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

DESIGN STRATEGY RECOMMENDATIONS REPORT

FINAL

Prepared for:

U.S. Environmental Protection Agency
Region 10

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ACRONYMS AND ABBREVIATIONS

AOC	Administrative Order on Consent
ARAR	applicable or relevant and appropriate requirement
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
DQO	data quality objective
EAA	early action area
Ecology	Washington State Department of Ecology
ENR/AC	enhanced natural recovery/activated carbon
EPA	U.S. Environmental Protection Agency
FS	feasibility study
LDW	Lower Duwamish Waterway
LDWG	Lower Duwamish Waterway Group
MOA	Memorandum of Agreement
MNR	monitored natural attenuation
MTCA	Model Toxics Control Act
PDI	pre-design investigation
PDIWP	pre-design investigation work plan
PLA	Pollutant Loading Assessment
QAPP	quality assurance project plan
RAL	remedial action level
RAWP	remedial action work plan
RD/RA	remedial design and remedial action
RDWP	remedial design work plan
RI	remedial investigation
RI/FS	remedial investigation and feasibility study
RM	river mile
ROD	Record of Decision
SCS	source control strategy
SCO	sediment cleanup objective

1 INTRODUCTION

In 2000, the City of Seattle, King County, the Port of Seattle, and The Boeing Company, working collectively as the Lower Duwamish Waterway Group (LDWG), agreed in an administrative order on consent (AOC) to conduct a remedial investigation and feasibility study (RI/FS) for the Lower Duwamish Waterway Site (LDW), with oversight by the U.S. Environmental Protection Agency (EPA) and the Washington State Department of Ecology (Ecology). In September 2001, the LDW was formally listed as a Comprehensive Environmental Response, Compensation and Liability Act (CERCLA, or Superfund) site; in February 2002, the LDW was formally listed as a Washington Model Toxics Control Act (MTCA) site. The remedial investigation (RI) was completed in 2010 (Windward 2010) and the feasibility study (FS) was completed in 2012 (AECOM 2012). A record of decision (ROD) was issued by EPA in 2014 (USEPA 2014).

A third amendment to the AOC (USEPA 2016) established a series of pre-design studies to be performed by LDWG to advance the implementation of the ROD. Task 10 of the third amendment to the AOC includes the development of a conceptual strategy for design of EPA's remedy for the LDW, the subject of this report.

1.1 REPORT PURPOSE AND OBJECTIVES

In accordance with Task 10 of the third amendment to the AOC (USEPA 2016), this report presents a conceptual strategy for integrating and sequencing the LDW data gathering efforts and remedial design process in a manner that will allow timely implementation of the cleanup. The strategy presented in this report is not prescriptive and is anticipated to be refined over time, based on considerations presented herein and other influencing factors that may arise in the future.

The remedial design for the LDW cleanup will draw upon existing data collected to support the RI/FS, multiple early action cleanups, and other studies within the LDW. The design will also incorporate findings from the LDW activated carbon pilot study (AMEC et al. 2015) and the pre-design studies (Tasks 2 through 9 of the third amendment to the AOC [USEPA 2016]), both in progress at the time of writing.

To complete the remedial design for the LDW cleanup, additional location-specific environmental and physical data will be required. Environmental data (e.g., surface and subsurface sediment chemistry) will be collected to refine remedial boundaries and technology assignments and to support other aspects of the design. Physical data (e.g., sediment geotechnical properties and bathymetry) will be collected to support design elements such as dredge prisms. Additional planning information will be collected to support the logistical aspects of remedy implementation.

A key objective of this report is to identify and delineate data needs that should be addressed early in the design process, data gathering that may occur throughout or later in design, and data needs that should be addressed by the selected construction contractor to support planning and execution of the cleanup.

The conceptual strategy addresses the applicable requirements of the third amendment to the AOC (USEPA 2016) and the Pre-Design Studies Work Plan (Windward and Integral 2017). This strategy also anticipates the technical, reporting, and schedule requirements likely to be established by EPA for conducting the future remedial design and remedial action (RD/RA).

The LDW is a working waterway, and in addition to the Superfund cleanup work, a variety of in-water and adjacent upland activities and projects can be expected to occur during the anticipated 10+ years of RD/RA activities. Some of these actions may have significant considerations for aspects of RD/RA such as material transportation, import, and disposal, as well as design phasing and assessing community and ecological impacts. It is expected that the Performing Parties will appropriately coordinate the RD/RA work with these ongoing non-Superfund activities

The detailed approaches for accomplishing the remedial design and associated data acquisition will be presented in one or more remedial design work plans (RDWPs), and are subject to EPA review and approval. The RDWP is beyond the scope of this recommendations report.

1.2 SITE SETTING

The LDW (Figure 1-1), which extends from river mile (RM) 0 to RM 5.0, was modified in the early 1900s; the river was converted from a natural estuary to a straightened waterway to better accommodate commercial traffic. A federal navigation channel is located in the center of the LDW. Subtidal areas border the navigation channel, and shallow intertidal bench areas exist along the shoreline. The shoreline of the waterway comprises approximately 88 percent steepened hard surfaces (e.g., riprap, sheet piling walls, and piers and bulkheads), 1 percent concrete boat ramps, and approximately 11 percent more gently sloped beach and intertidal areas that remain throughout the waterway (AECOM 2012). Since its development, the navigation channel has been dredged to maintain sufficient depths for navigation (up to the turning basin at RM 4.7). The U.S. Army Corps of Engineers currently performs maintenance dredging in the turning basin approximately every 1 to 3 years; the turning basin and adjacent navigation channel were last dredged in 2017 (USEPA 2014; USACE 2018). Many berthing areas are also periodically dredged by users to maintain desired berthing depths. With limited exceptions, the U.S. Army Corps of Engineers has not dredged the navigation channel north of RM 3.4 since the mid-1980s due, in part, to limitations on open water disposal.

The LDW corridor is the City of Seattle's primary industrial area. Current land use, zoning requirements, and land ownership within most of this corridor are characteristic of an active industrial waterway. The *Waterway User Survey and Assessment of In-Water Structures Data Report* (prepared under Task 8 of the third amendment to the AOC) (Integral et al. 2018b) indicates that 73 properties along the LDW corridor engage in water-dependent industrial and recreational business activities, and an additional 65 shoreline properties within the LDW site boundary include residential and other waterfront properties without water-dependent uses. The LDW is used by tribal fishers for a commercial fishery for salmon as well as for cultural and subsistence uses. The LDW is also a migratory corridor for a number of salmon species.

A comprehensive description of the LDW environmental and physical site characteristics is presented in the LDW RI (Windward 2010), FS (AECOM 2012), ROD (USEPA 2014), and other studies identified in Section 1.3.

1.3 RELEVANT DATA SOURCES

The remedial design for the LDW cleanup will draw upon the large body of environmental and physical data collected within the LDW over the past two decades to support the RI/FS, multiple early action area (EAA) cleanups, and other studies. The design will also incorporate findings from the LDW activated carbon pilot study (AMEC et al. 2015) and the pre-design studies (Tasks 2 through 9 of the third amendment to the AOC [USEPA 2016]), both in progress at the time of writing. While the objectives of these past and ongoing studies do not focus on specific data needs for design of the LDW cleanup, it is anticipated that these data will serve as an important resource to inform LDW design investigation planning and post-cleanup recovery monitoring.

The following sections briefly summarize data compilation efforts that have been completed to date, as well as anticipated future data from ongoing studies within the waterway. Upon initiation of the LDW remedial design, the RDWP would establish data quality objectives (DQOs) for the uses of existing data as they relate to remedial design data needs.

1.3.1 Existing Data Compilation

A comprehensive compilation of existing available data was performed under Task 2 of the third amendment to the AOC, existing data compilation (USEPA 2016). As described in the resulting technical memorandum (Windward and Integral 2018), the compilation contains data that became available after April 2010 (or earlier if associated with EAAs) that were not already in the RI/FS data set, including in-waterway data, source control-related data, and upstream data. The compiled in-waterway data include sediment, surface water, tissue, porewater, groundwater, and seep sampling results. Source control and upstream data include combined sewer system/storm drain solids, bank soils, Green/Duwamish River suspended solids, and surface water results. The data compilation included a data quality review for all waterway data (except source data). The data cutoff was June 15, 2018, to allow for completion of the Task 2 memorandum. These data and the baseline and source control-related data collected under Task 4 of the third amendment to the AOC will be imported into an EQuIS™ database and combined with the existing LDW RI/FS data set. These comprehensive data sets will be used to support the pre-design studies data evaluation report and recovery category recommendations report (Tasks 6 and 9 of the third amendment to the AOC). The project database will be available for future use during remedial design. The remedial design work plans will describe how these existing data will be used during remedial design (e.g., direct use of certain data, identification of data gaps, guiding sampling locations).

The Task 2 memorandum also includes a review of two ongoing studies to assess relationships between chemical concentrations in various media in the LDW. These studies include porewater studies led by the Massachusetts Institute of Technology (Kerns 2017, pers. comm.), and an enhanced natural recovery/activated carbon (ENR/AC) pilot study being conducted by LDWG (AMEC et al. 2015). Data from these studies will be evaluated in the data evaluation report, as available, or during the LDW remedial design phase.

1.3.2 LDW Baseline Investigation

Under Tasks 3 through 5 of the third amendment to the AOC (USEPA 2016), a LDW site-wide investigation is being performed to fulfill the following objectives (Windward and Integral 2017):

- Establish post-EAA cleanup baseline conditions in environmental media
- Evaluate the effectiveness of EAA cleanups and the degree to which natural recovery has occurred on a site-wide basis since the RI/FS
- Establish baseline data for comparison to post-remedial action data
- Aid in the evaluation of source control.

The scope of the baseline investigation does not include filling of area-specific remedial design data needs, nor does it include duplication of characterization efforts being conducted under MTCA or CERCLA at specific sites along the waterway. Data from the baseline investigation will be assessed together with the compiled RI/FS and post-FS data set as part of the Task 6 data evaluation report, scheduled to be completed in 2019. In addition to supporting the above objectives, the findings from this study will also inform planning of the LDW cleanup.

1.3.3 LDW Waterway User Survey and Structures Assessment

In addition to environmental data described in the previous sections, Tasks 7 and 8 of the third amendment to the AOC (USEPA 2016) include a waterway user survey and assessment of in-water structures (Integral et al. 2018b). The objective of this effort is to gather information to support review of the recovery category and technology assignments developed in the FS and ROD, considering up-to-date and planned future waterway use information.

Preliminary recommendations for possible adjustments to recovery categories and technology assignments will be developed under Task 9 of the third amendment to the AOC (USEPA 2016), considering updated information provided in the *Waterway User Survey and Assessment of In-Water Structures Data Report* (Integral et al. 2018b). Final adjustments to recovery categories and/or technology assignments, if needed, will be determined during remedial design, considering two additional decision lines of evidence defined in the ROD, vessel scour and contaminant trend characteristics. Table 23 of the ROD (included in Appendix A of this report) summarizes the application of these decision criteria for assigning recovery categories.

1.3.4 Other Potential Data Sources

In addition to the data sources noted above, potentially relevant environmental and physical data may be generated from ongoing and/or future monitoring of the LDW EAAs; upland and riverbank characterization data may be obtained from cleanup sites, source control activities, and possible future dredging and marine/shoreline development projects within the waterway. The remedial design engineer will track projects and changes to the waterway that have the potential to influence remedy design and construction. It is anticipated that potential new data sources would be identified and evaluated for possible use in the RDWP, based on DQOs established for remedial design investigation activities.

2 OVERVIEW OF LDW REMEDY

The following sections provide an overview of the selected remedy for the LDW and identify key implementation considerations and related assumptions that were used in development of the conceptual design strategy presented herein.

2.1 REMEDY DESCRIPTION

The selected remedy for the LDW is described in detail in the ROD (USEPA 2014) and briefly summarized in this section. It addresses unacceptable human health risks associated with consumption of resident fish and shellfish, and with direct contact (skin contact and incidental ingestion) with sediment from net fishing, clamming, and beach play. It also addresses ecological risks to bottom-dwelling organisms (benthic invertebrates), fish, and wildlife. The selected remedy is the third component of an overall strategy for addressing contamination and associated risks at the LDW site that includes:

1. Cleanup of the most contaminated areas in the waterway (e.g., EAAs)
2. Controlling sources of contamination to the waterway
3. Cleanup of the remaining contamination in the waterway, including long-term monitoring to assess the success of the remedy in achieving cleanup goals.

The ROD stipulates that the selected remedy will be implemented after cleanup of the EAAs has been completed and sources have been sufficiently controlled to prevent or minimize recontamination following implementation of the remedy.

The selected remedy addresses all areas within the site where contaminant concentrations exceed the cleanup levels, through a combination of active cleanup technologies, monitored natural recovery (MNR), and institutional controls. The approximate extents of the various remedial technologies (based on RI/FS data) are shown in Figure 2-1. Figures 19 through 23 of the ROD (included in Appendix A of this report) illustrate the criteria and decision process used for application of the remedial action levels (RALs) and technology assignments for the selected remedy. These decision rules, along with the recovery category criteria in Table 23 of the ROD, form the basis for a large portion of the pre-design investigation (PDI) data needs. Once sufficient data are available for completing the technology assignments, then additional PDIs can be targeted as needed to complete the design (e.g., subsurface characterization for dredge prism design).

In summary, the selected remedy consists of the following elements (refer to the ROD for detailed description of remedy):

- Dredge or partially dredge and cap approximately 105 acres of contaminated sediment (approximately 960,000 cubic yards)
- Place engineered sediment caps on approximately 24 acres of contaminated sediment where there is sufficient water depth for a cap
- Place a thin layer (6 to 9 in.) of clean material (enhanced natural recovery, or ENR) on approximately 48 acres of sediment in areas that meet the criteria for ENR
- Apply location-specific cleanup technologies to areas with structural or access restrictions (e.g., under-pier areas and in the vicinity of dolphins/pilings, bulkheads, and riprapped or engineered shorelines)
- Implement MNR in approximately 235 acres of sediment where surface sediment contaminant concentrations are predicted to be reduced over time
- Sample sediment and other media (as appropriate) in the LDW (441 acres) as part of baseline, construction, post-construction, and long-term monitoring
- Provide effective and appropriate institutional controls for the entire waterway, as needed to reduce human exposure to contaminants, ensure remedy protectiveness, and protect the integrity of the remedy.

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 (USEPA 2014). These estimates will be refined during remedial design, based on area-specific PDIs, engineering analyses, and the RAL and remedial technology assignment criteria identified in the ROD (and included in Appendix A of this report).

2.2 KEY REMEDY IMPLEMENTATION ASSUMPTIONS

This section describes key assumptions underlying the conceptual strategy for design and implementation of the selected remedy. While these assumptions are subject to change, the overall strategy is intended to be flexible in its application and is consistent with standard of practice for CERCLA sediment cleanups of similar scope and scale to the LDW selected remedy.

2.2.1 Source Control Strategy/Timing

Implementation of the LDW cleanup will be integrated with a comprehensive source control program led by Ecology, in coordination with EPA, the Source Control Workgroup,[1] and other

[1] The Source Control Workgroup currently includes 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.

public and private parties. Details of this program are presented in Ecology's source control strategy (SCS) report (Ecology 2016). Key elements of the SCS program relevant to remedial planning and implementation of the LDW cleanup are summarized below.

