Lower Duwamish Waterway Group

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

PRE-DESIGN INVESTIGATION QUALITY ASSURANCE PROJECT PLAN FOR THE LOWER DUWAMISH WATERWAY - MIDDLE REACH

FINAL

For submittal to

The US Environmental Protection Agency
Region 10
Seattle, WA

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FINAL

Title and Approval Page
Remedial Design of Middle Reach
Quality Assurance Project Plan

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ABBREVIATIONS

%RSD	percent relative standard deviation
AET	apparent effects threshold
AFDW	ash-free dry weight
Anchor QEA	Anchor QEA, LLC
AOC5	Fifth Amendment to the Administrative Order on consent
ARL	Analytical Resources, LLC
ASTM	American Society for Testing and Materials
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COC	contaminant of concern
cPAH	carcinogenic polycyclic aromatic hydrocarbon
CPT	cone penetration testing
CQAP	construction quality assurance plan
CRM	certified reference material
DCP	dynamic cone penetrometer
DER	data evaluation report
GPS	global positioning system
DL	detection limit
DMMP	Dredged Material Management Program
DO	dissolved oxygen
DQI	data quality indicator
DQO	data quality objective
dw	dry weight
EC50	concentration that causes a non-lethal effect in 50% of an exposed population
EcoAnalysts	EcoAnalysts, Inc.
Ecology	Washington State Department of Ecology
EDL	estimated detection limit
EF	exceedance factor
EIM	Environmental Information Management
EPA	US Environmental Protection Agency
ESD	explanation of significant differences
FC	field coordinator
FFP	full-flow penetrometer
FNC	Federal Navigation Channel
GC/MS	gas chromatography/mass spectrometry

GPC	gel permeation chromatography
HDPE	high-density polyethylene
HPAH	high-molecular-weight polycyclic aromatic hydrocarbon
HRGC/HRMS	high-resolution gas chromatography/high-resolution mass spectrometry
HpCDD	heptachlorodibenzo-*p*-dioxin
HpCDF	heptachlorodibenzofuran
HSP	health and safety plan
HxCDD	hexachlorodibenzo-*p*-dioxin
HxCDF	hexachlorodibenzofuran
ICAL	initial calibration
ICP-MS	inductively coupled plasma-mass spectrometry
ID	identification
LC50	concentration that is lethal to 50% of an exposed population
LCS	laboratory control sample
LCSD	laboratory control sample duplicate
LDC	Laboratory Data Consultants, Inc.
LDW	Lower Duwamish Waterway
LDWG	Lower Duwamish Waterway Group
LOQ	limit of quantitation
LPAH	low-molecular-weight polycyclic aromatic hydrocarbon
MDL	method detection limit
MHHW	mean higher high water
MLLW	mean lower low water
MS	matrix spike
MSD	matrix spike duplicate
MTC	Materials & Testing Consulting, Inc.
OC	organic carbon
OCDD	octachlorodibenzo-*p*-dioxin
OCDF	octachlorodibenzofuran
OSHA	Occupational Safety and Health Administration
OnSite	OnSite Environmental Inc.
PAH	polycyclic aromatic hydrocarbon
PARCCS	precision, accuracy, representativeness, completeness, comparability, and sensitivity
PCB	polychlorinated biphenyl
PDI	Pre-Design Investigation
PDIWP	Pre-Design Investigation Work Plan
PeCDD	pentachlorodibenzo-*p*-dioxin

PeCDF	pentachlorodibenzofuran
PM	project manager
PSEP	Puget Sound Estuary Program
QA	quality assurance
QC	quality control
QAPP	quality assurance project plan
RAL	remedial action level
RAO	remedial action objective
RD	remedial design
RDWP	Remedial Design Work Plan
RI/FS	remedial investigation/feasibility study
RL	reporting limit
RM	river mile
ROD	Record of Decision
RPD	relative percent difference
SCO	sediment cleanup objective
SCUM	Sediment Cleanup User's Manual II
SDG	sample delivery group
SIM	selective ion monitoring
SM	Standard Method
SMS	Washington State Sediment Management Standards
SOP	standard operating procedure
SPT	standard penetration testing
SVOC	semivolatile organic compound
TCDD	tetrachlorodibenzo-*p*-dioxin
TCDF	tetrachlorodibenzofuran
TEQ	toxic equivalent
TOC	total organic carbon
TM	task manager
UCT-KED	universal cell technology-kinetic energy discrimination
VST	vane shear testing
Windward	Windward Environmental LLC
ww	wet weight

