifacts and cultural or archaeological resources.			Draft Plan	Final Plan
Biological Assessment	Biological Assessment	Reasonable and prudent measures that will be taken to guide implementation of the selected remedy with respect to the protection of listed species.			Draft BA	Final BA
Clean Water Act Section 404 and Section 10 Rivers and Harbors Act of 1899 Memorandum	Clean Water Act Section 404 and Section 10 Rivers and Harbors Act of 1899 Memorandum	Documentation to evaluate compliance with Clean Water Act Section 404 requirements.			Draft Memo	Final Memo
Community Outreach and Communications Plan	Community Outreach and Communications Plan	Description of actions that will minimize the potential impacts, including safety issues, of remedy implementation on the community and a plan for communicating with and responding to the community.			Draft Plan	Final Plan
Compensatory Mitigation Plan	Compensatory Mitigation Plan	Plan for compensatory mitigation if necessary to comply with Clean Water Act Section 404 requirements.			Draft Plan	Final Plan
Permitting and Site Access Plan	Permitting and Site Access Plan	Plan for obtaining and complying with permits and obtaining site access needed for remedial action construction.			Draft Plan	Final Plan
Section 408 Compliance Documentation	Section 408 Compliance Documentation	Documentation to evaluate compliance with 33 U.S.C. Section 403 and Section 408.			Draft Memo	Final Memo

Other components of the Preliminary (30%) RD will include the following:

- Preliminary plans (i.e., drawings) including a list of all drawings to be included in the Intermediate (60%), Pre-Final (90%), and Final (100%) RD
- An outline of construction specifications prepared in Construction Specification Institute's (CSI) Master Format
- Identification of candidate transloading locations, transport methods, permitted upland off-site landfill facility, and import material sources
- A schedule, contracting strategy, contractor requirements, any needed controls and monitoring to comply with ARARs and minimize impacts (in accordance with Section 13.2.5 and Section 13.2.8 of the ROD), and plans to manage potential conflicts with other in-water work, treaty-protected uses, navigation, recreation and commerce, and upland developments and land use changes that may affect RD and construction in the upper reach
- Access and easement requirements
- Descriptions of how compliance with ARARs will be achieved and documented, specifying documentation requirements associated with ARARs (such as a Biological Assessment, Compensatory Mitigation Plan if needed, Archaeological Discovery Plan)
- An outline and description of LTMMP elements for the upper reach including any expected measures for climate change adaptation
- An outline of the Sediment Remedy ICIAP, including an evaluation of the most appropriate institutional, proprietary controls and location-specific use restrictions needed to ensure long-term effectiveness, consistent with ROD Section 13.2.4 (EPA 2014)
- An outline of an Emergency Response Plan

6.2.2 Intermediate (60%) Remedial Design

The Intermediate (60%) RD will be a continuation and expansion of the Preliminary (30%) RD. The Intermediate (60%) RD will address EPA's comments on the Preliminary (30%) RD and include the elements and deliverables required for the Preliminary (30%) RD at a 60% level of completion.

6.2.3 Pre-Final (90%) Remedial Design

The Pre-Final (90%) RD will be a continuation of the Intermediate (60%) RD. The Pre-Final (90%) RD will address EPA's comments on the Intermediate (60%) RD and include the elements and deliverables required for the Pre-Final (90%) RD at a 90% level of completion. The Pre-Final (90%) RD will also incorporate data collected during PDI Phase III (if data gaps following PDI

Phase II are identified). In addition to the documents prepared as part of the Preliminary (30%) RD, the following will be included with the Pre-Final (90%) RD:

- A complete set of construction plans and specifications that are stamped by a registered Professional Engineer, suitable for procurement, following the CSI Master Format (or equivalent), and meeting other relevant standards for design of sediment cleanup
- Survey and engineering drawings showing existing features in the upper reach, such as property boundaries, easements, bathymetry, structures to be protected or removed, and other relevant conditions
- A specification for all necessary construction documentation, including but not limited to photographs and videos, bathymetric surveys, and GPS coordinates
- Draft CQAP
- Draft WQMP
- Draft QAPP/HASP for remedial action construction and monitoring activities
- Draft Permitting and Site Access Plan
- Outline of the Sediment Remedy ICIAP, including specific institutional control elements for each affected area, in accordance with *Recommended Evaluation of Institutional Controls: Supplement to the "Comprehensive Five-Year Review Guidance"* (EPA 2011); *Institutional Controls: A Guide to Planning, Implementing, Maintaining, and Enforcing Institutional Controls at Contaminated Sites* (EPA 2012a); and *Institutional Controls: A Guide to Preparing Institutional Controls Implementation and Assurance Plans at Contaminated Sites* (EPA 2012b)
- Required elements of a Vessel Management Plan (to be finalized by contractor)
- Annotated outline and conceptual description of LTMMP elements specific to the upper reach, discussing how the elements and schedule fit into a likely LTMMP approach for the LDW site as a whole
- Habitat Area Identification Memorandum, which will comply with the Endangered Species Act and Section 404 of the Clean Water Act; identify habitat areas and proposed elevations and substrate materials for caps, ENR, or placement of backfill materials in any identified habitat areas; and identify any areas where loss of aquatic habitat is unavoidable
- Draft Biological Assessment for use in consultation related to the Endangered Species Act
- Draft Clean Water Act Section 404 and Section 10 Rivers and Harbors Act of 1899 Memorandum
- Engineer's Capital and Operation and Maintenance Cost Estimate
- Engineer's Construction Project Schedule
- Community Outreach and Communications Plan

- Draft Archeological Discovery Plan
- Compensatory Mitigation Plan if necessary to comply with Clean Water Act Section 404 requirements
- Section 408 Compliance Documentation to evaluate compliance with 33 U.S.C. Section 403 and Section 408
- Any additional plans identified in the RDWP

The Pre-Final (90%) RD will serve as the approved Final (100%) RD if EPA approves the Pre-Final (90%) RD without comments.

6.2.4 Final (100%) Remedial Design

The Final (100%) RD will address EPA's comments on the Pre-Final (90%) RD and include final versions of all pre-final RD elements and deliverables. The Sediment Remedy ICIAP and LTMMP will remain as annotated outlines in the Final (100%) RD.

7 Remedial Design Project Schedule

The upper reach RD project schedule is presented in AOC4 SOW and in Table 7-1 and Figure 7-1. If schedule modifications are determined to be necessary, LDWG will submit a proposed revised project schedule to EPA for approval in accordance with the provisions of Paragraph 6.1 of AOC4 SOW.

Table 7-1
LDW Upper Reach Remedial Design Project Schedule

Deliverable, Task	SOW or AOC Reference	Deadline
PDI QAPP/HASP	5.4b/c	60 days after receipt of EPA comments on the revised draft PDIWP
Completion of PDI field work	5.4a	In accordance with the schedule in the approved PDIWP, unless otherwise approved by EPA
PDI Data	5.4d	For each round of data collection, 10 days after Respondents' receipt of validated PDI sampling data
PDI Data Evaluation Report – Phase I	5.4e	60 days after Respondents' submittal of PDI data for first phase of data collection to EPA
PDI Data Evaluation Report – Phase II	5.4e	45 days after Respondents' submittal of PDI data for second phase of data collection to EPA
Preliminary (30%) RD Submittal	5.6	45 days from EPA approval of PDI Data Evaluation Report - Phase II
Intermediate (60%) RD Submittal	5.7	120 days after EPA comments on Preliminary (30%) RD
Pre-Final (90%) RD Submittal	5.8	90 days after EPA comments on Intermediate (60%) RD
Final (100%) RD Submittal	5.9	60 days after EPA comments on Pre-Final (90%) RD
Periodic Monitoring QAPP Addendum	4.2	4 years from AOC4 effective date
Periodic Monitoring Data/Evaluation Report	4.2	5 years from AOC4 effective date