Overall, source control activities will occur on two scales: 1) the immediate source area to the LDW where source control activities are focused on controlling sources and pathways of contamination to LDW sediment (the focus of the SCS); and 2) the larger watershed. Ecology has ongoing programs to address persistent organic pollutants in sediment, surface water, stormwater, and air. Ecology will update the SCS based on the Pollutant Loading Assessment (PLA), long-term monitoring data, and other factors. With respect to remedial design strategy for the LDW cleanup, progress towards item 1 will have the greatest influence on the RD/RA implementation schedule, while item 2 is a long-term measure that will provide context for interpreting the long-term monitoring data following active remediation.

In 2014, EPA and Ecology initiated the Green/Duwamish River PLA (USEPA and Ecology 2014b), which focuses on the larger watershed source control activities. One goal of the PLA is to determine ways to reduce ongoing sources in the entire watershed and to inform targets and strategies for reducing those sources. The PLA is not expected to directly inform RD/RA activities for the LDW.

In accordance with a 2014 Memorandum of Agreement (MOA) (USEPA and Ecology 2014a), EPA and Ecology will coordinate before initiating active in-waterway cleanup to ensure that sources have been sufficiently controlled. Of particular relevance to the LDW cleanup strategy, the MOA states:

i. The sequencing of active in-waterway sediment remediation and associated source control is likely to begin at the upper portion of the in-waterway portion of the LDW Site and work downstream;

ii. 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;

iii. 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;

iv. After EPA concurs that an area is ready to begin active in-waterway sediment cleanup activities, EPA intends to direct PRPs to remediate the area in accordance with the LDW ROD and consistent with any enforceable agreement.

The concept of sufficiency is defined in the ROD (and incorporated into the SCS), which states, "the focus [of the SCS] is to control sources sufficiently such that recontamination above the benthic SCO criteria and human health remedial action levels (RALs) … is unlikely... This will prevent or minimize the likelihood that sediment will be recontaminated at levels that trigger additional active in-waterway sediment remediation."

The process for determining if source control is sufficient to proceed with sediment remedial actions will follow a line of evidence approach, building upon previous source control activities, existing conditions, and new data. For the purposes of sufficiency recommendations, Ecology will focus on evaluation of direct discharges, groundwater, and bank erosion pathways.

The geographic scope of any given source control sufficiency evaluation will be driven by the scale of the planned in-waterway remediation. This includes any source control areas that may affect the planned remediation area. For example, a sediment dredging area may extend across multiple source control areas.

Design and implementation of the LDW remedy will be performed in a manner that is consistent with the source control goals and priorities described above. To establish a conceptual framework for this design strategy report, it is assumed that the LDW remedy would be implemented from upstream to downstream in three "reaches" of roughly similar scope and scale. The three reaches would correspond approximately to the three primary source control reaches identified in the SCS report and shown in Figure 2-2. The precise administrative boundaries (i.e., river-miles) between the reaches for remedial design purposes are anticipated to be developed during negotiation of future administrative agreements between EPA and the performing parties.[2] For the purposes of a design strategy, this segmentation of the waterway is a reasonable approximation because any implementation scenario would need to group remedy actions to minimize staging and other implementation logistics and to support a viable residuals management strategy. In developing a conceptual schedule for the cleanup, it is assumed that source control sufficiency would be successfully achieved prior to initiating contracting for remedial construction for each reach of the LDW.

While this three-reach implementation scenario is further developed in this design strategy report, other implementation strategies may need to be assessed as remedial planning advances, taking into consideration actual source control progress. For example, Ecology may determine that further segmenting of the waterway or a particular reach may be necessary due to varying degrees of source control progress. Any such modifications to the anticipated source control boundaries could be accommodated with modifications to the design and/or an appropriately detailed construction sequencing plan that anticipates source control timing, along with other

[2] In accordance with the fourth amendment to the AOC (USEPA 2018), the administrative boundary for the upper reach is defined as RM 3 to 5.

sequencing considerations (e.g., residuals management). See Section 4 for further discussion of remedial design and construction schedule considerations.

In light of the inherent uncertainties in source control timing, ongoing coordination between Ecology, EPA, and the performing parties will be necessary to ensure that the remedial design details (e.g., areas targeted for active in-waterway sediment remediation activities) are provided to Ecology in a timely manner, through routine check-ins at critical remedial design milestones, such as:

- Following Phase I data evaluations, when active remedial footprints are approximately defined
- Following 30% design, when remedial footprint boundaries and technology assignments are nearly complete
- At 90% design phase, when remedial contracting schedules are being planned.

A framework for this coordination will be established in the RDWP for each reach or other designated remediation area.

2.2.2 Remedial Design Development and Phasing

Remedial design development for each reach of the LDW cleanup will follow a phased approach that allows sufficient time for data gathering, engineering analyses, and agency and stakeholder review at key project milestones. Remedial design activities for each reach will be carried out in accordance with applicable EPA administrative/judicial agreements or orders, and deliverables will be prepared in accordance with EPA approved work plan(s) prepared by the performing parties.

Figure 2-3 presents a conceptual overview of the anticipated remedial design administrative framework (this framework is further developed in Section 4). As indicated, the various investigation and design phases are integrated in a manner that allows for a systematic progression of the design. The overall approach will be described in the remedial design and pre-design investigation work plans (RDWP and PDIWP) prepared by the performing parties. For the purpose of this conceptual strategy report, design deliverables will be submitted to EPA at the preliminary (30%), intermediate (60%), pre-final (90%), and final (100%) stage of design development. This design strategy also includes provisions for phased PDIs (up to three phases) that allow for delineation and refinement of remedial action footprints, verification and design of remedial technologies, and filling of design-related data gaps. In addition to data collected to support design, the remedial construction contractor may collect data to support execution of the work. Additional details associated with each design step and PDI phase are provided in Sections 3 and 4.

2.2.3 Construction Duration

The design conceptual strategy (Section 4) assumes that the total duration of the remedial action construction is 7 years, based on an assumed allowable in-water construction window from October 1 to February 15. The estimated 7-year duration is based on the conceptual analysis presented in the FS (AECOM 2012) and does not include provisions for remedial work plan preparation, pre-design investigations, design, and RD/RA contracting (estimated to be approximately 6 years for each reach of the waterway[3]). The FS also makes the simplifying assumption that the total number of construction seasons required to complete remedial construction is controlled by the open water dredging production rate.[4] It is further assumed that other construction work (under-pier work, capping, and ENR/*in situ*) will occur largely in parallel with dredging activities. While these assumptions were appropriate for FS purposes, actual planning, scheduling, and logistical constraints identified during remedial design may preclude concurrent implementation of all of these activities. For example, it may be deemed prudent to delay backfilling, residuals management, ENR/*in situ*, or capping work until after each season's dredging has been completed in certain areas to minimize potential recontamination from resuspended dredge material.

While the FS 7-year construction duration estimate has been maintained for the conceptual strategy and schedule developed in this report, it is assumed that construction will occur in three separate reaches as described in the previous section. Accordingly, provisions have been incorporated into the conceptual schedule to allow for remedial action contracting and RDWP preparation for each reach. While this sequencing assumption may result in a brief lag in construction between the reaches, it provides greater opportunities to build upon lessons learned and refine approaches as the work progresses from one reach to the next.

The actual construction sequence and duration will be further refined during remedial design and construction contracting, consistent with the requirements of any applicable EPA administrative/judicial agreements or orders. An overarching goal of such refinements will be to complete the remedy in the most efficient and timely manner possible. As discussed in Section 4.2, opportunities may exist to further refine the conceptual strategy and schedule to allow the remedial construction to occur in a more continuous uninterrupted sequence (e.g., without a lag between reaches).

[3] The conceptual schedule (Figure 4-2) assumes the pre-construction activities for the middle and lower reaches would be conducted in an overlapping sequence to allow the remedy to be implemented in a timely manner.
[4] The assumed average dredging production rate developed for the FS was 1,000 cubic yards per day, which was approximately equal to the throughput capacity of existing offloading/rail transport in the Duwamish corridor at the time of the FS. These and other production-limiting constraints should be considered during remedial construction planning.

3 REMEDIAL DESIGN DATA NEEDS

This section describes the types of data that will be collected to complete the various aspects of the LDW design and includes considerations for the timing of associated data collection efforts. Such data include location-specific environmental data (e.g., surface and subsurface sediment chemistry) that will be collected to refine remedial boundaries and technology assignments, and also used to support other aspects of the design (e.g., cap modeling). Physical data (e.g., sediment geotechnical properties and bathymetry) will be collected to support design elements such as dredge prism and cap designs.

In addition, certain planning information (including community input via EPA's Roundtable) will be collected to support the logistical aspects of remedy implementation. This will include identifying factors vital to accommodating waterway users who may be affected by construction activities and approaches for minimizing the effects of the remedial action construction on the community.

3.1 PRE-DESIGN INVESTIGATION PLANNING

As part of the remedial design planning process, available post-ROD data (Section 1.3) will be reviewed to identify data that satisfy DQOs for the various remedial design elements. From this review, data gaps will be identified and used to inform the scope and approach of the PDI. The PDI will proceed in a phased approach (Section 2.2.2) where initial data collection and design analyses will be sequenced to inform subsequent phases of data collection and analyses.

The PDI will be organized to collect data that are required to implement the individual components of the selected remedy (Section 2.1):

- Dredging, capping, ENR, and MNR design
- Dredged material management
- Permitting and regulatory requirements (including biological, archaeological, and cultural assessments).

As discussed in the following sections, in addition to data and information collected by the PDI, the design team will collect various other information throughout the design process, as needed to support design analyses and evaluations.

3.2 DATA TYPES AND TIMING CONSIDERATIONS

A detailed list and relative phasing of the data collection needed for remedial design is presented in Appendix B. Appendix B differentiates between data that will be collected as part of the PDI and information that is typically gathered or developed by the remedial design engineering team as part of performing the 30%, 60%, 90%, and 100% stages of design. The list identifies the anticipated relative phasing of data collection activities. The timing considerations presented in this report are conceptual and will change based on various factors and considerations encountered during the remedial design planning process.

3.2.1 Environmental Information

Surface sediment, tissue, surface water, and porewater are being characterized as part of the third amendment to the AOC pre-design studies (USEPA 2016) to establish baseline conditions for comparison to post-remedial action data. This work has been sequenced to follow the cleanup actions at the EAAs to facilitate tracking and assessing progress towards the remedial actions objectives and compliance with applicable or relevant and appropriate requirements (ARARs).

Location-specific sampling and characterization of contaminants of concern will be performed as part of the phased PDI (Section 2.2.2) to support the delineation of remedial technology assignment boundaries—including MNR areas where concentrations of contaminants of concern exceed the sediment cleanup objectives (SCOs) (MNR > SCO areas; see Table 27 of the ROD), the definition of dredge prisms, and waste characterization.

The initial phase (Phase I) of the PDI will involve sampling and analysis to identify areas subject to active (dredging, capping, ENR) or passive (MNR) remedial technologies. This will involve characterizing the limits of RAL exceedances in the 0–10 cm and, where applicable, 0–45 or 0–60 cm sediment depth intervals. In accordance with the ROD (USEPA 2014), an approach will be developed for the PDI to characterize shoaled areas within the federal navigation channel with sediment accumulation above the authorized depth, including the over-dredge depth used for maintenance dredging. This work will be informed by a new bathymetric survey (Section 3.2.2).

Characterization of sediments beneath overwater structures poses specific challenges, including access and health and safety. A strategy will be developed in the PDI for characterizing sediments beneath overwater structures. This strategy will be focused on specific structures, and will consider adjacent sediment data, upland data, site history, or other relevant factors. Sampling methods (e.g., diver-assisted grab or core sampling) will be selected to address specific physical access constraints and health and safety considerations. The strategy will be informed by the *Waterway User Survey and Assessment of In-Water Structures Data Report* (Integral et al. 2018b) and, if needed, additional field reconnaissance.

Following the delineation of active and passive remedial technology boundaries, a subsequent phase (Phase II) of sediment sampling will be performed to support development of dredge prisms, cap sections, and waste characterization.

The data obtained during the Phase I PDI, combined with existing data and analyses, may be sufficient to characterize surface sediment (0–10 cm) for purposes of evaluating sedimentation and recovery in delineated MNR > SCO areas. The remedial design and PDI work plans will address timing and need for additional data.

The ENR/AC pilot study is currently obtaining a variety of data that will be used to assess the potential use of carbon as an amendment for ENR areas. The ENR/AC pilot study report will identify additional data that may be needed for implementation of AC. This report is anticipated to be available in advance of Phase II of the PDI, with sufficient time to incorporate an approach for collecting any additional data that may be needed.

For most areas, it is anticipated that conservative porewater equilibrium partitioning assumptions will be sufficient for the purpose of cap design. If preliminary cap modeling performed during the 30% design indicates additional porewater data are needed to complete the design, those data will be collected as part of Phase II of the PDI, following the development of cap limits and preliminary design objectives.

3.2.2 Geotechnical and Hydrogeological Data

The PDI program will include geotechnical sampling and analysis to support the following:

- Determine sediment stability and dredge cut side-slope requirements
- Characterize sediment dredgeability
- Support assessment of sediment bearing capacity and consolidation for cap design
- Support static and seismic slope stability evaluations for cap design
- Support selection of dredge equipment during implementation
- Support the design of sediment handling, transport, dewatering, and treatment systems.

In general, geotechnical data collection will be sequenced to follow characterization and delineation of dredging and capping areas. It is recommended that the design team look for opportunities to collect useful geotechnical information (e.g., standard index properties, such as water content, gradation, Atterberg limits) as part of sediment chemistry investigations. These parameters can be correlated with sediment strength and consolidation properties to support dredging and capping designs, potentially reducing geotechnical investigation time and costs.

It is anticipated that existing compiled hydrogeologic information and modeling will be sufficient to provide conservative estimates of groundwater upwelling rates for the purpose of cap modeling. If additional data (e.g., from seepage meters) are needed for certain areas, based on the preliminary cap design, those data will be collected as part of a later phase of the PDI (Phase II or III).

3.2.3 Geophysical and Physical Data

Phase I of the PDI will include a multibeam bathymetric survey to support the design of dredging, capping, and recovery areas. Digital terrain models and sun-illuminated maps will be generated to provide updated evaluations of scour evidence, to inform revisions to recovery categories and technology assignments during the 30% design phase. The process for finalizing recovery categories and technology assignments is further described in the draft *Recovery Category Recommendations Report* (Integral et al. 2018a). A geophysical survey of debris and utilities may be conducted simultaneously, for efficiency, to support debris removal planning and to locate utilities for avoidance and protection during construction. The results of these surveys will also support cultural/archaeological assessments. Alternatively, the geophysical survey could be accomplished in a later phase of the PDI so that the effort is focused on areas requiring active remediation.

Focused engineering evaluations will be conducted as part of the 60% design, as needed, to assess the condition and stability of existing natural and engineered shorelines and structures that may be affected by remedial construction. Building on the reconnaissance structures survey performed as part of the third amendment to the AOC pre-design studies (USEPA 2016), the remedial design evaluations may involve review of structural drawings and/or additional survey/inspections of specific structures that may be affected by remedial construction. This engineering evaluation, if needed, will follow the finalization of technology assignments and delineation of associated remedial footprints (refer to Appendix A for additional details).