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1 Introduction

This quality assurance project plan (QAPP) describes the quality assurance (QA) objectives, methods, and procedures for Pre-Design Investigation (PDI) sampling in the middle reach of the Lower Duwamish Waterway (LDW) (river mile [RM] 1.6 to RM 3.0) (Map 1). This work supports the remedial design (RD) for the middle reach per the Fifth Amendment to the Administrative Order on Consent (AOC5) for the LDW (EPA 2021a). Sampling will include the collection and chemical analysis of sediment samples to delineate exceedances of sediment remedial action levels (RALs) presented in Tables 27 and 28[1] of the US Environmental Protection Agency (EPA) Record of Decision (ROD) (EPA 2014b) and in the Explanation of Significant Differences (ESD) (EPA 2021b) for carcinogenic polycyclic aromatic hydrocarbons (cPAHs). Sampling will also include the collection of engineering data to provide the information needed to determine appropriate remedial technologies in remedial action areas as well as other information needed to design the area-specific remedy in the middle reach. The remedial action areas and technologies in the remedy will be determined in accordance with ROD Figures 19 and 20.[2]

The Middle Reach Pre-Design Investigation Work Plan (PDIWP) (Windward and Anchor QEA 2022) provides the objectives, background, and conceptual study design for PDI sampling. This QAPP presents a more detailed study design, including project organization and schedule, sampling locations, field collection methods, laboratory analysis methods and procedures, data management protocols, and reporting requirements. This document was prepared in accordance with EPA's (2002) guidance on preparing QAPPs.

Design sampling will be done in phases (Figure 1-1). Phase I will involve the collection of data needed to delineate the extent of RAL exceedances in surface (0- to 10-cm), subsurface (0- to 45-cm and 0- to 60-cm), and shoaled sediment in the Federal Navigation Channel (FNC) to identify Phase I RAL exceedance areas and make preliminary technology assignments. Phase II will involve the collection of data to further refine the delineation of RAL exceedances (as needed), to assess the vertical distribution of contamination in dredge and cap areas, and to acquire area-specific engineering information needed for design. Phase II data may also be collected during Phase I if access is limited in certain areas. Phase III will be conducted if data needs remain after Phase II. Following Phases I and II, data evaluation reports (DERs) will be prepared to interpret the information and guide the development of subsequent design sampling phases.

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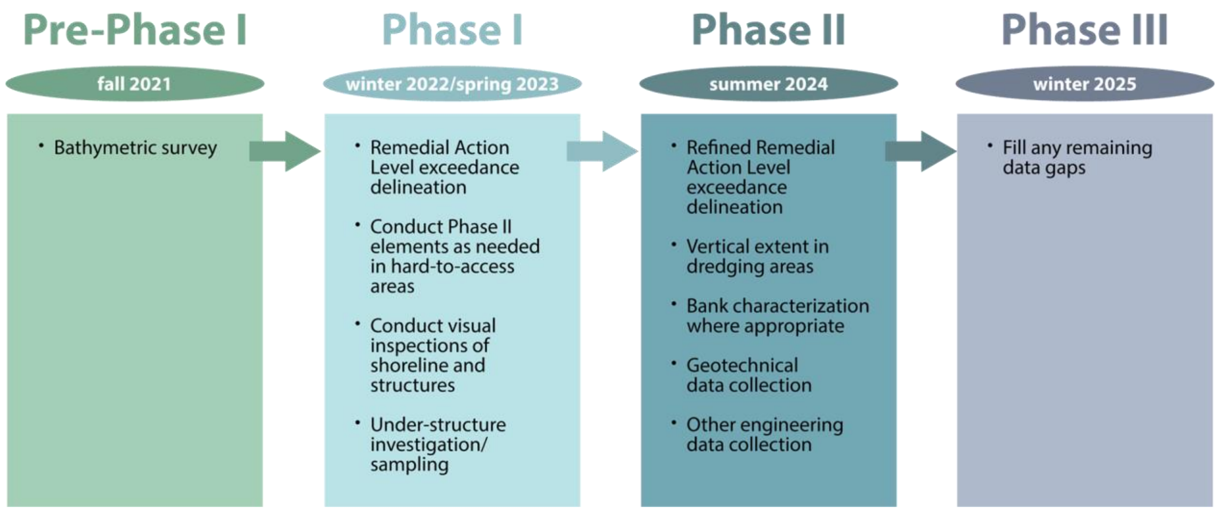
[1] ROD Table 27 is titled *Selected Remedy RAO 3 RALs* and Table 28 is titled *Remedial Action Levels, ENR Upper Limits, and Areas and Depths of Application.*