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Figures

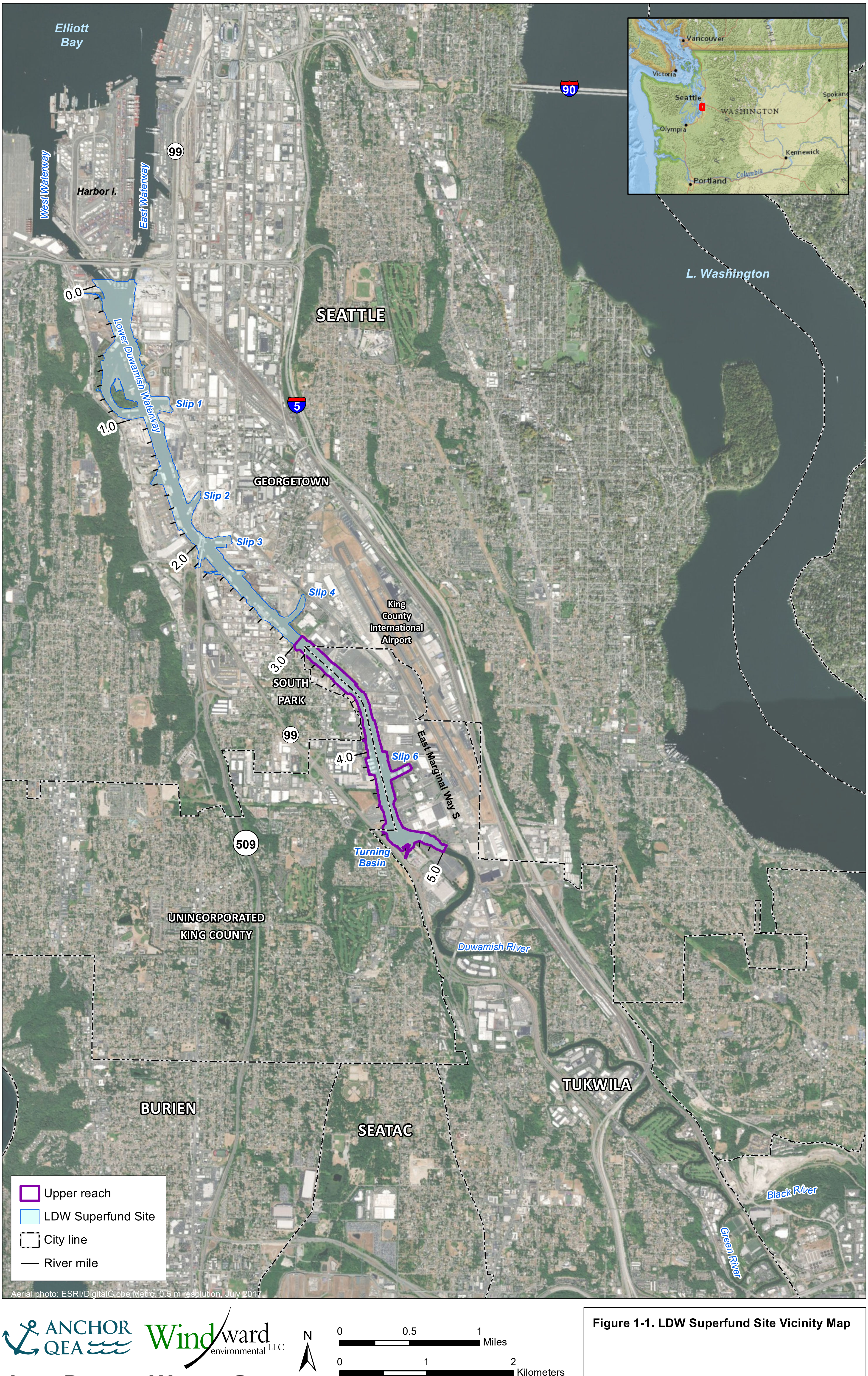

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Figure 1-1. LDW Superfund Site Vicinity Map