3.2.4 Hydrodynamic Data

As discussed in Section 1.3, the waterway user survey and assessment of in-water structures have provided preliminary information that will be used to inform the identification of scour areas. The bathymetric survey (Section 3.2.3) will be used to identify physical evidence of scour areas and finalize recovery category assignments. Together, this information will inform development of parameters that can be used to calculate estimates of vessel-induced erosion/scour forces (e.g., propeller scour, wake waves) for cap areas. Other readily available data will be compiled by the design engineer and used to evaluate forces associated with river currents and outfall discharges. This information will in turn inform the development of sediment cap material specifications that are appropriately resistant to erosion under a range of anticipated conditions and performance requirements. Hydrodynamic information will also be used in the selection of ENR materials.

A hydrodynamic assessment will be performed during remedial design to evaluate the effect (if any) of the design remedial elements (e.g., sediment cap, riverbank armor) on water surface elevations, shear stress, and sediment mobility. In general, the design will seek to avoid any such hydrodynamic effects.

Each of these design activities is anticipated to be performed with existing compiled information and the bathymetric survey that is conducted as part of the PDI. The need for additional data will be evaluated throughout the remedial design development and collected if necessary with Phase II or III efforts. Consistent with engineering best practices and available guidance (Ecology 2017), these evaluations of hydrodynamic data will consider potential vulnerabilities due to climate change and incorporate measures to increase resiliency of the remedial action. Such measures are anticipated to include selection of materials used for sediment caps and armoring, and design details for sediment caps on banks.

3.2.5 Habitat and Archaeological/Cultural Information

To meet the substantive and procedural requirements of the Endangered Species Act and Section 404 of the Clean Water Act, sensitive species and their habitat will be identified within the project area to facilitate the biological assessment. The biological assessment is an evaluation of potential impacts associated with the remedial action, submitted with the 90% design. Existing data from the RI/FS, EAAs, and ENR/AC pilot will support this effort.

Similarly, for compliance with the archaeological requirements of Section 106 of the amended National Historic Preservation Act of 1966, an archaeological and cultural resource assessment will be conducted during remedial design for submittal with the 90% design. The assessment, with any follow-up surveys as needed, will identify resources that may be affected by the remedial action and an archaeological discovery plan will be developed. The plan is submitted with the 90% design and describes measures to be taken in the event resources are encountered during construction.

3.2.6 Implementation Planning and Other Information

Ancillary information, supplemental to the key items discussed above, will be developed as part of the remedial design. Such information needs are anticipated to include the following:

- Space requirements for construction support areas (e.g., laydown areas, construction field offices)

- Preliminary identification of transloading and disposal facility location(s) and transport methods
- Minimum requirements for material haul routes (e.g., avoidance of residential streets as practicable)
- Identification of potential backfill and reactive amendment material sources to support the engineer's cost estimate, based on the physical and geochemical performance criteria that are established by the design
- Current and reasonably anticipated future uses (e.g., future berth expansion or other waterfront use) that may influence the PDI, remedial design, and implementation of institutional controls
- Logistical details to be used for coordination with waterway users and identification of potential disruption from construction
- Bench-scale column settling and/or treatability testing, if needed, based on dredging and water management requirements that are established by the remedial design.

During design, EPA's Roundtable process for stakeholder involvement and input may provide information for several of these topics. Much of the information listed above will be incorporated as performance requirements in the design specifications. The construction contractor will then develop and finalize construction details in the remedial action work plan (RAWP). For example, the construction contractor will be responsible for identifying and securing specific transloading facility locations, equipment types, haul routes, and import material sources. The contractor additionally will be responsible for development and implementation of vessel management plans, coordination with tribal fishing activities, and development of detailed work schedules. As the RAWP and construction schedule are finalized, they will be used by the performing parties to secure access agreements. The timing considerations presented in Appendix B indicate information that is anticipated to be developed by the contractor.

4 REMEDIAL DESIGN STRATEGY AND SCHEDULE

This section presents a proposed conceptual strategy and schedule for design and implementation of the LDW cleanup. The strategy integrates the data needs presented in Section 3 with the remedial design framework and implementation assumptions presented in Section 2 (e.g., source control timing, RD/RA phasing, construction duration). This framework is intended to be flexible and can be applied to different remedial action areas and construction staging and sequencing scenarios.

4.1 RD/RA FRAMEWORK AND KEY DELIVERABLES

An overview of the conceptual design strategy and key deliverables is presented in Figure 4-1. As indicated and summarized below, the various investigation phases and design steps are integrated to allow a systematic development of the design and to provide for agency and stakeholder review and input at appropriate interim milestones.[5] As currently envisioned, the deliverables described below would be separately developed in sequence for each of the three reaches of the LDW. The timing of completion of each design coincides with Ecology's SCS. As discussed in Sections 4.2 and 4.3, there may be opportunities for efficiencies for some elements of design by using information or methods developed for design of the upper reach of the LDW.

4.1.1 Remedial Design Work Plan

Following selection of a remedial design consultant, the performing parties will prepare a RDWP. The RDWP will include a plan and schedule for implementing all remedial design activities and will identify supporting documents. The RDWP will include, among other elements, proposed strategies and approaches for project management, contracting, permitting, remedial design investigations, and deliverables.

The RDWP will also include a PDIWP summarizing existing data, data gaps, proposed investigation strategies, and scheduling. The PDIWP will draw on existing LDW data identified in Section 1.3, and the data needs identified in Section 3. PDIs will be phased to facilitate a stepwise progression of data collection and design development. Each PDI phase will include a quality assurance project plan (QAPP) or QAPP addendum defining sampling and analysis protocols and DQOs.

[5] For illustration purposes, the conceptual remedial design strategy presented herein focuses only on key elements and reporting requirements for each phase of remedial design and PDI activities. It is anticipated that additional technical and reporting requirements may be defined in RDWPs and PDIWPs.

4.1.2 Pre-Design Investigations

As discussed in Section 3, it is anticipated that the initial PDI (Phase I) will focus on characterization of surface sediment (defined as 0-10, 0-45 and 0-60 cm, depending on the location) to facilitate initial delineation of remedial footprints and technology assignments. Bathymetric and geophysical surveys will also be performed to support development of a design base map and refine the definition of potential scour areas. A Phase II PDI will focus on characterization of subsurface sediment chemistry and geotechnical parameters to support further delineation of RAL exceedances, refinement of remedial footprints and technology assignments, dredge prisms, dredge and cap designs, and waste characterization. Subsequent PDIs may be performed, if necessary, to address additional data gaps and bench-scale/treatability testing needs identified during remedial design. Appendix B contains a comprehensive listing of potential RD/RA data needs and timing considerations.

4.1.3 Remedial Design

The preliminary (30%) remedial design will incorporate findings from the Phase I and II PDIs. This 30% design package will include a draft basis of design report, preliminary plans, and an outline of the required specifications. The basis of design report will identify candidate transportation routes and transloading facilities, waste disposal options, import capping material sources, ARARs, and permitting and access requirements. The basis of design report will also include outlines of the emergency response plan, community outreach and communications plan, archeological discovery plan, and Section 408 compliance documentation to support evaluation of compliance with 33 U.S.C. Section 403 and Section 408. Outlines will also be developed for the long-term monitoring and maintenance plan and institutional controls implementation and assurance plan. These supporting deliverables will be further developed as the design progresses through the 60/90/100% design stages.

The intermediate (60%) design package will incorporate EPA/stakeholder input on the 30% design package and advance the preliminary design concepts presented therein, such as technology assignment footprints, dredge prisms and associated structural setbacks, engineered cap designs, the basis of design report, and design plans and specifications.

The pre-final (90%) design package will be near-final, including certified construction drawings and specifications, and a construction quality assurance plan, water quality monitoring plan, permitting and site access plan, QAPP and health and safety plan to support remedial construction and monitoring activities. The 90% design will also provide an assessment of proposed remedial activities in habitat areas and include a draft biological assessment and a Clean Water Act 404 and Section 10 memorandum, although associated coordination with EPA and the resource agencies should be initiated sufficiently early in the design process (e.g., ~60%) to ensure that approvals can be obtained in advance of the planned construction period. An engineer's remedial cost estimate and construction schedule will also be developed in the 90% design package.

The final (100%) design package will incorporate EPA comments on the 90% design submittal and include final versions of all supporting design deliverables. The annotated outlines for the institutional controls implementation and assurance plan and the long-term monitoring and maintenance plan will be further developed for the 100% design package to reflect up-to-date design information, and will be finalized after remedial action construction, taking into consideration the as-built features of the remedy and project-specific protection, monitoring, and maintenance needs. Ultimately, the long-term monitoring and maintenance plans will be integrated across reaches and will apply waterway-wide, including in early action areas.

4.1.4 Remedial Action

The remedial action for a proposed cleanup area will be initiated upon completion of Ecology's source control sufficiency evaluation, assuming a favorable determination with EPA concurrence for that area. For conceptual planning purposes, it is assumed that the source control sufficiency evaluation will be completed for each reach coinciding with the 100% design submittal. The performing parties will then initiate solicitation and contracting with a remedial construction contractor.[6] In coordination with the performing parties and EPA, the selected contractor will prepare a RAWP, identifying the means and methods that will be used to execute the work (e.g., equipment, vessel management plan, transload details, haul routes, construction schedule, access agreements). The RAWP will also identify pre-construction data needs and any proposed investigation activities (e.g., pre-construction condition surveys).

As discussed in Section 2.2.1, the source control sufficiency evaluation for each reach will be initiated early in the design process to allow a sufficiency determination to be made in advance of remedial action construction. EPA and the performing parties will support Ecology in this effort, including timely delivery of relevant pre-design investigation data. In the event that Ecology identifies outstanding source control issues, the current conceptual strategy and schedule would allow an additional ~12 months to resolve the issues (concurrent with remedial action contracting and RAWP preparation) before construction is scheduled for a given location. See Sections 4.2 and 4.3 for further discussion of possible source control challenges and management strategies.

The process for soliciting construction bids, awarding contracts, developing the RAWP and obtaining agency approval, and mobilizing can take 6 months or longer, and must be timed to initiate construction at the beginning of the construction season in-water work window (assumed October 1–February 14). The estimated time period to complete construction for each

[6] This contracting scenario assumes that the remedial action will be performed under a traditional design-bid-build project delivery method. Alternative contracting methods may be evaluated and proposed in the RDWP.

reach will be approximately 2–3 construction seasons, based on the production assumptions established in the FS.

As suggested in the preceding paragraphs, ongoing and close coordination between the performing parties, EPA, Ecology, the resource agencies, and other stakeholders will be essential to identifying and addressing potential source control and other implementation challenges early.

4.2 CONCEPTUAL RIVERWIDE RD/RA SCHEDULE

This section presents a conceptual schedule for completing the LDW cleanup. The schedule, shown in Figure 4-2, incorporates the proposed RD/RA framework, implementation assumptions, and anticipated LDW-specific data needs described in the preceding sections. Recognizing that some of these underlying assumptions are uncertain or subject to change (e.g., area-specific data needs, source control timing, construction sequencing), this schedule is intended to serve as a framework that may be modified as the design, contracting, and construction process proceeds. These assumptions and additional schedule details are summarized as follows:

- It is assumed that the remedy will be implemented in three stages corresponding to the source control reaches identified in the SCS document (Ecology 2016). Accordingly, the RD/RA framework of deliverables developed in Section 2 is applied separately to each of these reaches. This RD/RA framework is expanded in Figure 4-2 for the upper reach for illustration purposes and condensed for the subsequent reaches.
- The overall RD/RA schedule has been developed to allow the remedial action activities (e.g., remedial action contracting, RAWP preparation, and remedial construction) to proceed from the upstream to the downstream reach. This schedule construct requires overlapping the remedial design activities for each of the reaches, with an approximately 3-year period between the remedial design start date for the upper and middle reaches, and a similar period between the remedial design start dates for middle and lower reaches.
- Task durations for PDI deliverables include provisions for preparation and EPA review of draft, draft final, and final submittals.
- Task durations for remedial design deliverables include provisions for preparation and EPA review of interim deliverables at 30/60/90/100% design steps.
- EPA/stakeholder review periods are assumed to be 30 to 45 days (depending on deliverable and draft stage).

- For the middle and lower reaches, the duration of remedial design, PDI, and RAWP submittal preparation activities has been reduced relative to the upper reach, considering potential efficiencies that may be realized as the work progresses.
- It is assumed that enforcement order(s) are negotiated and executed with performing party group with timing that does not affect the critical path of RD/RA activities. Contracting, RAWP preparation, and remedial action construction will be initiated immediately following EPA approval of the 100% remedial design package for that reach, with the assumption herein that sources have been sufficiently controlled.
- In accordance with the LDW SCS, it is assumed that all PDI data will be provided to Ecology when validated data are provided to EPA. Any PDI data collected after 60% design will be provided at least 6 months prior to the planned advertisement of construction bids for a given reach, to allow sufficient time for Ecology to complete its source control sufficiency determination. This determination will be needed to provide reasonable certainty in contracting.
- The remedial action construction is estimated to require seven construction seasons, based on the LDW FS. This duration has been apportioned on a reach-by-reach basis, taking into consideration the relative area of active remediation within each reach. In addition, the schedule includes provisions for remedial action contracting and RAWP preparation for each reach, with an estimated duration of approximately 1 year per reach.
- The assumed in-water work window is October 1 to February 15, as described in the FS. This is a primary assumption in the FS-estimated 7-year construction duration, and full utilization of each in-water work window was also assumed in the FS. Because Figure 4-2 is a conceptual depiction of the overall schedule, and at this time has considerable uncertainty, the construction tasks were not forced to fall within these in-water work windows. As more detailed schedules are developed in the RD/RA work plans, the in-water work windows will be important drivers for attaining milestones and avoiding missing construction windows.

In summary, the conceptual schedule presented in Figure 4-2 demonstrates that the RD/RA activities for each reach can be sequenced in a manner that will allow timely implementation of the LDW cleanup. Based on the assumptions presented herein, the estimated time to complete the active phase of the LDW cleanup is approximately 13.5 years[7], including PDIs, design, RD/RA contracting and work plans, and remedial construction. This duration assumes overlapping sequencing of RD/RA activities on a reach-by-reach basis, each requiring

[7] This estimated duration is comparable to the remedy implementation time frame presented in the LDW FS and ROD, after accounting for remedial design and remedial action contracting and planning. See Section 2.2.3 for further discussion of FS schedule assumptions.

approximately 7–9 years to complete. Additional discussion of schedule management strategies follows in Section 4.3

4.3 FUTURE PLANNING CONSIDERATIONS

The remedial strategy and schedule for the LDW cleanup will continue to be developed over time and will evolve depending on various factors, including those identified in this report. The following considerations are offered to inform the strategic planning process going forward.