[2] ROD Figures 19 and 20 are titled *Intertidal Areas – Remedial Technology Applications* and *Subtidal Areas – Remedial Technology Applications*, respectively. Note that ROD Figure 20 was updated in an erratum (EPA 2015).

Figure 1-1
Design Sampling Phases



The PDI sampling design, which has multiple phases, is intended to provide sufficient characterization (horizontal and vertical data) for the engineering design, and to limit contingency action work during remedial action construction. The conceptual site model for the site, as well as the previous sampling data, inform the PDI sampling design.

The PDI information to be collected will help identify both the horizontal extent of the remedial action and the depths of required removal in areas necessitating dredging. Engineering design takes into account uncertainties in the horizontal and vertical definitions of remedial action area boundaries when developing the limits of dredging and other remedial actions (e.g., capping). As discussed in the Remedial Design Work Plan (RDWP) (Section 3), the engineering design will define the limits of dredging and other remedial actions (e.g., capping) using the interpolated RAL exceedance area boundaries defined in the Phase II DER. The boundaries will be developed using the most appropriate interpolation method based on the data (e.g., kriging, inverse distance weighting, Thiessen polygon). These boundaries will then be adjusted during 30, 60, and 90% design to account for design considerations, such as equipment capabilities, constructability, geography, and waterway use.

Sampling during construction (to be defined in the construction quality assurance plan) helps to reduce vertical extent uncertainties within remedial action areas requiring dredging. The construction quality assurance plan sampling results will be used to assess whether pockets of deeper contamination (i.e., missed inventory) may remain that may require contingency actions (e.g., contingency re-dredging and/or placing residuals management clean cover material) within the remedial action areas following initial dredging to design depths.

This QAPP provides detailed methods and protocols for all phases and types of design data collection. Details regarding study design for Phase I design sampling, including location coordinates and rationale, are also provided. Based on the Phase I results, QAPP addenda will be prepared to present detailed locations and other specifics—including any additional standard operating procedures (SOPs) or modified SOPs—for Phase II and, if needed, Phase III.

This QAPP is organized into the following sections:

- Section 2 – Project Objectives and Description
- Section 3 – Project Organization and Responsibilities
- Section 4 – Data Generation and Acquisition for Sediment and Bank-Area Sediment Samples
- Section 5 – Data Generation and Acquisition of Engineering PDI Elements
- Section 6 – Data Validation and Usability
- Section 7 – Assessment and Oversight
- Section 8 – References

This QAPP is supported by seven appendices, as follows:

- Appendix A – Health and Safety Plan
- Appendix B – Archaeological Monitoring and Inadvertent Discovery Plan
- Appendix C – Field Forms
- Appendix D – Sampling Location Details
- Appendix E – SOPs
- Appendix F – Site-specific Dive Safety and Work Plan
- Appendix G – Analytical Methods and Reporting Limits (RLs)

2 Project Objectives and Description

This section presents an overview of the data quality objectives (DQOs) and the scope of the design sampling.