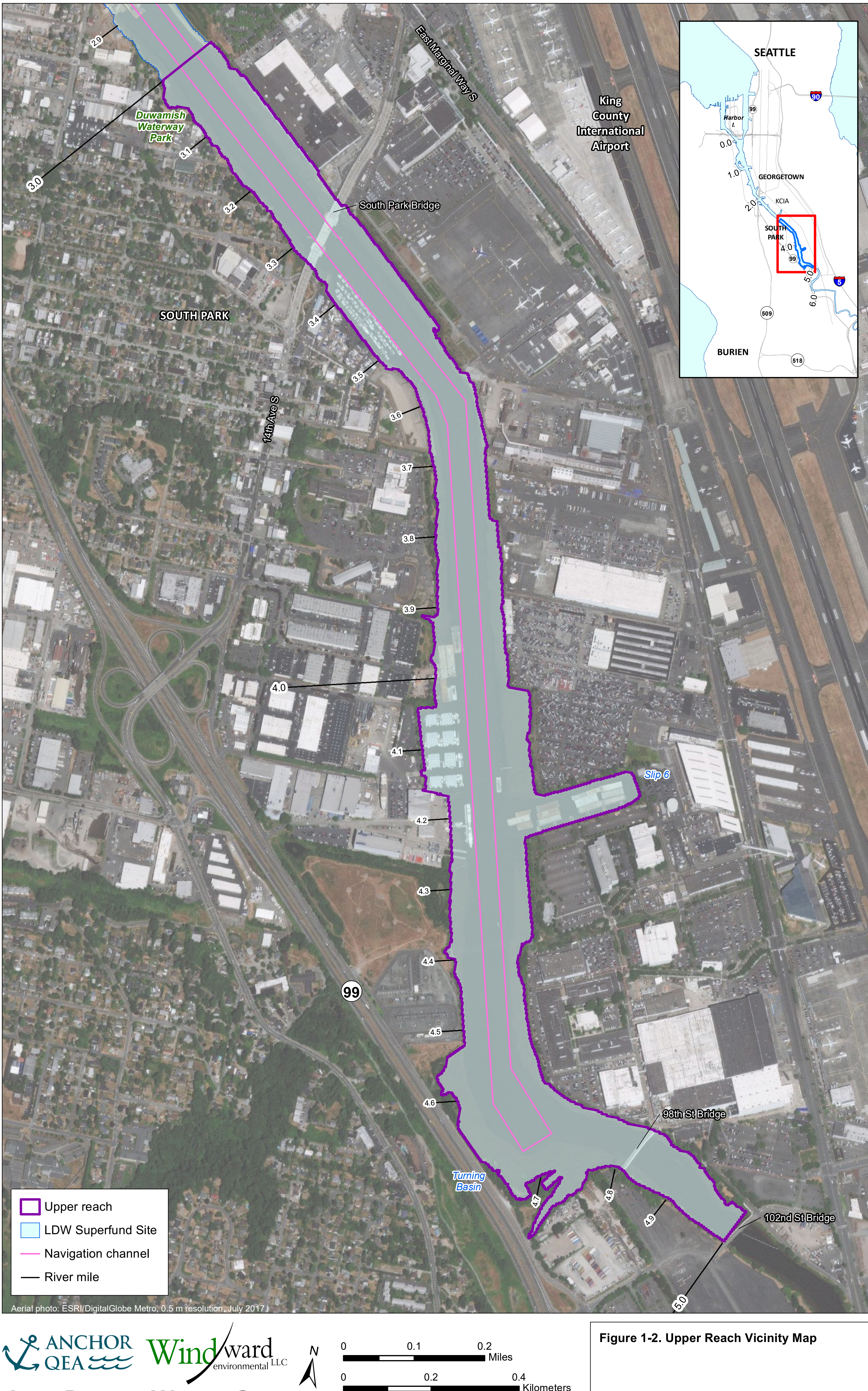

Figure 1-2. Upper Reach Vicinity Map

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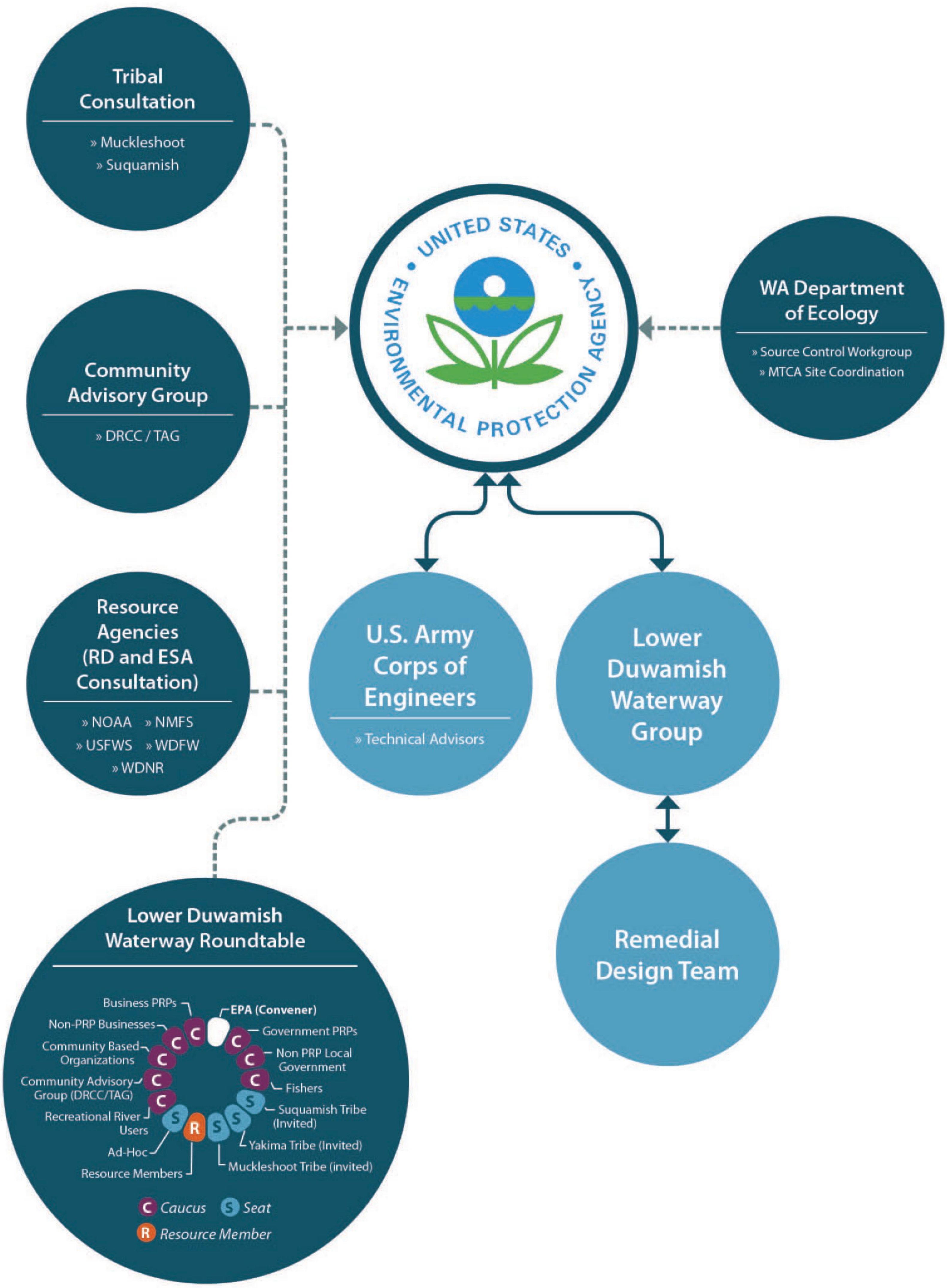

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Figure 1-3. Lower Duwamish Waterway Remedial Design Coordination