4.3.1 Scheduling Issues and Strategies

In considering the conceptual schedule presented in Section 4.2, it should be noted that this schedule is idealized and does not include contingencies or lag time to accommodate uncertainties (e.g., remedial action construction duration) or other potential delays identified in this report (e.g., source control timing, administrative/legal decisions, construction resource and logistical constraints). Conversely, there may be opportunities to further compress the schedule by greater overlapping of the RD/RA activities for each reach, reducing the number of remedial design submittals (e.g., eliminate 60% remedial design package), reducing agency/stakeholder review cycle times, assessing opportunities to increase dredge production rates, and/or possibly combining the middle and lower reaches into a single project. Such compression, however, will affect the timing requirements for source control and reduce the potential to take advantage of adaptive management opportunities.

A summary and analysis of these and other potential schedule uncertainties and opportunities for efficiencies is presented in Table 4-1, including a conceptual level estimate of the potential effect of these items on the overall RD/RA duration (relative to the conceptual schedule presented in Figure 4.2). The analysis also provides a qualitative assessment of the pros and cons and other considerations for each item, with the goal of focusing future planning efforts.

As indicated Table 4-1, there is a range of potential strategies that could result in a reduction of the overall RD/RA time frame, from several months (for example, by more aggressive overlapping of upper and lower reach remedial design activities), to as much as ~2 years (for example, in the event that removal volumes are less and construction production rates are higher than anticipated). It is important to note, however, these opportunities are offset in many cases by uncertainties that are difficult to predict or control (e.g., source control timing, remedial areas/volumes, rail capacity) and could extend the duration of the cleanup beyond current estimates. Nonetheless, the analysis indicates that there are multiple viable options to further refine and optimize the conceptual schedule as remedial planning progresses. Ongoing coordination among the performing parties, EPA, Ecology, and other stakeholders will be important to the success of such planning efforts.

4.3.2 Alternative Implementation Scenarios

While the hypothetical reach-by-reach implementation scenario developed for this conceptual strategy report is a reasonable representation of possible sequencing approaches, there are other viable scenarios that could be considered (e.g., combining reaches or further segmenting the waterway into smaller remedial action areas). The actual implementation strategy will depend on multiple factors, including the timing and structure of administrative agreement(s) between EPA and the performing parties responsible for executing the work, the implementation preferences of those performing parties, the timing and geographical boundaries of source control, and other factors. Accordingly, the conceptual strategy presented herein should be revisited and updated in the RD/RA Work Plans to reflect major new developments.

4.3.3 Source Control Timing

Under any remedy implementation scenario, it will be important to continuously monitor source control progress and to adjust planning and scheduling accordingly. Ecology's source control sufficiency evaluation (Ecology 2016) is needed prior to advertisement for construction bids, to provide reasonable certainty that the contract can be executed without delays. If outstanding source control issues are identified, an agreed plan should be developed (including EPA, Ecology, and the Performing Parties) before bidding, to address the outstanding source control issues on a timeline allowing uninterrupted construction. If a viable plan cannot be developed, it may be become necessary to delay remedy implementation in a reach or portion of a reach if sources have not been sufficiently controlled. In such cases, the remedial design for a given project area, if complete, would need to be set aside pending a positive source control sufficiency determination. Such a delay could involve inherent administrative challenges, and potential revisions and updates to the design could be required prior to implementation. As previously noted, this risk will be mitigated, in part, through coordination with Ecology throughout the design process, to ensure that relevant design information is provided in a timely manner, through routine check-ins at critical remedial design milestones.

4.3.4 Stakeholder Involvement

EPA is convening a roundtable forum for the design and implementation of the cleanup with the objective of mitigating the impact of the cleanup on affected communities, businesses, and waterway users. Early communications should be taken into consideration during planning of PDI activities. Continued outreach with stakeholders will inform implementation of coordination and community safety measures during construction.

4.3.5 Access Agreements

Under any remedy implementation scenario, access agreements are needed for construction. Sometimes these can involve complex activity disruption accommodations or property rights transactions. These agreements are ideally negotiated prior to advertisement for construction bids, to provide reasonable certainty that the contract can be executed without delays. However, the timing and exact extent of the disruption at any given facility can only be estimated at the time of bid advertisement, and facility operational needs can change over time. It is expected that some of the agreements will need to be finalized (or modified) during RAWP development or during the remedial action construction period.

4.3.6 Opportunities for Adaptive Management

Subdividing the LDW cleanup into multiple remediation reaches may offer opportunities for adaptive management and optimization as the remedy progresses. Such opportunities may include, but not be limited to, advancements or refinements to:

- Pre-design investigation methods
- Construction methods, equipment, and environmental controls
- Dewatering and transloading processes
- Remedial technologies
- Monitoring tools and methods
- Regulatory coordination
- RD/RA documentation and review processes

The project designers may also benefit from lessons learned during implementation of the LDW early actions (e.g., dredge methods, working in confined waterway, material sources, residuals management, Tribal fishing considerations). Additional information can be obtained from the remedial action completion reports for these projects.

A risk register is a planning tool that can also be used throughout RD/RA to identify key risks and develop strategies to minimize project impacts. This could inform adaptive management strategies as well as other project approaches, such as scheduling issues and strategies (Section 4.3.1) and alternative implementation scenarios (Section 4.3.2)

4.3.7 Performing Party Group Organization and Remedial Planning

The conceptual strategy presented in this report does not consider potential changes to the membership of the performing parties group that will be responsible for design and implementation of the cleanup. The performing party group may propose different approaches than those illustrated in this recommendations report.

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FIGURES

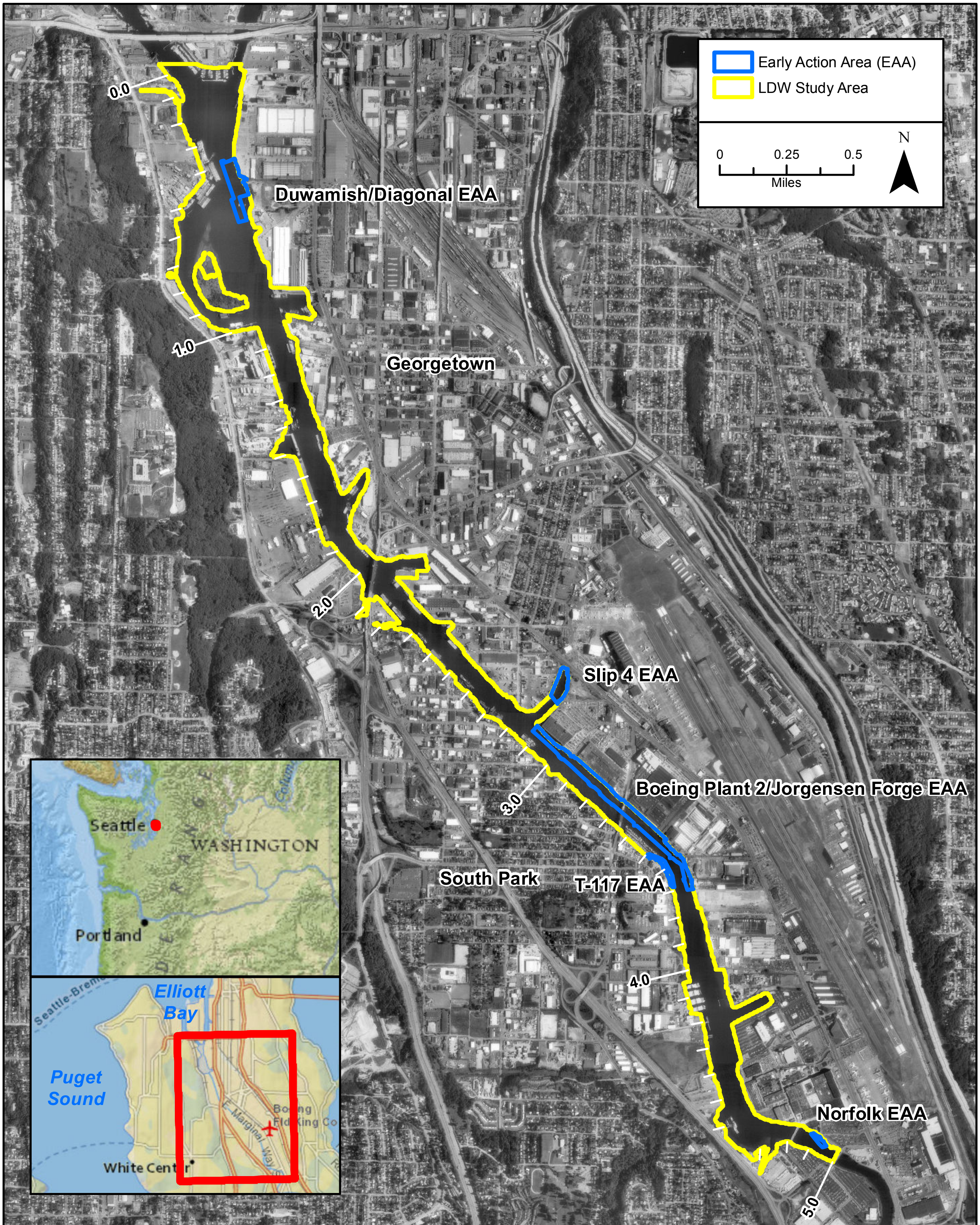

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Figure 1-1.
Lower Duwamish Waterway Location Map

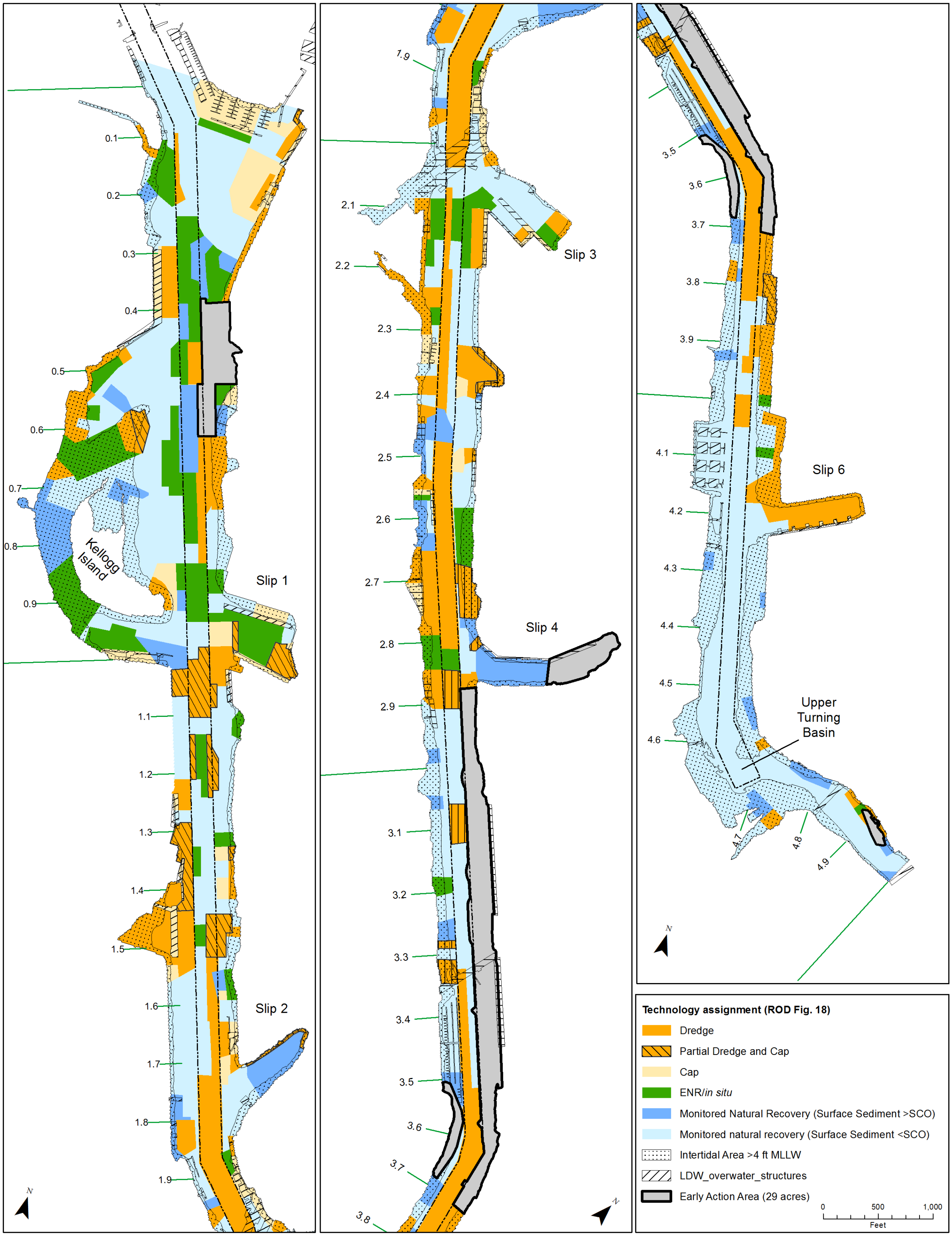

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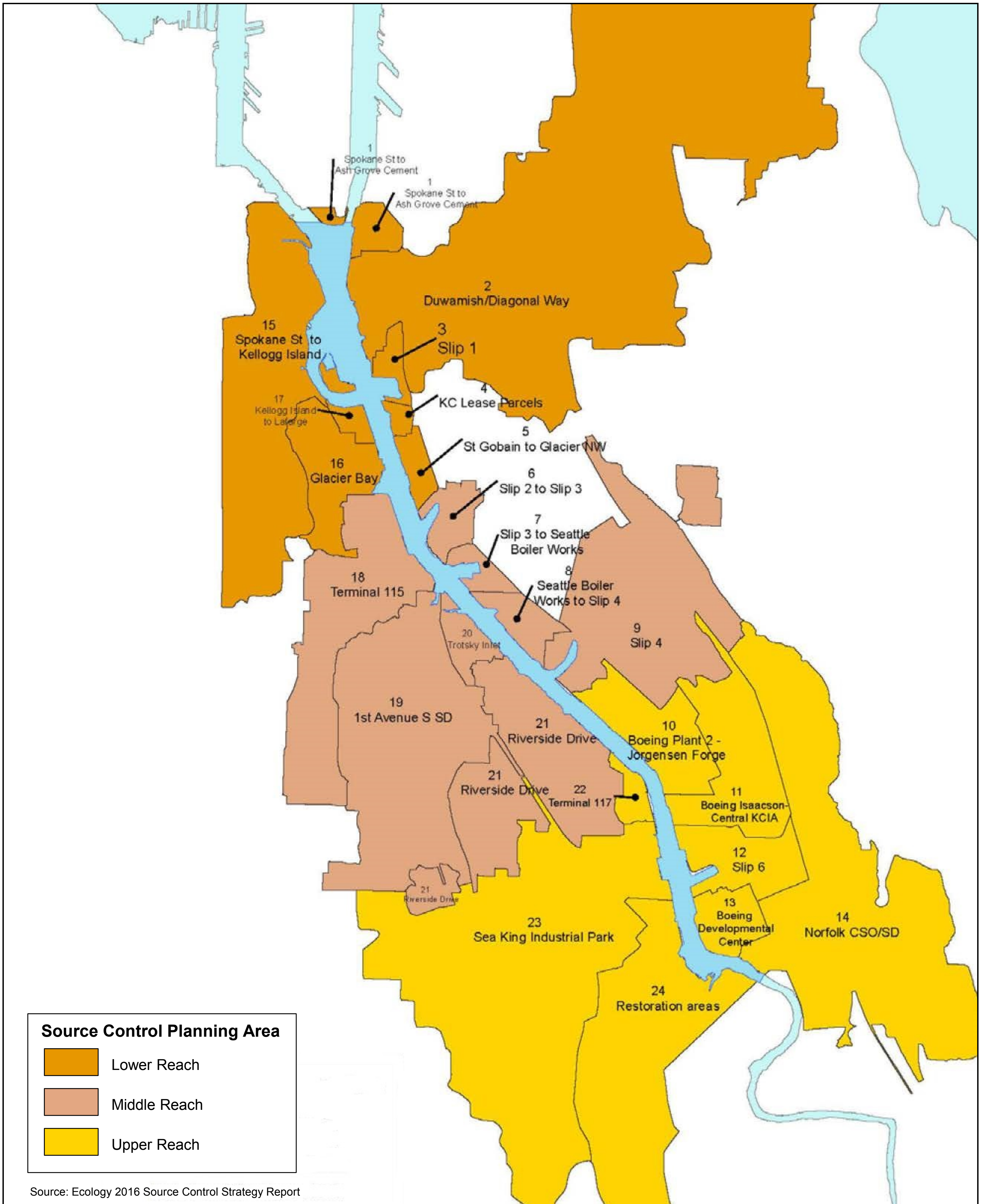
Figure 2-1.
Selected Remedy from EPA Record of Decision