2.1 Data Quality Objectives

The PDI has two objectives: 1) to collect data needed to delineate remedial action areas, and 2) to support remedial technology applications in designing a remedy consistent with the ROD (ROD Tables 27 and 28 and ROD Figures 19, 20, and 21 (8/26/15 revision); EPA 2014b).[3]

DQOs were identified in the PDIWP (Windward and Anchor QEA 2022) for Phases I and II and are further discussed in Tables 2-1, 2-2, and 2-3. Eight of the nine Phase I DQOs focus on delineating exceedances of the RALs,[4] including under-structure characterization. The eighth DQO involves a visual inspection of the middle reach banks. The RAL exceedances to be delineated are based on the depth interval of sediment (e.g., 0- to 10-cm), bathymetry (e.g., intertidal, shoaling area in the navigation channel), and recovery category.[5] Phase II DQOs involve additional refinement of the extent of RAL exceedances, as needed, and collection of engineering data (including vertical contamination and bank characterization) required for design of the remedy in the middle reach. DQOs for bathymetric surveying are included in the Pre-Design Survey QAPP (Attachment B to the PDIWP).

The Phase II PDI will collect all data needed to progress through 30% design. Phase III will be conducted if data needs remain following Phase II or are otherwise identified during preparation or EPA review of the 30% design. Phase III DQOs will be presented in the QAPP Addendum for Phase III, if needed, and the data will be available for the 90% design.

[3] ROD Figure 21 is titled *Intertidal and Subtidal Areas – Natural Recovery Application*.

[4] The RALs are listed in ROD Tables 27 and 28 (EPA 2014b) (and in the ESD (EPA 2021b) for cPAHs).

[5] As defined in ROD Figure 12, three recovery categories have been delineated based on whether limited natural recovery is presumed for an area (Recovery Category 1), recovery is less certain (Recovery Category 2), or natural recovery through sedimentation (Recovery Category 3) is predicted.

Table 2-1
DQOs for Phases I and II of the PDI in the Middle Reach

Phase I	Phase II
DQO1 – Delineate 0–10-cm RAL exceedances in Recovery Category 2/3 DQO2 – Delineate 0–10-cm RAL exceedances in Recovery Category 1 DQO3 – Delineate 0–45-cm intertidal RAL exceedances in Recovery Category 2/3 DQO4 – Delineate 0–45-cm intertidal RAL exceedances in Recovery Category 1 DQO5 – Delineate 0–60-cm PCB RAL exceedances in potential vessel scour areas in Recovery Category 2/3 DQO6 – Delineate 0–60-cm RAL exceedances in Recovery Category 1 DQO7 – Delineate RAL exceedances in shoaling areas DQO8 – Conduct a visual inspection of the banks in the middle reach to identify features relevant to design, such as the presence/absence of bank armoring, and to plan how to access banks and areas under structures for sampling purposes DQO9 – Sample areas under structures, if feasible, safe, and appropriate, to delineate RAL exceedances	DQO10 – Further delineate RAL exceedances, as needed for unbounded areas DQO11 – Assess chemical and physical characteristics of sediment in banks, as needed, depending on remedial technology selected and whether or not the bank is erosional DQO12 – Delineate vertical elevation of RAL exceedances in dredge (and dredge/cap) areas and collect vertical information in cap areas where deeper contamination under caps may be located. DQO13 – Collect geotechnical data as needed depending on technology proposed and/or physical characteristics of remedial action areas DQO14 – Collect other engineering applicable data as needed (e.g., structures inspection, utility location verification, thickness of sediment on top of riprap layers)

Notes:
The topographic survey in banks areas within RAL exceedance areas will be conducted in Phase II and will be described in a Survey QAPP Addendum, including survey specific DQOs.
DQO: data quality objective
PCB: polychlorinated biphenyl
PDI: Pre-Design Investigation
RAL: remedial action level