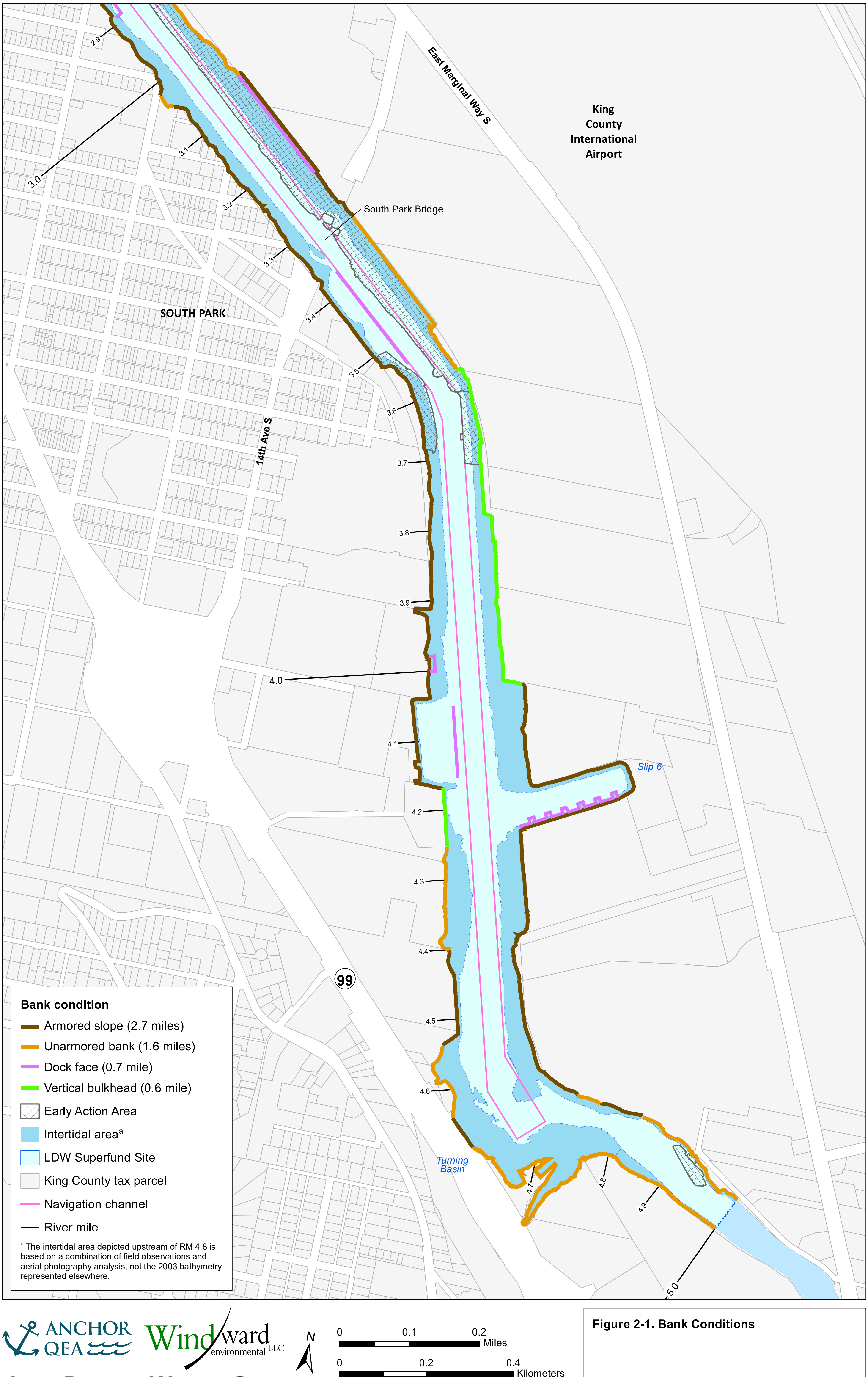

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Figure 2-1. Bank Conditions

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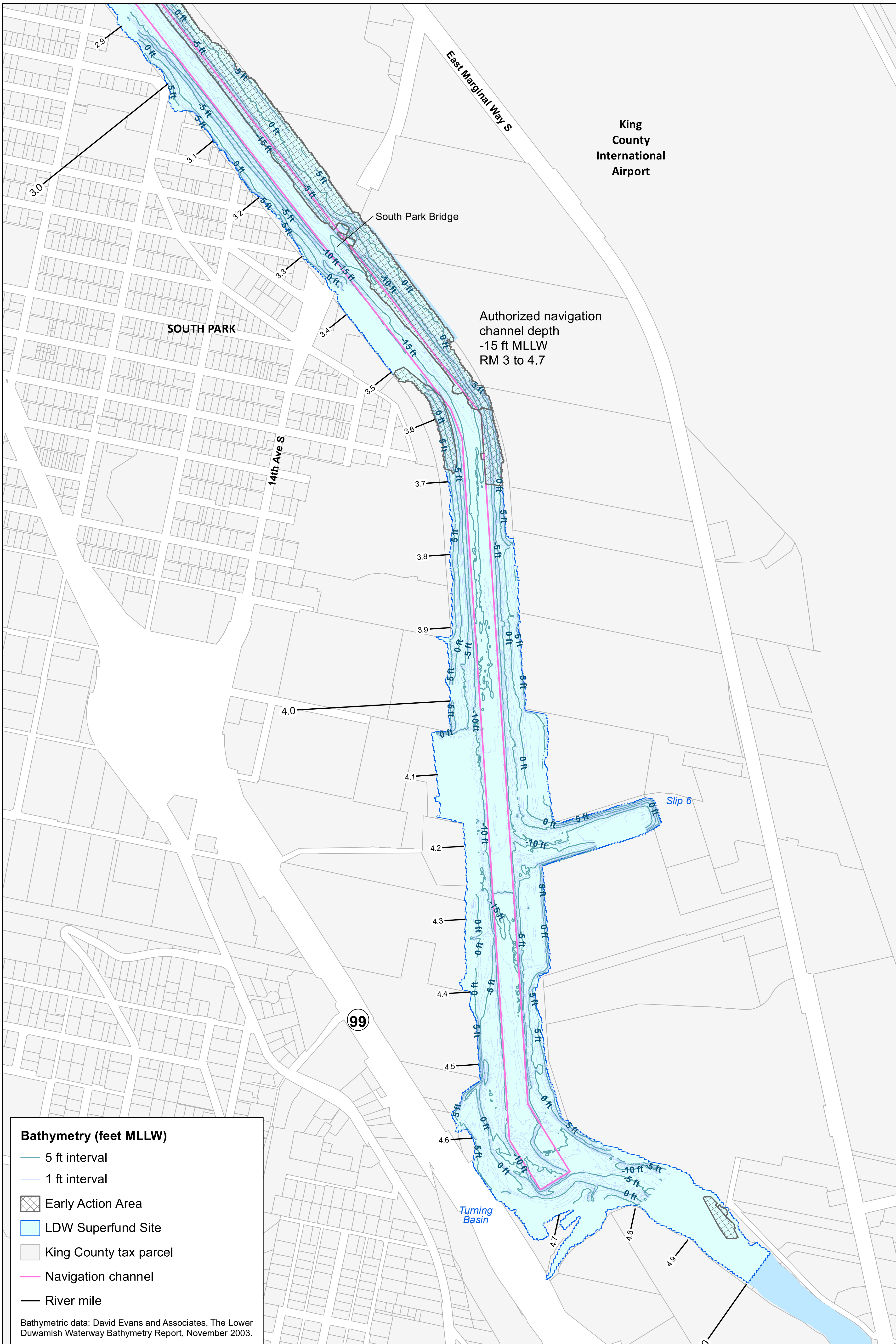

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Figure 2-2. 2003 Bathymetric Conditions

REMEDIAL DESIGN WORK PLAN

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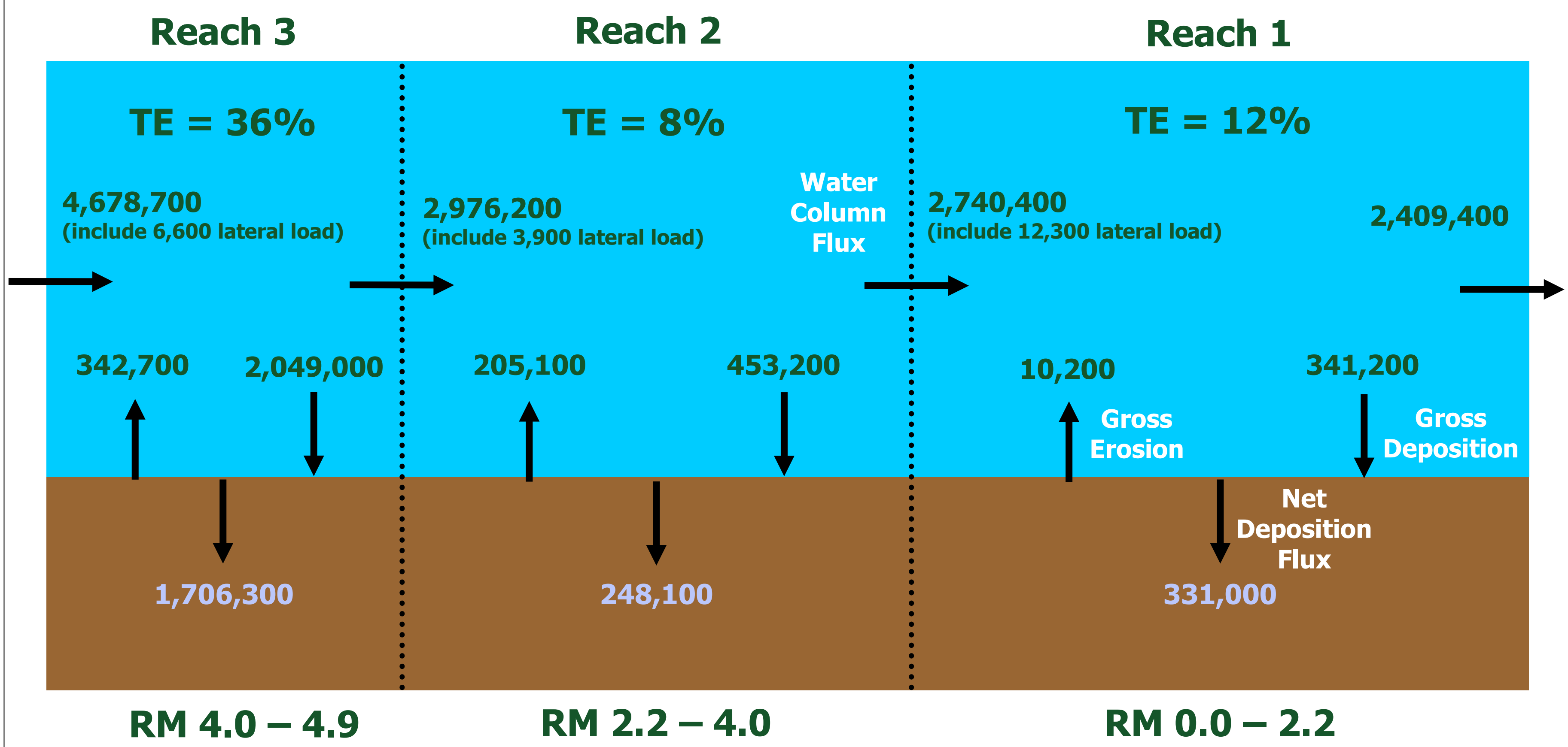

Notes:
Sediment flux units are metric tons.
RM: river mile
STM: sediment transport model
TE: trapping efficiency

Source: Integral, Anchor QEA, and Windward Environmental LLC, 2019. Recovery Category Recommendations Report – Final. Prepared for: U.S. Environmental Protection Agency, Region 10. February 11, 2019.

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Figure 2-3. Total Sediment Mass Balance Based on STM Predictions for 21-Year Period