Source: Ecology 2016 Source Control Strategy Report

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Figure 2-2.
Lower Duwamish Waterway Source Control Reaches

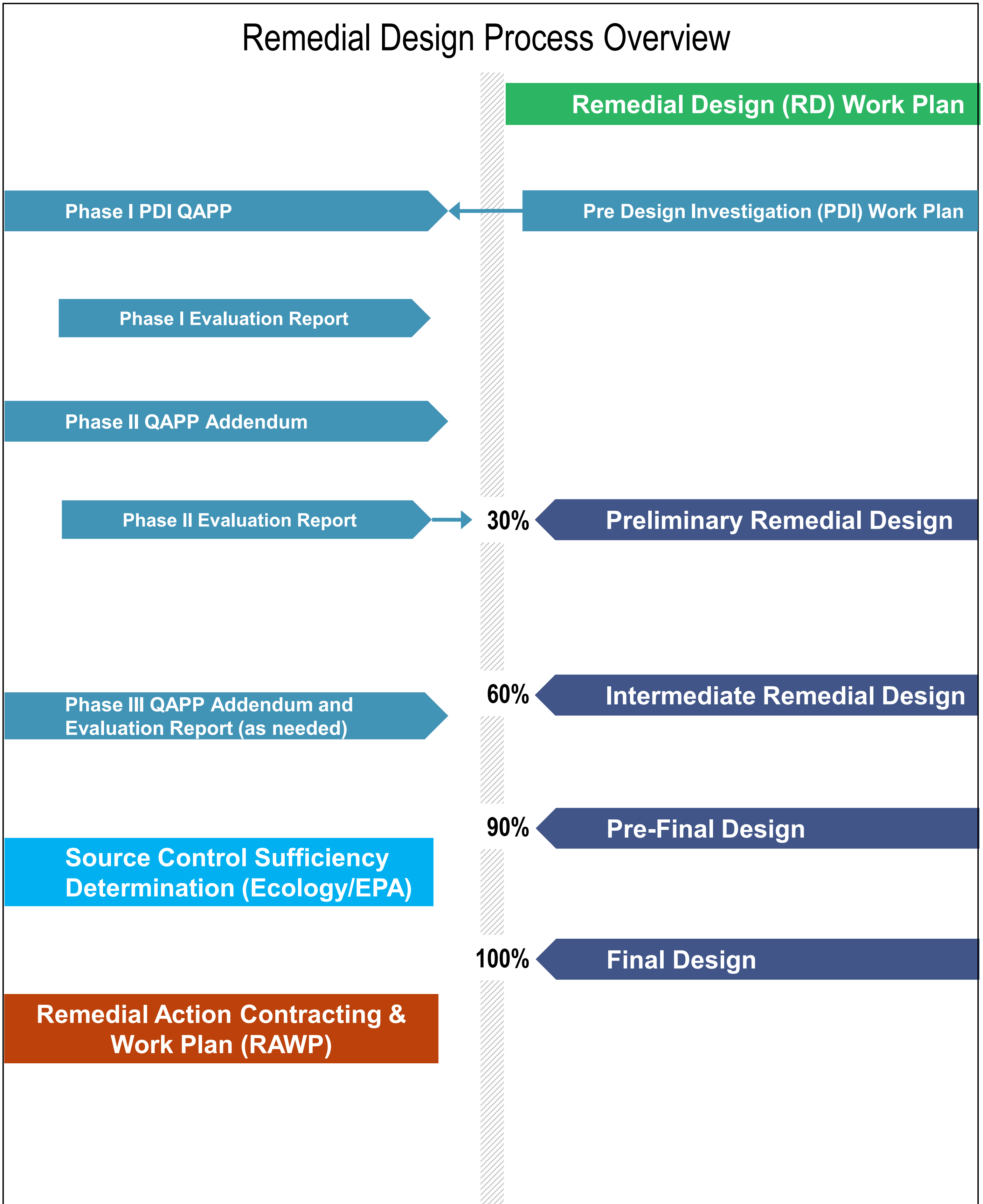

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Figure 2-3.
Remedial Design Process Overview

Remedial Design Conceptual Strategy and Key Deliverables

Remedial Design (RD) Work Plan

- Design and construction management strategy
- Contracting strategy
- Approaches for permitting and site access
- RD investigation approach
- Description of elements of RD deliverables

Pre Design Investigation (PDI) Work Plan

- Summary of existing data, data gaps
- Investigation strategy and conceptual approaches
- Investigation schedule

Phase I PDI QAPP

- Surface sediment characterization (0-10cm, 0-45 cm, and 0-60 cm)
- Geophysical surveys

Phase I Evaluation Report

- Delineation of remedial footprints
- Initial technology assignments
- Engineering base map

Phase II QAPP Addendum

- Subsurface and geotechnical characterization
- Technology assignment verification (e.g., sedimentation rate, chemical trends)

Phase II Evaluation Report

- Depth of RAL exceedances, dredge prisms
- Development of design parameters (e.g., soil strength)
- Pre-final technology assignments
- Waste characterization

Phase III QAPP Addendum and Evaluation Report (as needed)

- Address any data gaps that may be identified during design development

30% Preliminary Remedial Design

- Preliminary Basis of Design Report
- Preliminary plans and key specifications
- Candidate transportation, off-site disposal, and import sources
- Identification of ARAR / permit requirements
- Access and easement requirements
- LTMMP and ICIAP outlines

60% Intermediate Remedial Design

- Intermediate level of development of all 30% design components

90% Pre-Final Design

- Near-final level of development of all design components, certified by registered P.E.
- Draft CQAP, WQMP, PSAP, Outreach Plan
- Habitat / BA / 404 analyses
- Cost and schedule estimates

100% Final Design

- Final RD documents

Source Control Sufficiency (Ecology/EPA)

Remedial Action Contracting & RA Work Plan

- Identification of means and methods (e.g., equipment, transload details, haul routes, detailed schedule)
- Pre-construction conditions survey

Note: For illustration, only select content elements are listed in the bullets.

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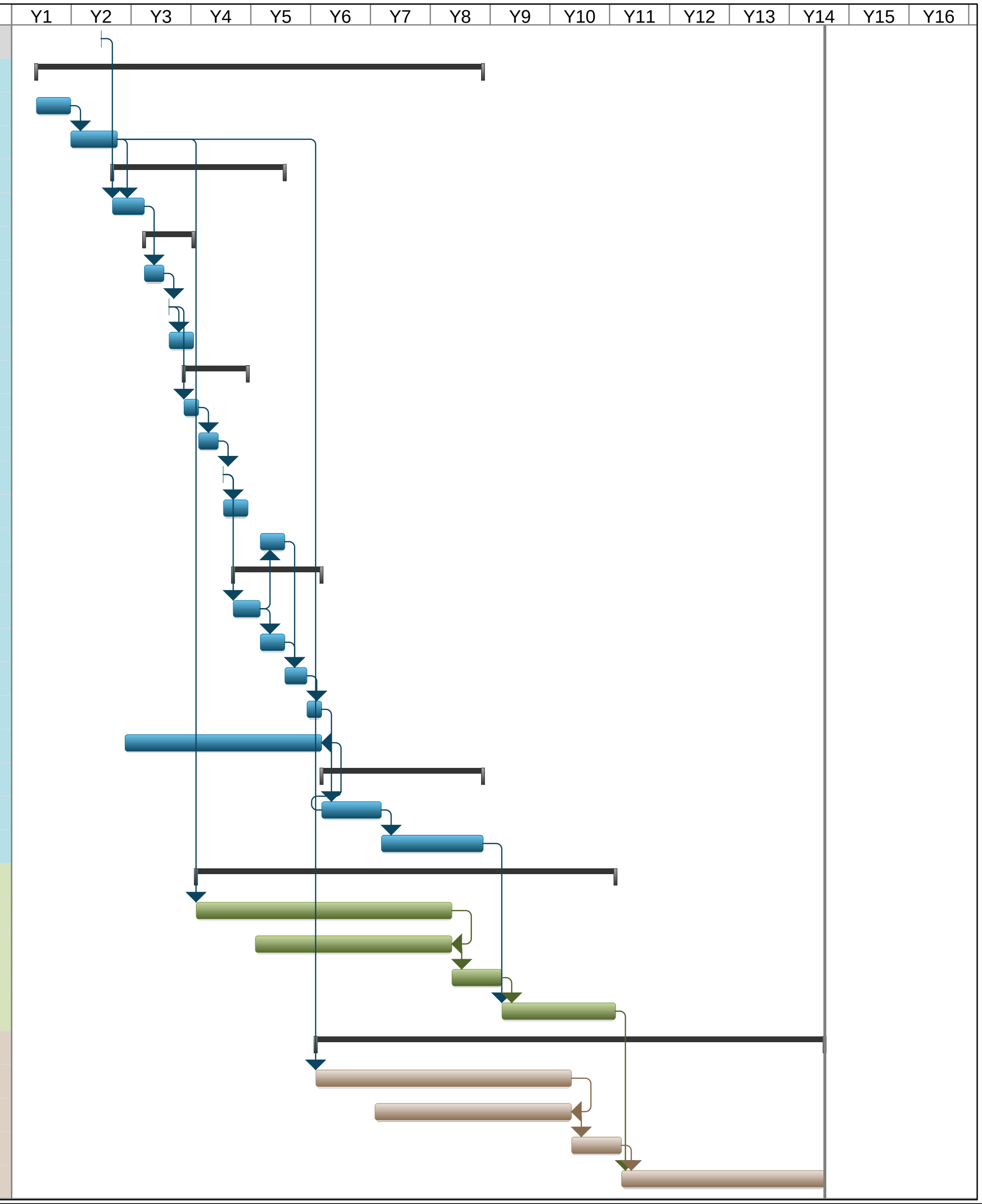
Figure 4-1.
Remedial Design Conceptual Strategy and Key Deliverables

ID	Task Name	Duration	Predecessors
1	LDWG Pre-Design Studies Completion	1 day	
2	UPPER REACH RD/RA	2728 days	
3	Design Contracting	210 days	
4	RD Work Plan (Incl. PDI Work Plan)	285 days	3
5	Pre Design Investigations	1052 days	
6	PDI QAPP	195 days	4FS-30 days,1
7	Phase I PDI	301 days	
8	Field/Analytical/Validation	120 days	6
9	Data Submittal	1 day	8FS+30 days
10	Data Evaluation Report	150 days	9
11	Phase II PDI	391 days	
12	Phase II QAPP Addendum	90 days	9FS+90 days
13	Field/Analytical/Validation	120 days	12
14	Data Submittal	1 day	13FS+30 days
15	Data Evaluation Report	150 days	14
16	Phase III PDI (if needed)	150 days	18
17	Remedial Design	540 days	
18	Preliminary (30%) Design	165 days	14FS+60 days
19	Intermediate (60%) Design	150 days	18
20	Draft Final (90%) Design	135 days	19,16
21	Final (100%) Design	90 days	20
22	Source Control Sufficiency Determination	1200 days	24SF
23	Remedial Action	986 days	
24	RA Contracting, RAWP Preparation	365 days	21
25	RA Construction	621 days	24
26	MIDDLE REACH RD/RA	2560 days	
27	RD Contracting, RDWP, PDI, RD	1561 days	4
28	Source Control Sufficiency Determination	1200 days	27FF
29	RA Contracting, RAWP Preparation	305 days	28
30	RA Construction	694 days	29,25
31	LOWER REACH RD/RA	3107 days	
32	RD Contracting, RDWP, PDI, RD	1561 days	4
33	Source Control Sufficiency Determination	1200 days	32FF
34	RA Contracting, RAWP Preparation	305 days	33
35	RA Construction	1241 days	34,30



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Lower Duwamish Waterway Group

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

Figure 4-2.
Remedial Design/Remedial Action Conceptual Schedule

TABLES

Table 4-1. Summary of Potential Schedule Uncertainties and Strategies for LDW Remedial Design/Remedial Action Activities

No.	Schedule Item [a]	Description	Potential Implication to RD/RA Duration [b,c]	Comments
General Schedule Considerations				
1	Construction scope and duration	Construction quantities and production rates are based on estimates in the ROD	−2 to +2 years	• Scope of required active remediation (e.g., dredge quantities) is highly uncertain until after 30% design for each segment. • Production rates depend on many factors and will be re-evaluated in RD, with best estimates developed by the contractor in its RA work plan. • Higher production rates can affect project quality, environmental impacts, costs, and quality of life factors; contract incentives must balance these tradeoffs. • Inherent uncertainties, such as rail capacity, availability of construction resources, and economic conditions, are not controllable.
2	Timing of design completion	Timing of design approval and construction contracting, for full utilization of in-water construction windows	0 to +12 months per reach	• Construction window is assumed as Oct 1–February 14. • 100% design should be approved in the period Jan–March to allow RA contracting, development, and approval of work plans, finalization of site access, mobilization, and facility preparation by Oct 1. • Later design approval will result in partial or complete loss of a construction season. • Conceptual schedule currently assumes no schedule losses from this factor. • Close coordination required throughout the design process to reduce the potential schedule implication.
3	Source control sufficiency recommendations and timing	Timing of source control sufficiency, for full utilization of in-water construction windows	0 to +12 months per reach	• Sufficiency recommendation should be complete prior to construction bid advertisement (i.e., in the period Jan–March). • Localized insufficiency can potentially be dealt with through modified scheduling of the construction in that area, assuming a plan is in place to address the problem, and by adding optional construction components in the construction contract. • Conceptual schedule currently assumes no schedule losses from this factor. • Close coordination required throughout the design process to reduce this schedule risk.
4	Pilot studies	Pilot studies to support remedial design	0 to +3 months per reach	• The selected RD contractor could propose to conduct bench- or pilot-level studies to support certain elements of the design or construction, such as dewatering or water treatment. • Current conceptual strategy and schedule does not anticipate or include provisions for pilot studies, although certain bench testing programs could potentially be achieved within the conceptual timeline. • The need for bench/pilot testing will be identified in the RDWP.
5	Coordination with Tribal fishers	Coordination with Tribal fishing activities	0 to +3 months per reach	• Active net fishing within the LDW during remedial construction activities could lead to delays. • Coordination/negotiation with the Tribes may be necessary to facilitate construction in areas that are subject to Tribal fishing rights.
Middle/Lower Reach Schedule Strategies [d]				
6	RD schedule start	Initiate RD contracting and design sooner to reduce time between RD/RA activities in each reach	−3 to +3 months per reach	Pros: • Potentially reduces overall RD/RA time frame. • Provides increased opportunity for real-time coordination between upstream/downstream RD/RA activities. Cons: • More intensive overlapping of upper and middle reach PDI/RD/RA deliverables may overwhelm agency and performing party resources, possibly leading to delays. • Reduces opportunities for adaptive management/lessons learned. • Schedule compression would require earlier completion of source control sufficiency determination. [e]