Table 2-2
DQOs for RAL Delineation in the Phase I Middle Reach PDI

DQO Step	DQO 1	DQO 2	DQO 3	DQO 4	DQO 5	DQO 6	DQO 7
STEP 1: State the problem.	Additional sediment data are needed to delineate RAL exceedances in the 0- to 10-cm interval to define horizontal and vertical extents of contamination that require remedial action, and to assess whether any revisions to recovery categories are needed based on chemical trends.		Additional sediment data are needed to delineate RAL exceedances in the 0- to 45-cm interval to define horizontal and vertical extents of contamination that require remedial action.		Additional sediment data are needed to delineate RAL exceedances in the 0- to 60-cm interval to define horizontal and vertical extents of contamination that require remedial action, and to assess whether any revisions to recovery categories are needed.		Additional sediment data are needed to delineate RAL exceedances in the shoals in the FNC to define horizontal and vertical extents of contamination that require remedial action.
STEP 2: Identify the goals of the study.	Collect sufficient data in sediment intervals identified in ROD Table 28 to identify the following in the Phase I DER: 1) preliminary remedial action area boundaries and technologies, and 2) data needs for Phase II.						
STEP 3: Identify the information inputs.	Sediment data from the LDW were used to identify existing locations of RAL exceedances in the middle reach. Upland information was used to identify areas with potential sources of COCs. Recovery category and 2021 bathymetry information was used to identify where RALs apply.						
STEP 4: Define the boundaries of the study.	The boundary of the study has been defined by AOC5 as the middle reach (RM 1.6 to RM 3.0). Other relevant boundaries include those of recovery categories, RAL-application areas, intertidal areas, shoals, etc.						
STEP 5: Develop the analytical approach.	Sample analysis will be tiered. Tier 1 samples will be analyzed for chemicals with RALs, as described in ROD Table 28. The Tier 1 results will be used to determine which analytes are appropriate for the analysis of Tier 2 samples.						
STEP 6: Specify performance or acceptance criteria.	Performance or acceptance criteria are described in Section 4.11, including criteria for field QC samples and laboratory QC samples. DQIs for laboratory analyses (i.e., PARCCS) will be met, as described in Section 4.10. In addition, Phase II and Phase III data gaps analyses—including reviews of interpolation metrics—will be used to assess sampling needs to delineate contamination for design.						

Table 2-2
DQOs for RAL Delineation in the Phase I Middle Reach PDI

DQO Step	DQO 1	DQO 2	DQO 3	DQO 4	DQO 5	DQO 6	DQO 7
STEP 7: Develop the detailed plan for obtaining data.	Phase I samples will generally be collected at the centroid of each grid cell, except where data from 2011 or newer exist within 50 ft of the centroid. Re-occupation of some locations with EFs > 0.9 will also occur.		Samples in the 0- to 45-cm interval will be collected in the intertidal area, often from the same locations as the 0- to 10-cm[1] samples unless data 2011 or newer exist within the 50-ft radius of the grid cell centroid.		Samples in the 0- to 60-cm interval will be collected in the subtidal area, often from the same locations as the 0- to 10-cm[1] samples in those areas unless data 2011 or newer exist within the 50-ft radius of the grid cell centroid.		Samples will be collected in the FNC in areas defined as shoals in ROD Table 28. The depth of the interval will be based on the depth of the shoal as discussed in Section 4.1.1.

Notes:

1. It is not necessary for the 0- to 10-cm and the 0- to 45-cm (or 0- to 60-cm) samples to be co-located because the data interpolations in the DERs will be done separately for surface and subsurface sediment. Several factors could result in surface and subsurface samples not being co-located, including the presence of existing data in just one of the intervals, field conditions (especially under structures), and the location of the centroid relative to intertidal and shoal boundaries.