REMEDIAL DESIGN WORK PLAN

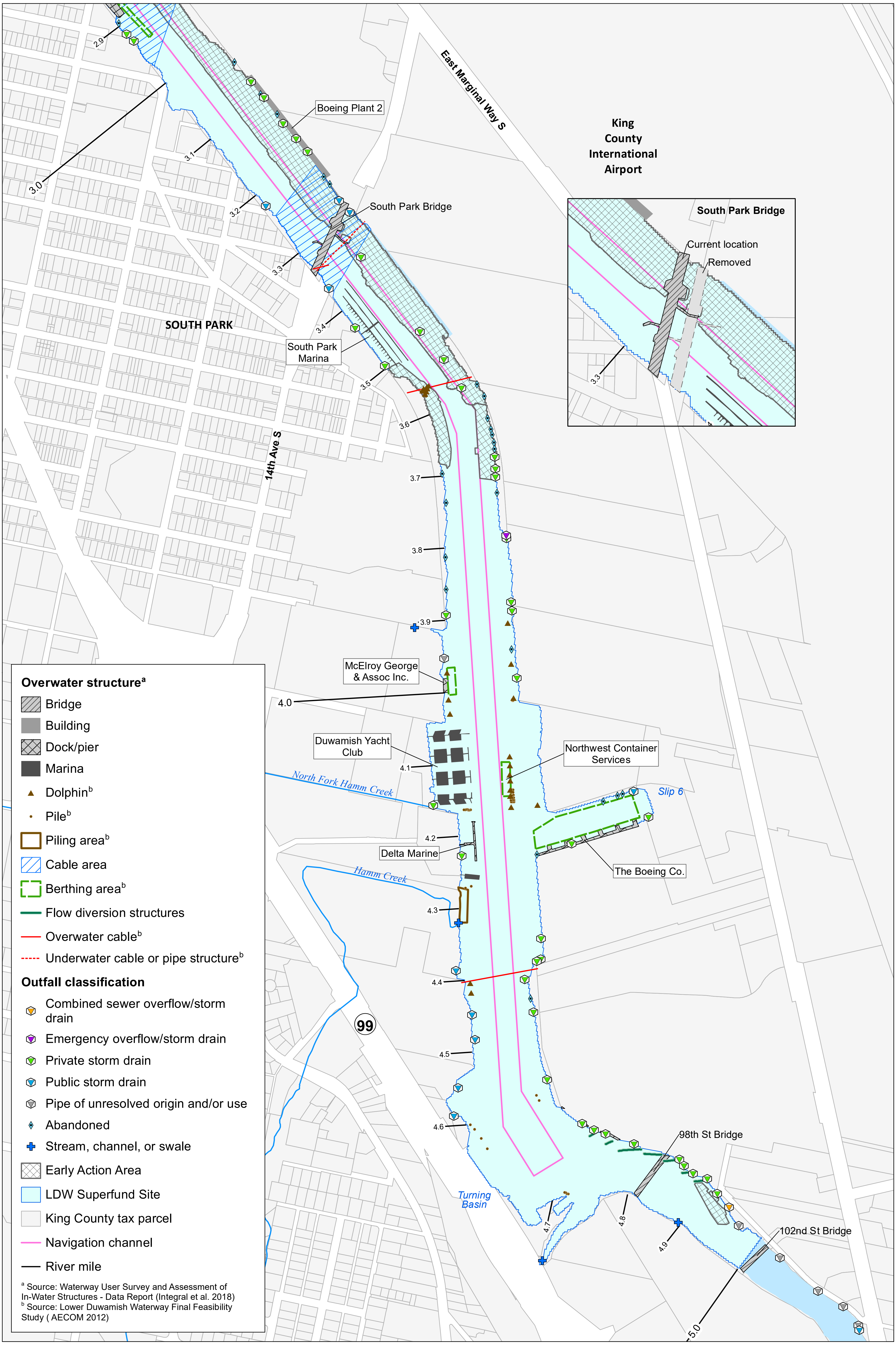

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Figure 2-4. Infrastructure

REMEDIAL DESIGN WORK PLAN

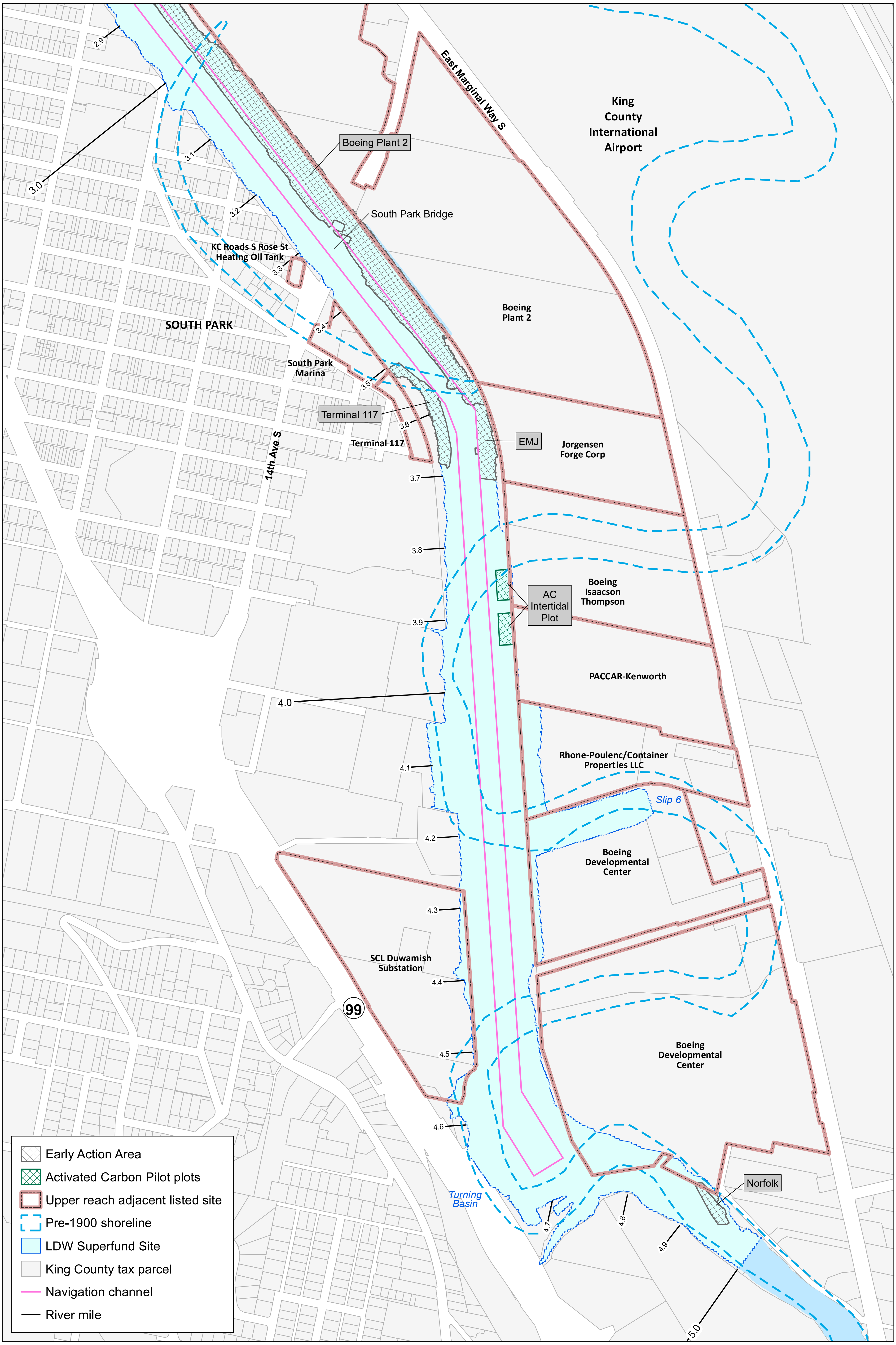

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Figure 2-5. Early Action Areas

REMEDIAL DESIGN WORK PLAN

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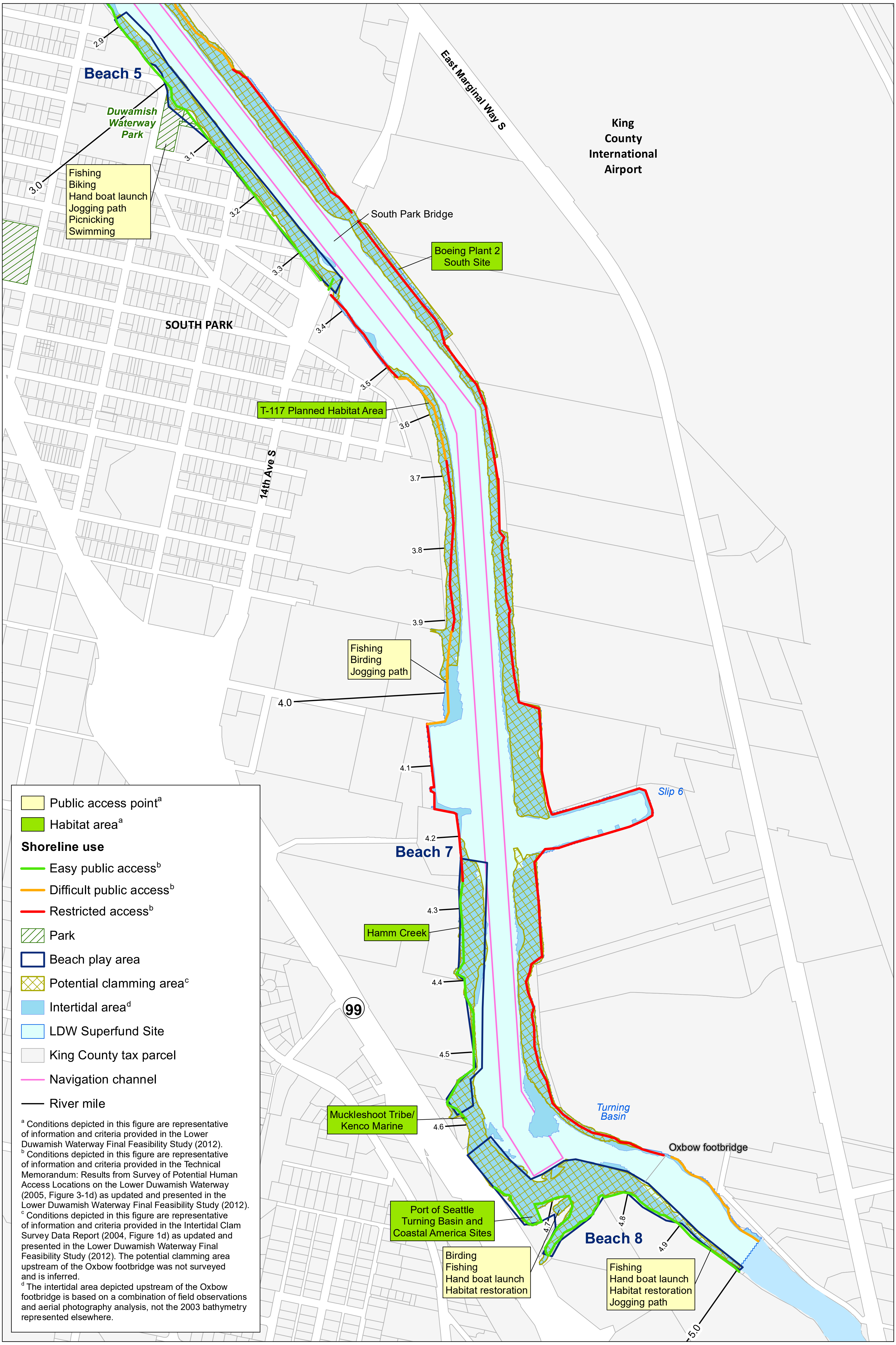