Table 4-1. Summary of Potential Schedule Uncertainties and Strategies for LDW Remedial Design/Remedial Action Activities

No.	Schedule Item [a]	Description	Potential Implication to RD/RA Duration [b,c]	Comments
7	RD/PDI work plans	Adopt Upper Reach RD/PDI Work Plans to reduce preparation time for these deliverables, amended as needed to accommodate site specific requirements	−4 to +1 month per reach	Pros • Potentially reduces overall RD time frame. • Provides opportunity for reporting efficiencies, reduces potential for duplication of efforts. Cons • May constrain RD contractor's project approach, opportunities for innovation, cost savings, and adaptive management. • There are potential contract and performance risks related to RD contractor's adoption of analyses and recommendations prepared by others. • Delays may occur if elements from upper reach work plans prove unsuitable for site-specific considerations. Notes • Potential time savings is uncertain due to likely unique RD/PDI requirements for each reach.
8	PDI QAPP and data evaluation reports	Instead of a sequenced approach, eliminate QAPP addenda for Phase II/III and consolidate data evaluation reports into a single submittal prepared at the completion of all PDI phases	−4 to +4 months per reach	Pros • Time savings would be gained from elimination of deliverable preparation and associated internal and agency reviews. Cons • Has the potential to draw out development and approval of QAPP. Notes • Design team would require flexibility to adjust approach as needed during performance of the PDI, without formal QAPP revision process. • As needed to inform data collection, design team would still be required to evaluate and synthesize data collected by initial PDI phase before proceeding to the next, which may limit overall schedule savings.
9	PDI data collection	Identify opportunities to increase PDI data collection efficiencies	−2 to + 2 months per reach	Pros • Potential PDI data collection efficiencies may be identified during development of PDI work plans/QAPPs, resulting in possible reduction in overall RD time frame. Cons • Current strategy assumes ~30 months to complete Phase I/II/III field, lab, and reporting activities, with limited opportunities for further schedule reductions. Notes • Note that Phase III investigations are conditional and concurrent with 60% design, limiting opportunities for further reduction in the conceptual schedule.
10	RD deliverables	Eliminate 60% design deliverables with 90% design package following 30% design	−4 to +2 months per reach	Pros • Potentially reduces overall RD time frame. • Provides opportunity for reporting and review efficiencies. Cons • Eliminates internal, agency, and stakeholder reviews at 60% design stage. • Increases risk of design rework and changes after the 90% design, resulting in potential schedule delays. • Would require deviation from typical AOC framework for projects of similar scope and scale, although not unprecedented. • Schedule compression would require earlier completion of source control sufficiency determination. [e] Notes • The final scope and schedule of PDI activities could limit the potential time savings associated with this schedule option, particularly considering the current assumed overlapping of PDI/RD tasks.

Table 4-1. Summary of Potential Schedule Uncertainties and Strategies for LDW Remedial Design/Remedial Action Activities

No.	Schedule Item [a]	Description	Potential Implication to RD/RA Duration [b,c]	Comments
11	RA contracting	Alternative project delivery methods to allow earlier construction start	−3 to +3 months per reach	<u>Pros</u> • Design/bid/build is the standard method; alternative project delivery method (either general contractor/construction manager or design/build) could provide opportunity for RA contractor to contribute to RD/RA planning earlier in process, leading to possible efficiencies and improved outcomes. • Potentially reduces overall cleanup time frame. <u>Cons</u> • Would require departure from typical design/bid/build project delivery method; may not be a viable option for performing parties due to business operation/contracting constraints. • Design/build is generally less suitable for projects with substantial external design drivers (e.g., agency reviews, affected waterfront facility operators, other stakeholders). • Would require deviation from typical AOC framework used for similar projects. • Alternative project delivery methods involve inherent risks that may not be acceptable to all parties. • Would require overlapping of RD/RA deliverables, potentially stressing agency and performing party resources. • Schedule compression would require earlier completion of source control sufficiency determination. [e] • Potential delays could occur due to late-stage design revisions not envisioned at time of RA contracting.
12	Combine middle/lower reach into single project	Complete RD/RA for the rest of the waterway as a single project to reduce reporting requirements and eliminate lag between construction phases for the two reaches	−12 to +3 months entire project	<u>Pros</u> • Potentially reduces overall cleanup time frame. • Provides opportunity for significant reduction in reporting requirements. <u>Cons</u> • Would require combining middle/lower reach PDI/RD tasks and deliverables, potentially overwhelming agency and performing party resources. • Has significant potential for design rework for areas where construction may occur 2–5 years after design completion. • May commit performing parties to a single contractor for large scale RD/RA effort, potentially reducing opportunities for competitive pricing, innovation, adaptive management, and recourse in the event of poor contractor performance. <u>Notes</u> • Will likely require some phasing to accommodate source control timing. • Need for design revisions, phased contracting, phased source control, etc. may offer little schedule advantage compared to separately executed middle and lower reach projects.
13	Agency reviews	Expedited or delayed agency/stakeholder review of RD/RA deliverables	−2 to +2 months per reach	<u>Pros</u> • Potentially reduces overall cleanup time frame. <u>Cons</u> • Schedule compression could result in design rework later in process resulting in delays. <u>Notes</u> • Combined total time required for agency/stakeholder review of critical path RD deliverables is roughly 6 months (per reach); changes in assumed review turnaround times will affect the overall RD time frame. • Opportunities to expedite agency/stakeholder reviews may be limited due to the planned overlapping of upper and lower reach deliverables and associated demands on reviewers.

Table 4-1. Summary of Potential Schedule Uncertainties and Strategies for LDW Remedial Design/Remedial Action Activities

No.	Schedule Item [a]	Description	Potential Implication to RD/RA Duration [b,c]	Comments
14	In-water construction window	Seek approval for extended in-water work window	-2 to 0 months per reach	Pros • Increases the overall progress of construction in a given work window. Cons • Accommodation of net fishing within the extended window may eliminate much of any schedule reduction. Notes • Deviation from typical in-water construction window may be possible, allowing for longer construction season. • Coordination/negotiation with the Tribes will be necessary.

Notes:

AOC = administrative order on consent
Ecology = Washington State Department of Ecology
EPA = U.S. Environmental Protection Agency
LDW = Lower Duwamish Waterway
PDI = pre-design investigation
QAPP = quality assurance project plan
RA = remedial action
RD = remedial design
RDWP = remedial design work plan
ROD = record of decision

[a] All schedule and duration references are relative to the conceptual LDW RD/RA schedule presented in Figure 4-2.
[b] Adjustment refers to a roughly estimated potential decrease (−) or increase (+) in the RD/RA duration. The maximum achievable reduction in the RD/RA duration is constrained by the assumed construction duration, 7 years per the LDW ROD. This duration is considered rough and subject to change during RD.
[c] Estimated schedule adjustments assume all other schedule assumptions remain unchanged. The adjustments should not necessarily be considered additive.
[d] It is assumed for this analysis that the upper reach RD framework and schedule is generally fixed. However, certain schedule strategies may warrant consideration for the upper reach, if deemed appropriate by EPA and the performing parties.
[e] Any strategy that results in compression of the project schedule will need to be coordinated with Ecology to ensure that source control sufficiency can be achieved within the targeted timeline.

APPENDIX A

RECOVERY CATEGORIES AND TECHNOLOGY ASSIGNMENT APPLICATION CRITERIA (EXCERPTS FROM LDW ROD [USEPA 2014])

– ROD TABLE 23. CRITERIA FOR ASSIGNING RECOVERY CATEGORIES

– ROD FIGURE 19. INTERTIDAL AREAS—REMEDIAL TECHNOLOGY APPLICATIONS

– ROD FIGURE 20. SUBTIDAL AREAS—REMEDIAL TECHNOLOGY APPLICATION

– ROD FIGURE 21. INTERTIDAL AND SUBTIDAL AREAS—NATURAL RECOVERY APPLICATION

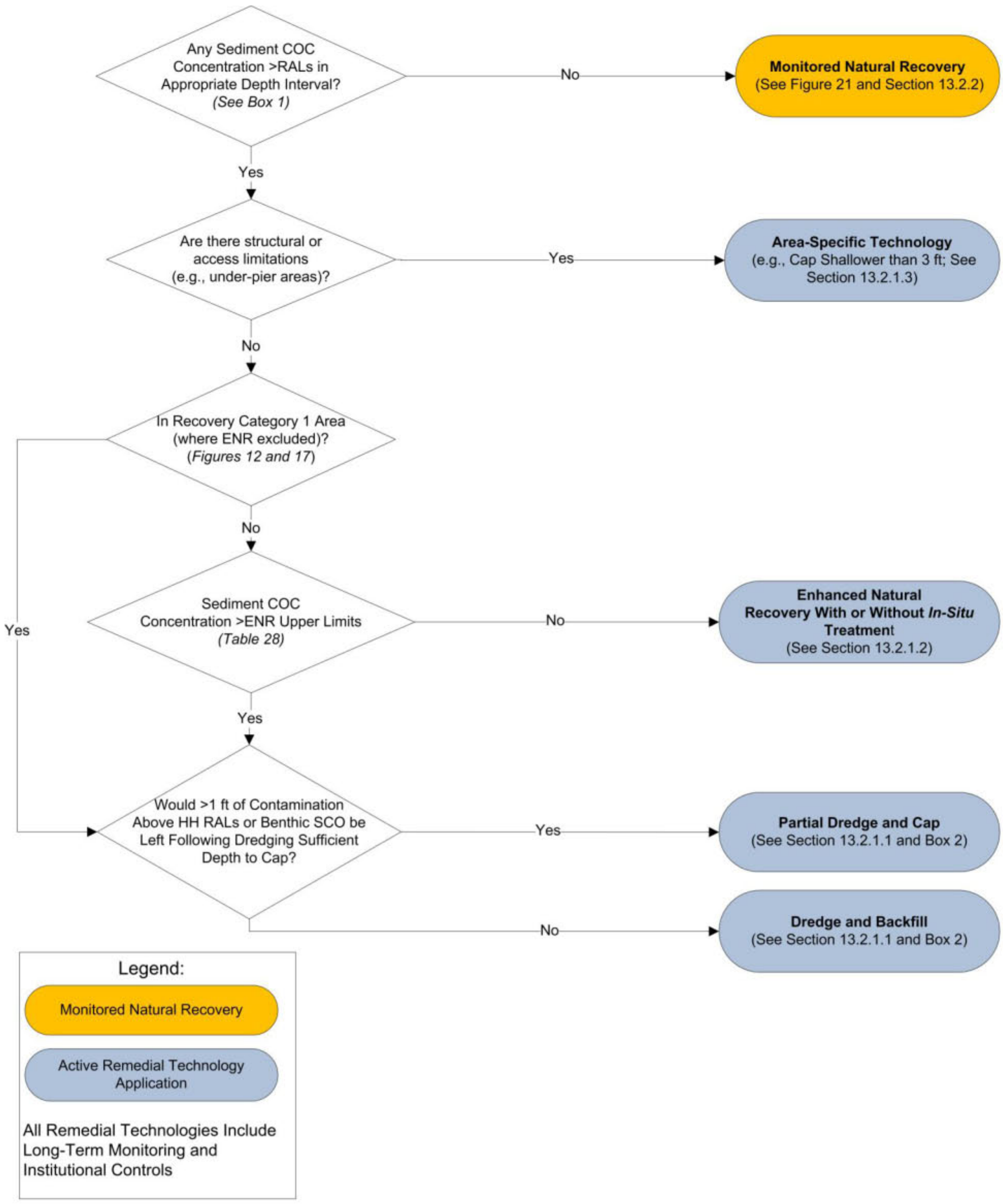
– ROD FIGURE 22. INTERTIDAL AREAS—REMEDIAL ACTION LEVELS APPLICATION

– ROD FIGURE 23. SUBTIDAL AREAS—REMEDIAL ACTION LEVELS APPLICATION

Table 23. Criteria for Assigning Recovery Categories[a]

Criteria		Recovery Categories: Category 1 Recovery Presumed to be Limited	Recovery Categories: Category 2 Recovery Less Certain	Recovery Categories: Category 3 Predicted to Recover
Physical Criteria				
Physical Conditions	Vessel scour	Observed vessel scour	No observed vessel scour	
	Berthing areas	Berthing areas with vessel scour	Berthing areas without vessel scour	Not in a berthing area
Sediment Transport Model	STM-predicted 100-year high-flow scour (depth in cm)	> 10 cm	< 10 cm	
	STM-derived net sedimentation using average flow conditions	Net scour	Net sedimentation	
Rules for applying criteria		If an area is in Category 1 for any one criterion, that area is designated Category 1	If conditions in an area meet a mixture of Category 2 and 3 criteria, that area is designated Category 2	An area is designated Category 3 only if it meets all Category 3 criteria
Empirical Contaminant Trend Criteria – used on a case-by-case basis to adjust recovery categories that would have been assigned based on physical criteria				
Empirical Contaminant Trend Criteria	Resampled surface sediment locations	Increasing PCBs or increasing concentrations of other detected COCs that exceed the SCO (> 50% increase)	Equilibrium and mixed (increases and decreases) results (for COCs that exceed the SCO)	Decreasing concentrations (> 50% decrease) or mixed results (decreases and equilibrium)
	Sediment cores (top 2 sample intervals in upper 60 cm)			

a. Recovery categories were not assigned to the Early Action Areas, for which remediation should be complete by the time of the remedial actions addressed in this ROD. At the time of the remedial design, EPA will consider assignment of categories to these areas based upon the logic in this table; this information will inform long term monitoring decisions.