AOC5: Fifth Amendment to the Administrative Order on Consent
COC: contaminant of concern
DER: data evaluation report
DQI: data quality indicator
DQO: data quality objective
EF: exceedance factor
FNC: Federal Navigation Channel
LDW: Lower Duwamish Waterway
PARCCS: precision, accuracy, representativeness, completeness, comparability, and sensitivity
PDI: Pre-Design Investigation
QC: quality control
RAL: remedial action level
RM: river mile
ROD: Record of Decision

Table 2-3
Phase I (DQOs 8 and 9) and Phase II (DQOs 10–14) PDI Data Needs for the Middle Reach

DQO Step	DQO 8	DQO 9	DQO 10	DQO 11	DQO 12	DQO 13	DQO 14
STEP 1: State the problem.	Insufficient information is available about bank features (e.g., access, stability, erodibility, armoring, vegetation) that may affect the design and implementation of remedial actions.	Limited sampling has been conducted under over-water structures.	Preliminary boundaries may need to be refined following Phase I data collection.	Additional information needed to assess bank areas below MHHW within and adjacent to RAL exceedances areas will depend on remedial technology and whether the bank is erosional.	In dredge and partial dredge and cap areas, additional sediment data are needed to delineate the depth of contamination. In capping areas, additional subsurface sediment chemistry information is needed to inform the design of caps.	Geotechnical data are needed to evaluate the remedial technology proposed and/or physical characteristics of remedial action areas.	Other engineering data are needed to design the remedy (e.g., structures inspection, utility location verification, thickness of sediment on top of riprap layers).
STEP 2: Identify the goals of the study.	Document bank features and conditions at a scale relevant for design.	Sample beneath over-water structures, where feasible, safe, and appropriate, to delineate RAL exceedances.	Collect data in sediment intervals identified in ROD Table 28 to bound or refine the horizontal extents of remedial action areas.	Collect characterization data and topographic survey data as needed for design.	Collect data to bound the vertical extents of contamination in dredge and dredge/cap areas, and collect vertical data as needed for cap design in capping areas.	Collect data required to evaluate remedial actions for dredge cut design, slope areas, actions adjacent to structures, and where caps will be placed.	Collect other engineering data needed to design the remedy.

Table 2-3
Phase I (DQOs 8 and 9) and Phase II (DQOs 10–14) PDI Data Needs for the Middle Reach

DQO Step	DQO 8	DQO 9	DQO 10	DQO 11	DQO 12	DQO 13	DQO 14
STEP 3: Identify the informatio n inputs.	Visual inspection and documentation (e.g., photos, notes, measurements) of the presence and condition of bank armoring, vegetation, and other features to be considered during RD); existing information collected during the RI and 2018 Waterway Users Survey maps	Waterway Users Survey information on structures, structure access and conditions identified during the Phase I structures inspection, and 2021 bathymetry and recovery category information	Existing and Phase I PDI data	Existing and Phase I PDI sediment data (below MHHW) as well as bank visual inspection data	Existing and Phase I PDI sediment data	Preliminary remedial action area boundaries identified in Phase I, existing geotechnical data, structure locations, and 2021 bathymetry	Preliminary remedial action area boundaries identified in Phase I
STEP 4: Define the boundaries of the study.	The boundary of the study has been defined in AOC5 as the middle reach (RM 1.6 to RM 3.0). Other relevant boundaries include those of recovery categories, RAL-application areas, intertidal areas, shoals, etc.						

Table 2-3
Phase I (DQOs 8 and 9) and Phase II (DQOs 10–14) PDI Data Needs for the Middle Reach

DQO Step	DQO 8	DQO 9	DQO 10	DQO 11	DQO 12	DQO 13	DQO 14
STEP 5: Develop the analytical approach.	Not applicable	Sediment samples will be analyzed for chemicals with RALs, per ROD Table 28.	Samples will be analyzed for chemicals based on Phase I results. Toxicity testing may also be conducted where warranted for remedial action area boundary delineation for areas with benthic RAL-only exceedances.	Samples will be analyzed for chemicals based on the results of Phase I.	Samples will be analyzed for chemicals based on Phase I results.	Geotechnical sampling locations will be provided in the PDI QAPP Addendum for Phase II. Geotechnical analyses will follow standard ASTM testing protocols.	Not applicable