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Figure 2-6. Parks and Habitat Restoration, Beach Play, and Potential Clamming Areas

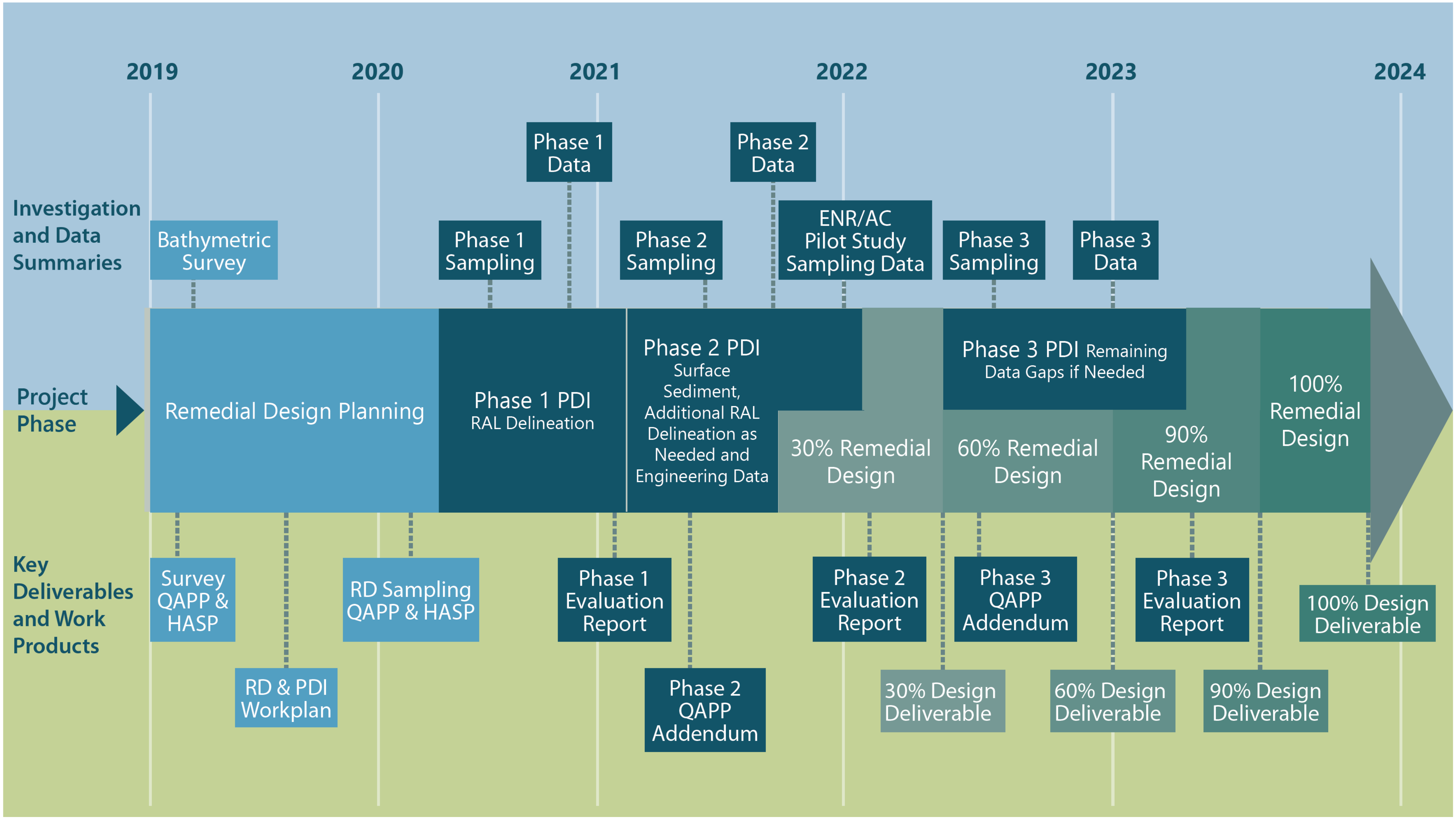

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Figure 3-1. LDW Upper Reach Remedial Design Timeline

REMEDIAL DESIGN WORK PLAN

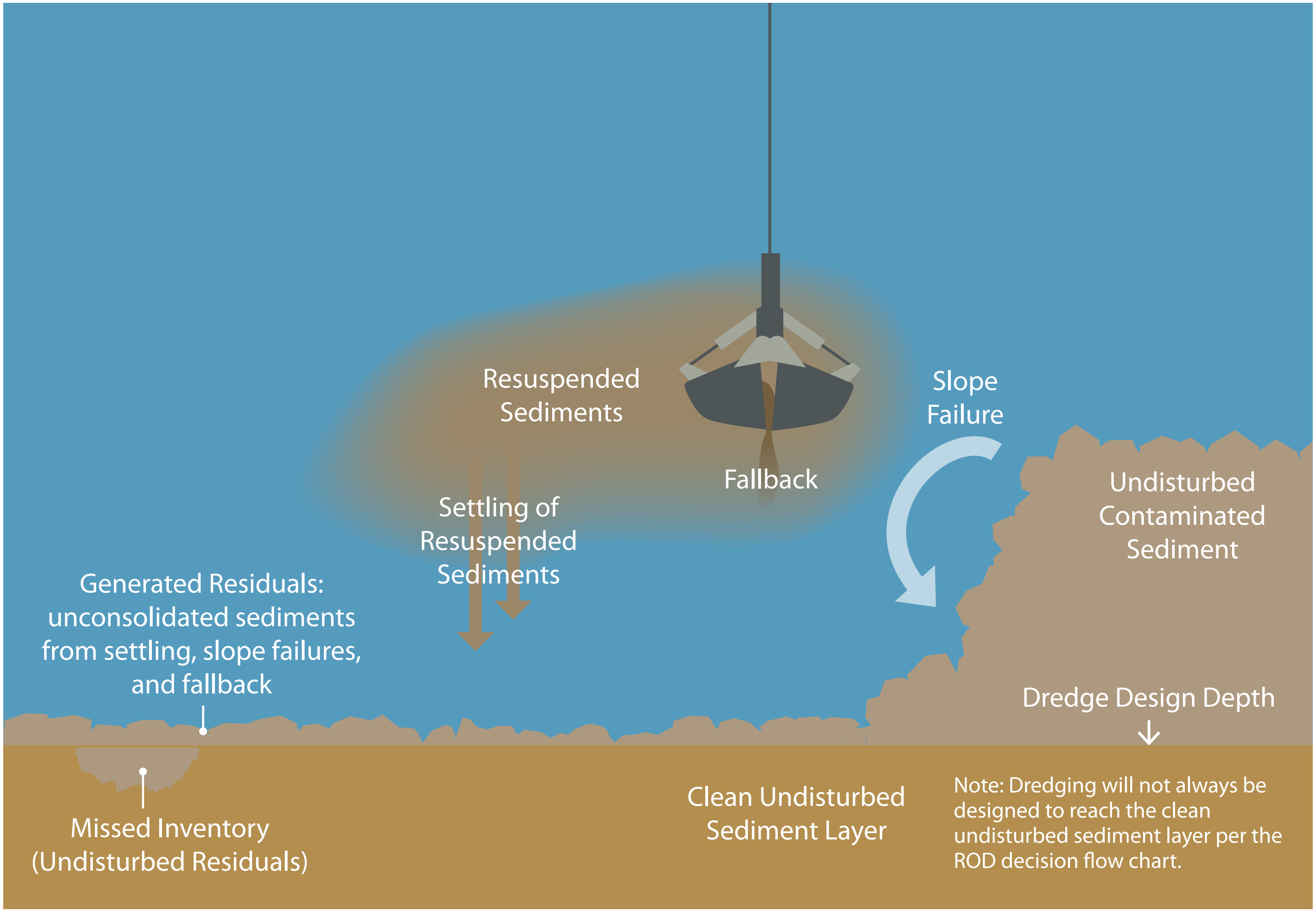

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Figure 3-2. Dredge Residuals Schematic