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

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

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

Notes:

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

[a] RAO 1 - Human health seafood consumption

[b] RAO 2 - Human health direct contact includes beach play, clamming, and netfishing

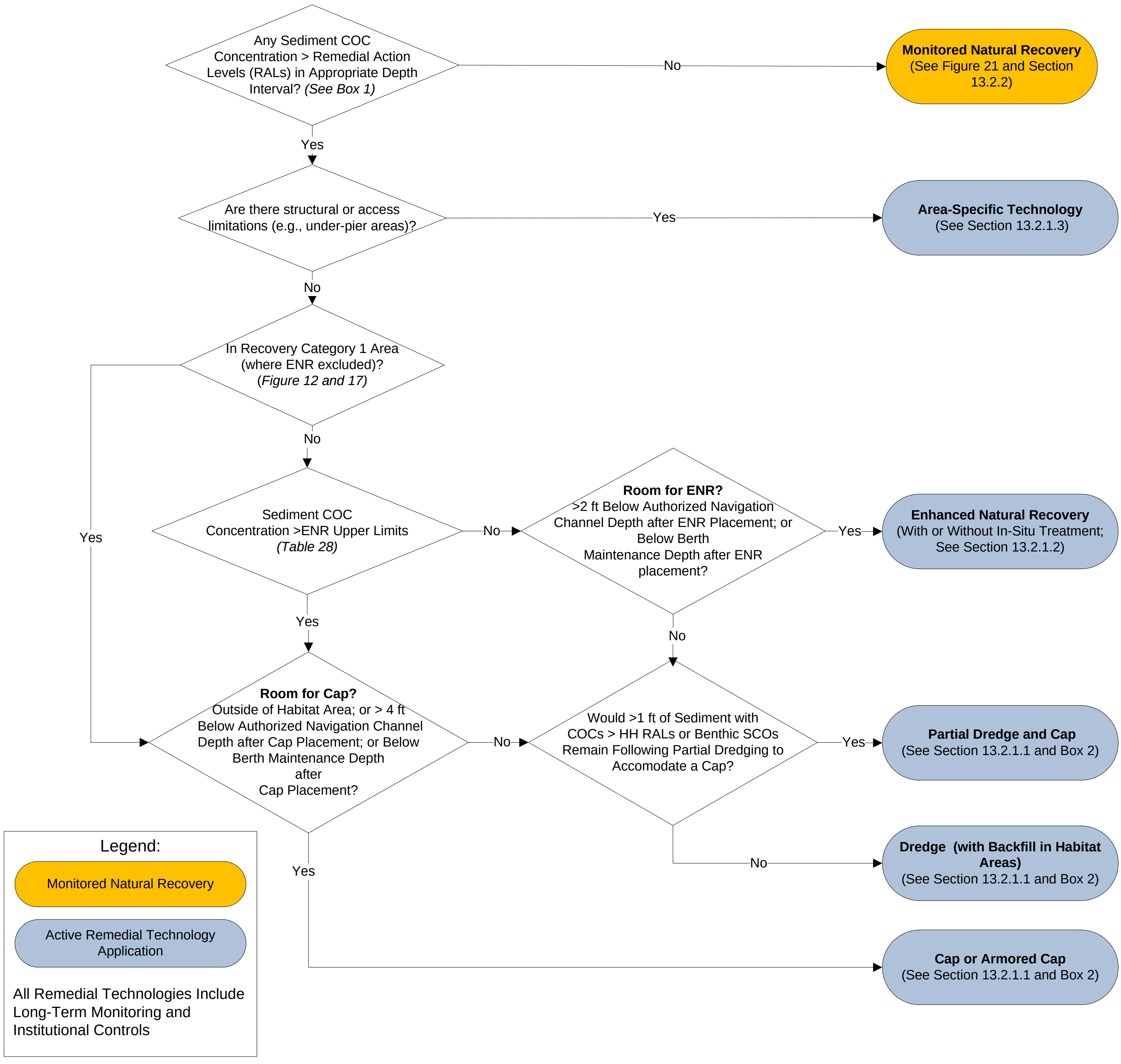
[c] RAO 4 - Ecological protection for river otter (addressed by meeting human health PCB RAL)

[d] RAO 3 - Ecological protection of benthic community

[e] There are 41 SMS COCs, but PCB and arsenic are principally RAO 1 COCs. SMS also lists toxicity test-out criteria using bioassays. Test-out is not allowed for PCBs or arsenic.

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

Figure 19. Intertidal Areas – Remedial Technology Applications



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

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

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

Notes

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

[a] RAO 1 - Human health seafood consumption

[b] RAO 2 - Human health direct contact includes beach play, clamming, and netfishing

[c] RAO 4 - Ecological protection for river otter (addressed by meeting human health PCB RAL)

[d] RAO 3 - Ecological protection of benthic community

[e] There are 41 SMS COCs, but PCB and arsenic are principally RAO 1 COCs. SMS Also lists toxicity test-out criteria using bioassays. Test-out is not allowed for PCBs or arsenic.

[f] Depth intervals to determine compliance will be determined during Remedial Design.

[g] Caps were assumed to be 3 ft for cost estimating purposes; cap thicknesses will be evaluated by EPA during Remedial Design in accordance with EPA and USACE (1998)

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

Revised Figure 20. Subtidal Areas – Remedial Technology Application

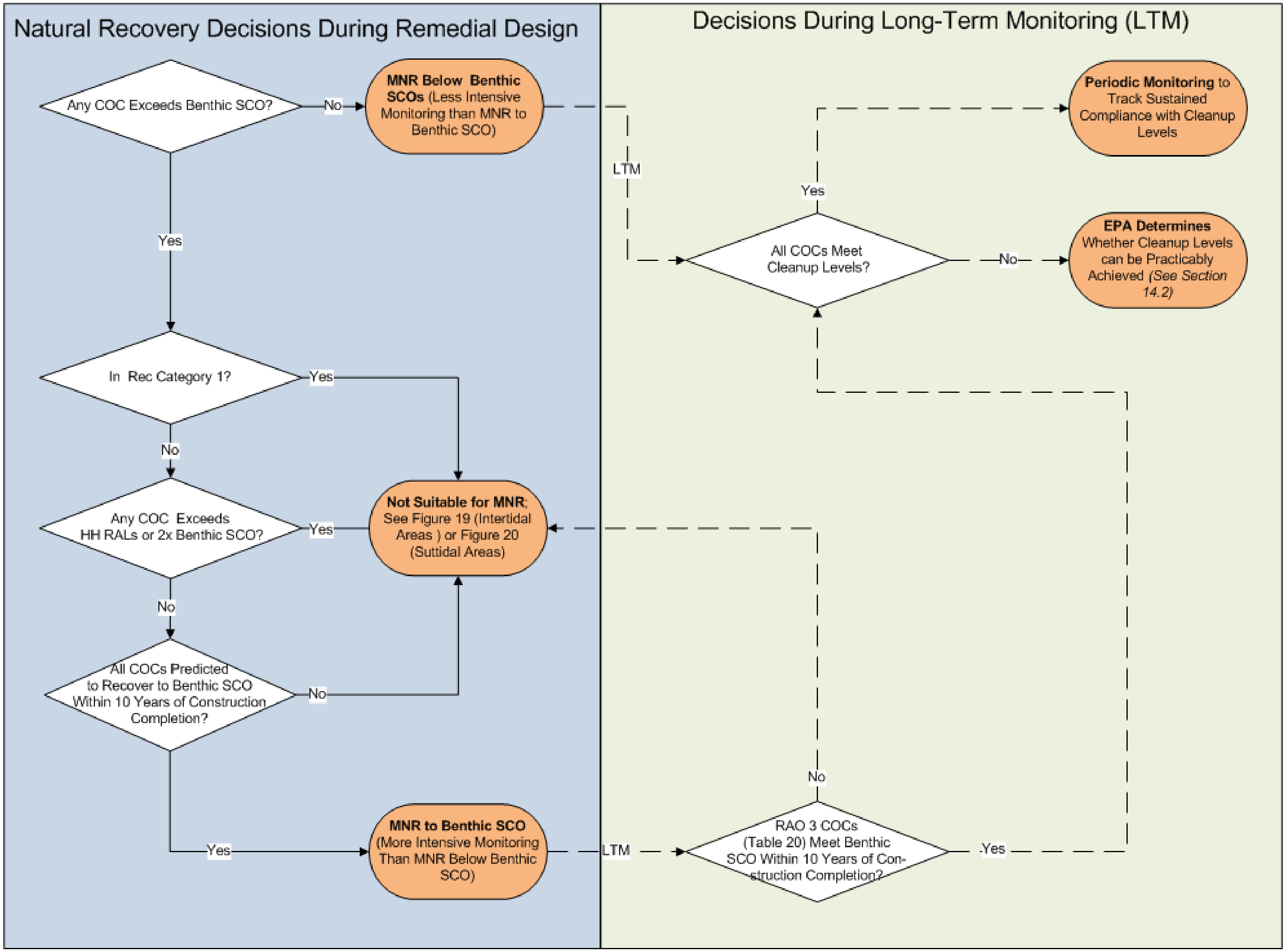


Figure 21. Intertidal and Subtidal Areas – Natural Recovery Application

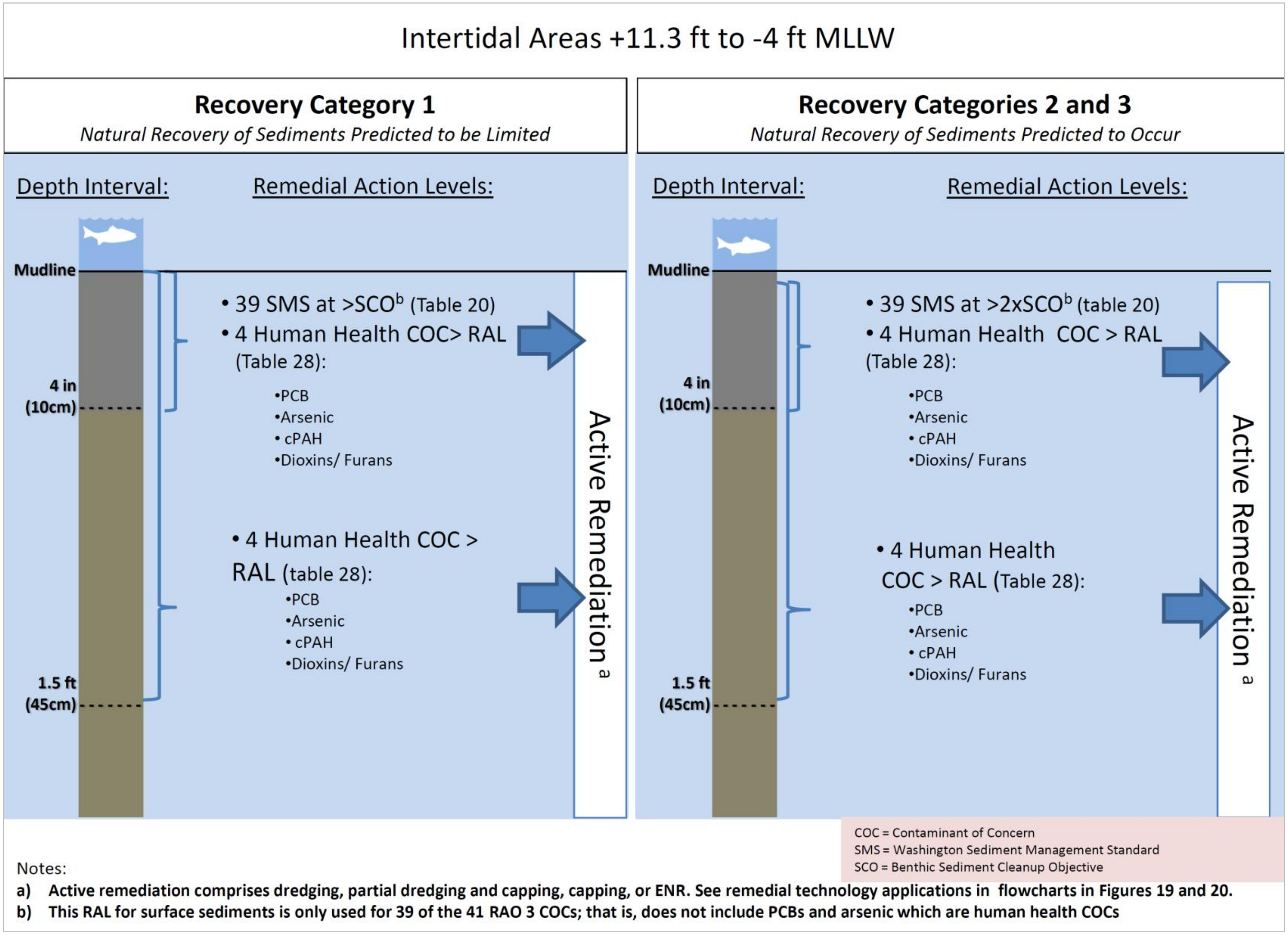
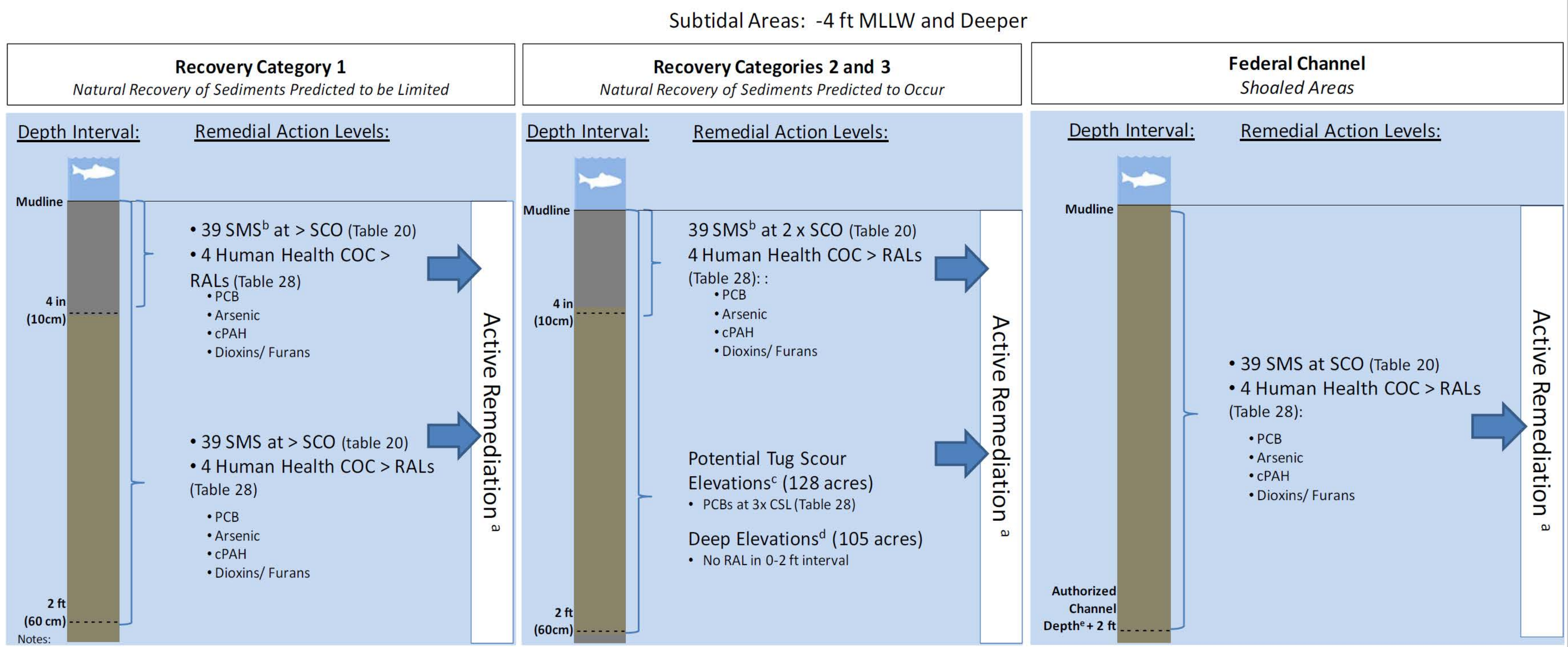