REMEDIAL DESIGN WORK PLAN

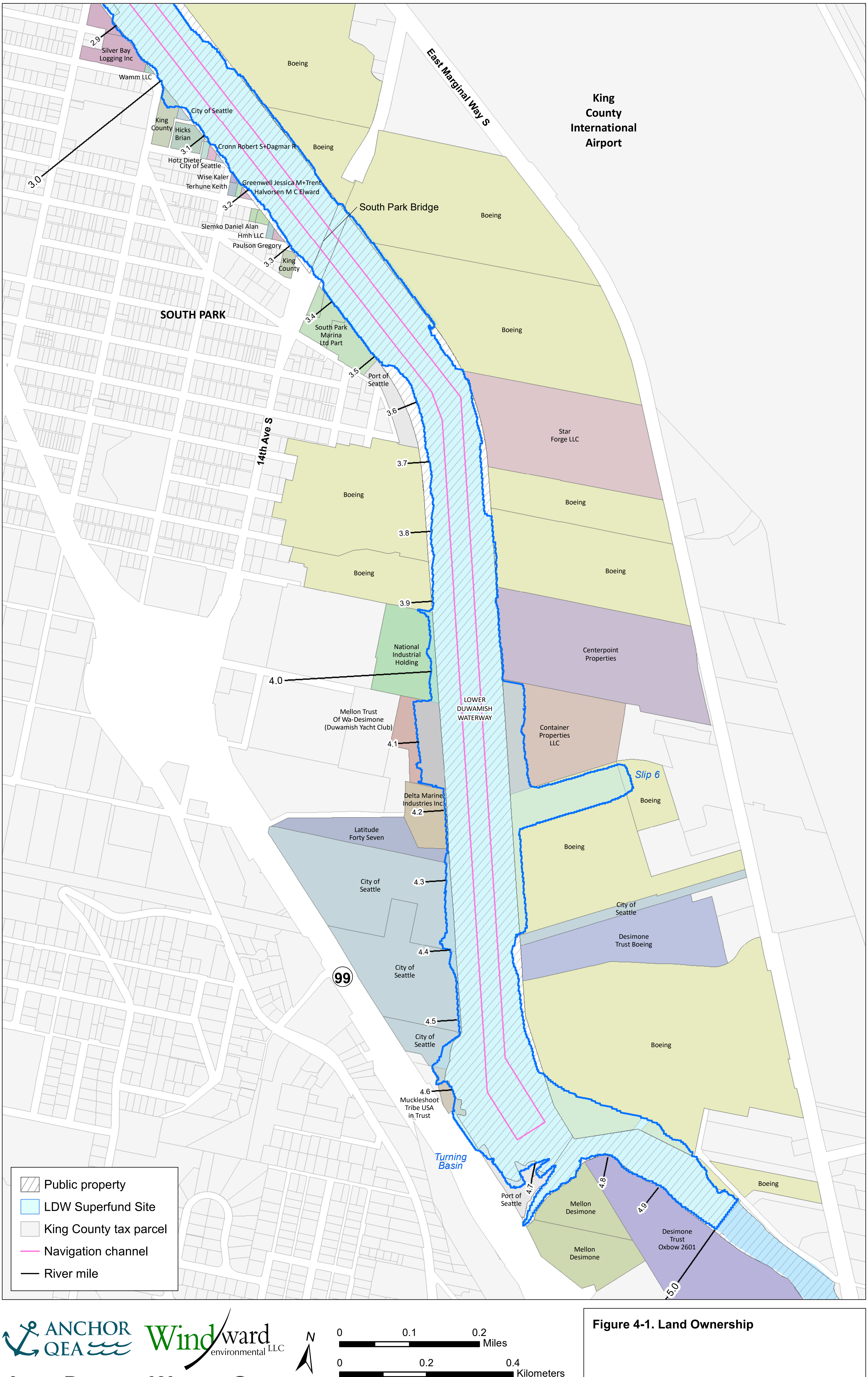

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Figure 4-1. Land Ownership

REMEDIAL DESIGN WORK PLAN

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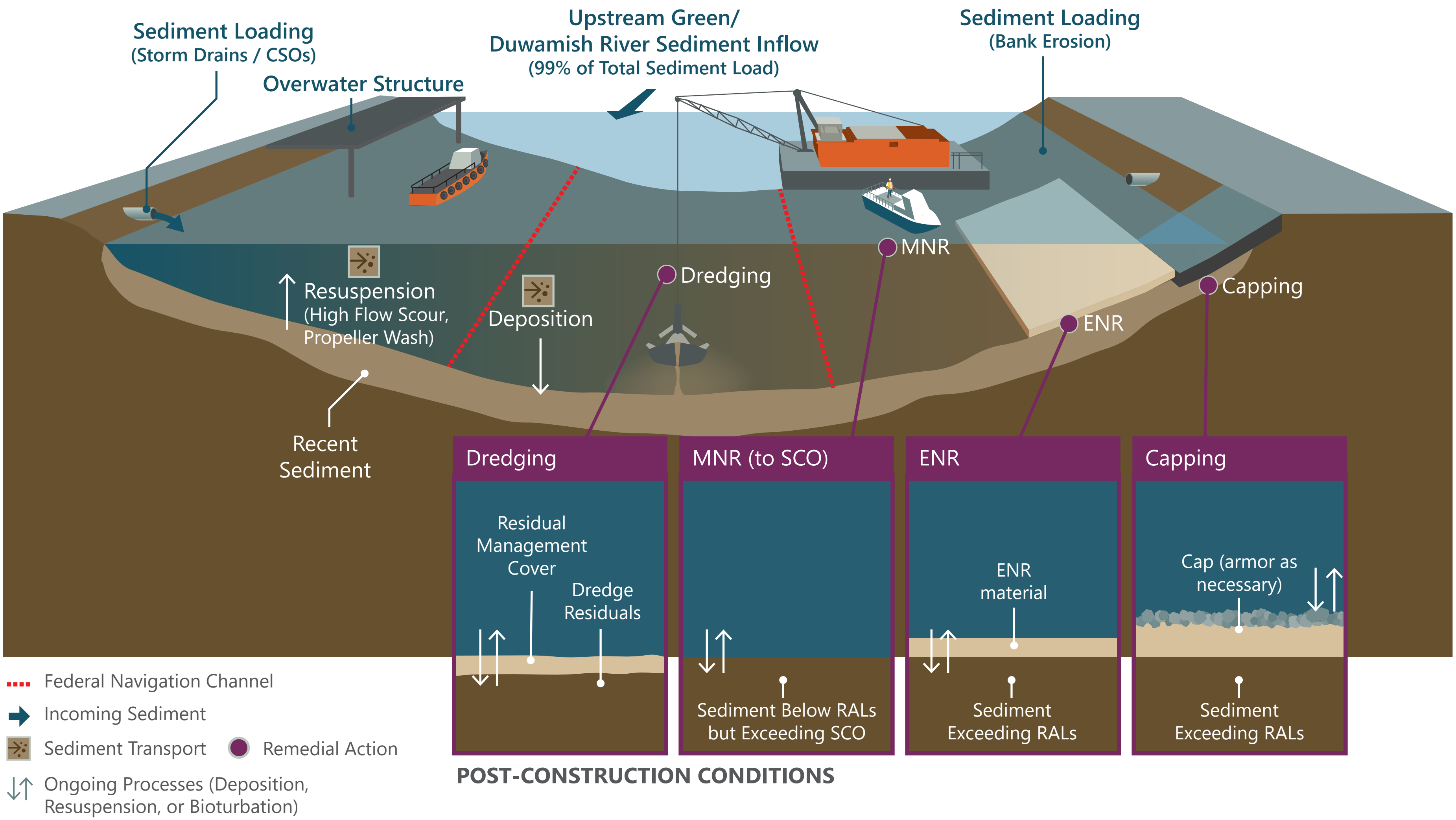

Note: Figure 5-1 does not illustrate other processes relevant to the remedial action, such as groundwater seeps, bioturbation, and contamination mobility.