Figure 22. Intertidal Areas - Remedial Action Levels Application



Notes:

a) Active Remediation comprises dredging, partial dredging and capping, capping, or ENR. See remedial technology applications in flowcharts in Figures 19 and 20.
b) This RAL for surface sediments would only be used for 39 of the 41 COCs, and is not used for PCBs or arsenic.
c) Potential tug scour elevations are shown in Figure 17. These are defined as -4 to -24 ft MLLW north of 1st Ave S Bridge and -4 to -18 ft MLLW south of 1st Ave S Bridge.
d) Deep elevations are defined as deeper than -24 ft MLLW north of 1st Ave S Bridge and deeper than -18 ft MLLW south of 1st Ave S Bridge.
e) Shoaled areas are those areas in navigation channel with sediment accumulation above the authorized depth including a 2 ft over-dredge depth, see Table 28. For areas in the navigation channel that are not shoaled, Recovery Categories 1 or 2 & 3 RALs apply. Authorized depths are: (1) from RM 0 to 2, 30 ft below MLLW (from Harbor Island to the First Avenue South Bridge); (2) from RM 2 to RM 2.8, 20 ft below MLLW (from the First Avenue South Bridge to Slip 4); and (3) from 15 ft below MLLW from RM 2.8 to 4.7 (Slip 4 to the Upper Turning Basin). To these depths, 2 ft overdredge depth should be added

COC = Contaminant of Concern
SMS = Washington State Sediment Management Standards
SCO = Benthic Sediment Cleanup Objective

Figure 23. Subtidal Areas – Remedial Action Levels Application

APPENDIX B

SUMMARY OF REMEDIAL DESIGN DATA NEEDS AND TIMING CONSIDERATIONS

No.	Data Need	Data Collection Activities	Timing Considerations	ENR/AC Pilot Study	Pre-Design Studies	Phased Pre-Design Investigation (PDI)			Remedial Design Engineering[b]	Remedial Action[c]
						Phase I PDI[a]	Phase II PDI[a]	Phase III PDI[a]		
Environmental Information										
1	Characterize surface sediment baseline conditions to provide the foundation for assessing trends from before to after sediment remediation.	Sampling and analysis of COCs in: • Site-wide sediment (0–10 cm) SWAC and 95UCL • Site-wide clamming area intertidal sediment (0–45 cm) mean and 95UCL • Individual beach play areas sediment (0−45 cm) means and 95UCL.	After early actions to establish baseline conditions for RAOs 1, 2, and 4.		✓					
2	Characterize tissue to establish baseline mean concentrations of risk drivers in order to assess concentration trends following remediation.	Sampling and analysis of COCs in fish, crab, and clam tissues.	2+ years after last early action and before the site-wide remedy is conducted to establish baseline conditions for tracking progress toward target tissue levels associated with RAO 1.		✓					
3	Characterize surface water baseline conditions to: • Assess progress toward water quality ARARs as sediment remediation and source control continue. • Establish baseline concentrations to be used to assess trends in PCB concentrations in surface water as sediment remediation and source control continue.	Sampling and analysis of water quality criteria parameters in surface water.	After early actions to establish baseline conditions and facilitate assessment of progress toward ARAR compliance.		✓					
4	Characterize COCs in sediment (including under-pier areas where appropriate) to support delineation of remedial technology assignment boundaries, definition of dredge prisms, waste characterization, and delineation of MNR > SCO areas.	Location-specific sampling and analysis of COCs in sediments, including: • Limits of sediment RAL exceedances (0–10 cm, 0–45 cm or 0–60 cm) • Subsurface coring to determine dredge prisms and characterize waste • Characterization of surface (0–10 cm) COCs, as-needed to evaluate empirical contaminant trend criteria and refine boundaries of MNR > SCO areas.	Data must be obtained during design to finalize technology assignments, establish accurate delineation of remedial technology footprints, and design dredge prisms.			✓	✓	✓		
5	Assess the relationship among concentrations of cPAHs in clam tissue, porewater, and sediment to help evaluate whether achieving sediment cleanup levels for cPAHs may reduce concentrations in clam tissue to target tissue levels.	*Ex situ* porewater evaluations performed in conjunction with sediment and clam tissue sampling activities.	Implement in conjunction with baseline sampling activities.		✓					

No.	Data Need	Data Collection Activities	Timing Considerations	ENR/AC Pilot Study	Pre-Design Studies	Phased Pre-Design Investigation (PDI)			Remedial Design Engineering[b]	Remedial Action[c]
						Phase I PDI[a]	Phase II PDI[a]	Phase III PDI[a]		
6	Establish baseline PCB porewater concentrations in MNR and ENR areas[d] to help assess the effect of reduced sediment concentrations on biota exposure and tissue concentrations.	*In situ and ex situ* porewater evaluations in MNR and/or ENR areas.	Implement in conjunction with ENR/AC pilot study and baseline sampling activities.	✓	✓					
7	Characterize PCBs in sediment porewater to support ENR with *in situ* treatment (AC) added.	For *in situ* treatment, ENR/AC pilot study to evaluate bulk sediment and porewater PCB data.	Decision for carbon amendment addition to ENR will be based on ENR/AC pilot study outcomes.	✓						
8	Develop cap modeling parameters.[e]	Equilibrium partitioning calculations based on available bulk sediment data will be used to develop conservative parameters for cap modeling. Area-specific sampling of sediment porewater may be performed, if needed, for unusual conditions. Groundwater upwelling velocities will be estimated using existing hydrogeologic information or modeling. Seepage meters may be used if more refined velocity estimates are needed.	Data gathering to support development of cap modeling parameters to be performed by the design engineer as part of the remedial design process. Additional data, if needed, would be collected based on preliminary cap design objectives established during 30% design.				✓	✓	✓	
9	Characterize COCs in relevant media to support source control sufficiency determinations.	Sampling and analysis of COCs in: • LDW surface sediment near outfalls • Bank soils • Groundwater seeps.	Implement early (i.e., pre-design), with supplemental information, as needed, during design.		✓			✓		
Hydrogeological/Geotechnical Information										
10	Conduct area-specific characterization of sediment geotechnical properties to: • Determine sediment stability and stable dredge cut side-slope requirements • Characterize sediment dredgeability • Support sediment consolidation assessment for cap design • Support selection of dredge equipment • Support design of sediment handling, transport, dewatering, treatment systems, and disposal requirements.	Area-specific geotechnical sampling and analysis of sediments, including: • Geologic characterization • Sediment index properties • Sediment strength and consolidation properties.	Data must be obtained during design investigation/design engineering phases to support accurate design and ensure safe and reliable performance of completed remedy. Certain data may be collected by remedial construction contractor to support design of sediment and dewatering processing systems.				✓	✓		✓

No.	Data Need	Data Collection Activities	Timing Considerations	ENR/AC Pilot Study	Pre-Design Studies	Phased Pre-Design Investigation (PDI)			Remedial Design Engineering[b]	Remedial Action[c]
						Phase I PDI[a]	Phase II PDI[a]	Phase III PDI[a]		
Geophysical/Physical Information										
11	Perform detailed geophysical characterization to: • Support accurate dredge, cap, and debris quantity estimates • Support design of dredge and cap areas.	Physical surveys: • Site-wide bathymetric and topographic surveys • Specialized surveys as appropriate for debris characterization (e.g., side-scan sonar, magnetometer, or sub-bottom profiling).	Data must be obtained during design investigation/design engineering to support accurate design.			✓	✓			✓
12	Obtain information regarding fixed structures to: • Assess constraints on future sampling activities, recovery categories, remedial technology assignments, and construction activities.	Perform assessment and survey of in-water structures.	Perform early reconnaissance-level identification of all structures with the potential to influence recovery categories to inform future sampling and/or design analyses. During remedial design, additional surveys/inspections of certain structures may be performed to support constructability and safety/stability analysis for dredging and capping activities. Remediation contractor will perform pre-construction surveys to document structure conditions prior to construction.		✓			✓	✓	✓
13	Physical/operational uses	Perform vessel/use survey.	Perform the vessel/use survey early to identify physical disturbances that may affect recovery categories, technology assignments, or design details. Review and update as needed during design investigation/design engineering.		✓				✓	

No.	Data Need	Data Collection Activities	Timing Considerations	ENR/AC Pilot Study	Pre-Design Studies	Phased Pre-Design Investigation (PDI) Phase I PDI[a]	Phase II PDI[a]	Phase III PDI[a]	Remedial Design Engineering[b]	Remedial Action[c]
Hydrodynamic Information										
14[f]	Evaluate sediment transport and erosion/scour/disturbance processes to support: • Delineation of MNR/ENR areas • Design of ENR/*in situ* treatment • Cap design • Outfall scour protection.	Perform location-specific pilot testing, bathymetric survey and engineering analyses.	The ENR/AC pilot study will provide information regarding the relative stability of AC with ENR. The pre-design studies (waterway user survey and assessment of in-water structures) will provide information that can be used during design to inform evaluation of vessel-induced erosion/scour forces. A bathymetric survey will be performed as part of the PDI (number 12 in this table) and will be used to support an evaluation of scour associated with berthing areas to finalize delineation of MNR/ENR areas. Readily available hydrodynamic parameters will be developed during remedial design to evaluate erosion/scour forces (due to river currents, vessels, outfall discharges, etc.) and to develop appropriate material specifications.	✓	✓	✓			✓	
15[f]	Evaluate effect of designed remedial elements (e.g., sediment cap, riverbank armor) on water surface elevations, velocities, shear stress, and sediment mobility.	Cross section analysis or hydrodynamic modeling.	Assessment to be performed as needed using the configuration of the remedy as designed.						✓	

No.	Data Need	Data Collection Activities	Timing Considerations	ENR/AC Pilot Study	Pre-Design Studies	Phased Pre-Design Investigation (PDI)			Remedial Design Engineering[b]	Remedial Action[c]
						Phase I PDI[a]	Phase II PDI[a]	Phase III PDI[a]		
Implementation Planning, and Other Information										
16[e]	Determine space requirements to establish construction support areas, including: • Transload facilities • Dredge material handling/stabilization areas • Construction water management/treatment • Laydown/material storage • Field office and support facilities.	Identify space requirements and candidate sites.	Identify space and performance requirements to be performed in conjunction with remedial design to facilitate contractor bids. Identify specific properties and negotiation of access, lease, and/or purchase agreements to be performed by owners during engineering design or by the selected remedial contractor(s) during the remedial action.						✓	✓
17[e]	Haul routes	Identify transportation routes for truck/rail/barge transport of materials.	Identify minimum requirements in design with details developed in contractor's remedial action work plan.						✓	✓
18[e]	Determine current and reasonably anticipated future uses that may influence sampling design, recovery categories, technology assignments, delineation of remedial boundaries, and institutional controls.	Identify and document known or reasonably anticipated future waterway-dependent uses with potential to disturb sediment bed.	Determine uses early (i.e., pre-remedial design) to inform location-specific remedial design activities. Refine and verify information during design engineering.		✓				✓	
19[e]	Establish logistic or design details to accommodate waterway users that may be affected by remedial construction activities (e.g., Tribes, recreational users, facility operators, bridge operators).	Identify waterway users that may be affected by remedial construction activities. Collect information that may be used in coordinating access and/or temporary restrictions. The remedial action contractor will be responsible for development of vessel management plans and coordination with waterfront operators, recreational users, and tribal fishing representatives during construction.	Pre-design investigation user survey (noted above) will be updated and refined throughout remedial design/remedial action phases to ensure the information is useful and current.		✓				✓	✓
20[e]	Identify in-river and shoreline areas with cultural and archaeological resources.	Establish area-specific delineation of archaeologically or culturally sensitive areas.	Identify areas during design, following establishment of dredge and capping limits, to facilitate development of discovery plan and associated construction specifications.						✓	

No.	Data Need	Data Collection Activities	Timing Considerations	ENR/AC Pilot Study	Pre-Design Studies	Phased Pre-Design Investigation (PDI)			Remedial Design Engineering[b]	Remedial Action[c]
						Phase I PDI[a]	Phase II PDI[a]	Phase III PDI[a]		
21	Identify potential backfill and reactive amendment material sources.	Develop acceptance criteria; research and compile locally available sources and data.	Conduct preliminary identification of potential sources as part of remedial design, in conjunction with development of specifications. Remediation contractor will perform final identification/ selection.						✓	✓
22	Perform bench-scale/treatability testing to support water treatment.[e]	Perform bench-scale tests, as-needed: • Column settling • Water treatability.	Perform tests during remedial design, if needed, based on dredging and water management requirements developed in design.					✓		

Notes:
The data needs and sequencing of data collection activities listed herein are expected to evolve as the remedial design progresses. The data needs have been identified in consideration of the technical elements and ARARs for the selected remedy. Data needs and objectives will be refined in response to new data/information that may become available, in coordination with EPA. Planning of the remedial design investigations will include a summary and assessment of relevant existing data and data gaps, followed by focused, location-specific investigations and analyses. Other efforts, such those related to institutional controls, are also expected to continue in parallel with the remedial design processes.

✓ Items marked with gray checkmarks will be completed only if needed.

[a] New remedial design field measurements (e.g., sampling, surveying) will be accomplished during the phased pre-design investigations. Additional data needs identified during early design phases as design elements mature will be addressed by subsequent phases of pre-design investigations (Phase II or III).

[b] Remedial design engineering includes agency, owner/operator, and stakeholder reviews and input on design packages (e.g.,30%, 60%, 90%, Final) with increasing development of details.

[c] Where noted, certain data needs are anticipated to be resolved in coordination with the selected remediation contractor; following remedial design but prior to implementation. Remedial action includes development of remedial action work plan with specific means and methods proposed by the contractor. Remedial action work plan includes agency, owner/operator, and stakeholder reviews/input.

[d] Preliminary ENR and MNR areas were established in Figure 18 of the ROD (USEPA 2014) based on RI/FS data. The boundaries of these areas are likely to change based on design-level sampling and evaluations.

[e] The need for these data will be confirmed during remedial design engineering based on design approaches and evaluation of existing data.

[f] Data collection and/or input parameterization will consider potential influence of regional climate change and associated long-term resiliency of the remedy.

95UCL = 95% upper confidence limit on the mean
AC = activated carbon
ARAR = applicable or relevant and appropriate requirement
COC = contaminant of concern
cPAH = carcinogenic polycyclic aromatic hydrocarbon
EAA = early action area
ENR = enhanced natural recovery
EPA = U.S. Environmental Protection Agency
LDW = Lower Duwamish Waterway
MNR = monitored natural recovery
PCB = polychlorinated biphenyl
RAL = remedial action level
RAO = remedial action objective
RI/FS = remedial investigation/feasibility study
ROD = Record of Decision
SCO = sediment cleanup objective
SWAC = surface area-weighted average concentration
TBD = to be determined

REFERENCES

USEPA. 2014. Record of Decision. Lower Duwamish Waterway Superfund Site. U.S. Environmental Protection Agency.

Windward. [in prep]. Pre-design studies work plan. Porewater addendum. Draft. Submitted to EPA April 4, 2017. Windward Environmental LLC, Seattle, WA.