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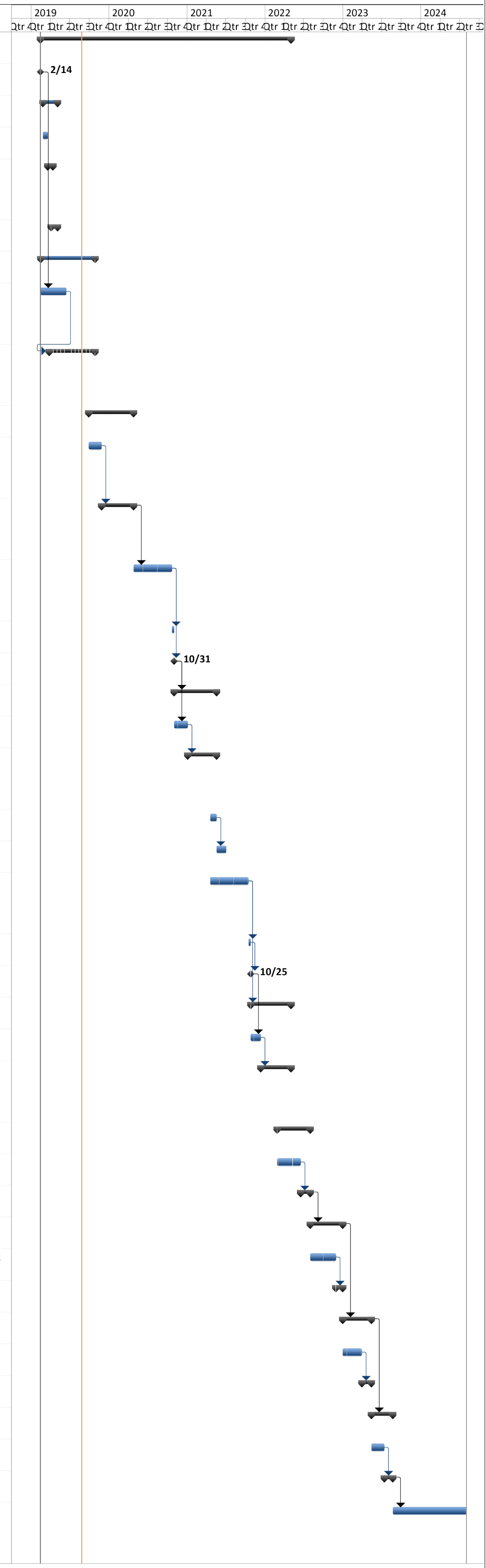
CSO: combined sewer overflow
ENR: enhanced natural recovery
MNR: monitored natural recovery
SCO: Sediment Cleanup Objective
RAL: remedial action level

Figure 5-1 Physical Conceptual Site Model of Sediment Movement in the Upper Reach

ID	Task Mode	Task Name	Duration	Start	Finish
1		**LDW Project**	**1174 days**	**Thu 2/14/19**	**Mon 5/2/22**
2		**NTP for AOC4 Contract**	**0 days**	**Thu 2/14/19**	**Thu 2/14/19**
3		**Pre-Design Survey**	**69 days**	**Mon 2/25/19**	**Sat 5/4/19**
4		**LDWG prepares Draft Survey QAPP (DSQ)**	23 days	Mon 2/25/19	Tue 3/19/19
5		**EPA review and approval process for Survey QAPP**	**24 days**	**Tue 3/19/19**	**Fri 4/12/19**
15		**Bathy Survey**	**30 days**	**Fri 4/5/19**	**Sat 5/4/19**
19		**RD and PDI Work Plans**	**255 days**	**Fri 2/15/19**	**Sun 10/27/19**
20		**LDWG prepares Draft RD and PDI Work Plans (WPs)**	**120 days**	**Fri 2/15/19**	**Fri 6/14/19**
21		**EPA review and approval process for RD and PDI Work Plans**	**215 days**	**Wed 3/27/19**	**Sun 10/27/19**
32		**Remedial Design Sampling QAPP and HASP**	**210 days**	**Sat 9/28/19**	**Fri 4/24/20**
33		**LDWG prepares Draft QAPP (w/Phase I SAP) and HASP**	**60 days**	**Sat 9/28/19**	**Tue 11/26/19**
34		**EPA review and approval process for QAPP (w/Phase I SAP) and HASP**	**150 days**	**Tue 11/26/19**	**Fri 4/24/20**
44		**Phase I PDI Field/Analytical/Validation (Preliminary)**	180 days	Sat 4/25/20	Wed 10/21/20
45		**Phase I PDI data submittal**	10 days	Thu 10/22/20	Sat 10/31/20
46		**Submit Phase I PDI Data to EPA**	0 days	Sat 10/31/20	Sat 10/31/20
47		**Phase I PDI Evaluation Report**	**199 days**	**Sun 11/1/20**	**Tue 5/18/21**
48		**LDWG prepares Phase I PDI Evaluation Report**	**64 days**	**Sun 11/1/20**	**Sun 1/3/21**
49		**EPA review and approval process for Phase I PDI Evaluation Report**	**135 days**	**Sun 1/3/21**	**Tue 5/18/21**
59		**LDWG prepares Phase II SAP**	30 days	Mon 4/19/21	Tue 5/18/21
60		**EPA review and approval process for Phase II SAP**	45 days	Wed 5/19/21	Fri 7/2/21
61		**Phase II PDI Field/Analytical/Validation (Preliminary)**	180 days	Mon 4/19/21	Fri 10/15/21
62		**Phase II PDI data submittal**	10 days	Sat 10/16/21	Mon 10/25/21
63		**Submit Phase II PDI Data to EPA**	0 days	Mon 10/25/21	Mon 10/25/21
64		**Phase II PDI Evaluation Report**	**189 days**	**Tue 10/26/21**	**Mon 5/2/22**
65		**LDWG prepares Phase II PDI Evaluation Report**	**47 days**	**Tue 10/26/21**	**Sat 12/11/21**
66		**EPA review and approval process for Phase II PDI Evaluation Report**	**142 days**	**Sat 12/11/21**	**Mon 5/2/22**
77		**30% Design**	**155 days**	**Sun 2/27/22**	**Sun 7/31/22**
78		**LDWG prepares 30% Design**	**110 days**	**Sun 2/27/22**	**Thu 6/16/22**
79		**EPA review of 30% design**	**45 days**	**Thu 6/16/22**	**Sun 7/31/22**
83		**60% Design**	**152 days**	**Mon 8/1/22**	**Fri 12/30/22**
84		**LDWG prepares 60% Design**	**120 days**	**Mon 8/1/22**	**Mon 11/28/22**
85		**EPA review of 60% design**	**32 days**	**Mon 11/28/22**	**Fri 12/30/22**
89		**90% Design**	**135 days**	**Sat 12/31/22**	**Sun 5/14/23**
90		**LDWG prepares 90% Design**	**90 days**	**Sat 12/31/22**	**Thu 3/30/23**
91		**EPA review of 90% design**	**45 days**	**Thu 3/30/23**	**Sun 5/14/23**
95		**100% Design**	**100 days**	**Mon 5/15/23**	**Tue 8/22/23**
96		**LDWG prepares 100% Design**	**60 days**	**Mon 5/15/23**	**Thu 7/13/23**
97		**EPA review and approval of 100% design**	**40 days**	**Thu 7/13/23**	**Tue 8/22/23**
102		**Contractor Procurement, Pre-Construction Planning and Submittals**	**345 days**	**Wed 8/23/23**	**Thu 8/1/24**



Project: Draft Sc
Date: Mon 8/26

Task		External Tasks		Manual Task		Finish-only	
Split		External Milestone		Duration-only		Deadline	
Milestone		Inactive Task		Manual Summary Rollup		Progress	
Summary		Inactive Milestone		Manual Summary			
Project Summary		Inactive Summary		Start-only			

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5/26/2019

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

Figure 7-1. Project Schedule

Remedial Design Work Plan