Table 2-3
Phase I (DQOs 8 and 9) and Phase II (DQOs 10–14) PDI Data Needs for the Middle Reach

<table>
<tr><th>DQO Step</th><th>DQO 8</th><th>DQO 9</th><th>DQO 10</th><th>DQO 11</th><th>DQO 12</th><th>DQO 13</th><th>DQO 14</th></tr>
<tr><td>STEP 6: Specify performance or acceptance criteria.</td><td>Not applicable</td><td colspan="2">Performance or acceptance criteria for chemistry and toxicity test samples are described in Sections 4.11 and 4.12.1, respectively, including those for field QC samples and laboratory QC samples. DQIs for laboratory analyses (i.e., PARCCS) will be met, as described in Section 4.10. In addition, Phase II and Phase III data gaps analyses—including reviews of interpolation metrics—will be used to assess sampling needs to delineate contamination for design.</td><td>Chemistry performance or acceptance criteria are as described for DQOs 9 and 10.</td><td>Performance or acceptance criteria are as described for DQOs 9 and 10.</td><td>Performance criteria for geotechnical testing are as described in each relevant ASTM standard for the test method used.</td><td>Not applicable</td></tr>
<tr><td>STEP 7: Develop the detailed plan for obtaining data.</td><td>Details on bank visual inspections are provided in Section 5.1.1.</td><td>Details on under-structure sampling are provided in Section 4.1.4.</td><td colspan="4">Detailed plans for obtaining data will be provided in the PDI QAPP Addendum for Phase II.</td><td>Data will be obtained in accordance with standard engineering practices.</td></tr>
</table>

Notes:
AOC5: Fifth Amendment to the Administrative Order on Consent
ASTM: American Society for Testing and Materials
DQI: data quality indicator
DQO: data quality objective
MHHW: mean higher high water
PARCCS: precision, accuracy, representativeness, completeness, comparability, and sensitivity

PDI: pre-design investigation
QAPP: quality assurance project plan
QC: quality control
RAL: remedial action level
RI: remedial investigation
RD: remedial design
RM: river mile
ROD: Record of Decision

2.2 Project Description and Schedule

To meet the DQOs, the conceptual design sampling plan described in the PDIWP (Windward and Anchor QEA 2022) identified the need for the following types of data. These data will be collected per the methods outlined in this QAPP, the *Quality Assurance Project Plan: Pre-Design Surveys of the Lower Duwamish Waterway Middle Reach* (PDIWP Attachment B) (hereinafter referred to as the Survey QAPP), and in forthcoming addenda to these documents.

- Phase I
  - Sediment chemistry data in sediment intervals with RALs (0 to 10 cm, 0 to 45 cm, 0 to 60 cm, and FNC shoals) to delineate RAL exceedances (DQOs 1 through 7)
  - Visual bank characterization data of the entire middle reach to identify key physical features that may factor into RD, general shoreline conditions (e.g., armoring), and vegetation (DQO 8)
  - Sediment chemistry data from under structures, as needed (DQO 9)
  - Bathymetry data from areas not accessible during the 2021 survey (DQOs 1 through 3 in the Pre-Design Survey QAPP; Attachment B to the PDIWP)
  - Phase II information from hard-to-access areas that may not be accessible during later phases (see DQOs below)
- Phase II (and III if needed)
  - Additional RAL delineation as needed (DQO 10)
  - Vertical (> 45 or 60 cm) extent data to evaluate depth of dredge prisms in dredge areas (DQO 12)
  - Subsurface sediment chemistry (> 45 or 60 cm) data below caps for cap design modeling (DQO 12)
  - Toxicity testing data in areas where only benthic RAL exceedances exist (DQO 1 and 2)
  - Bank-area sediment chemical characterization where needed and focused topographic survey data (as described in the upcoming Survey QAPP Addendum[6]) in middle reach bank areas where needed (DQO 11)
  - Area-specific sediment geotechnical properties, including geological characterization, sediment index, and sediment strength and consolidation properties (DQO 13), to:
    - Determine sediment stability and stable dredge cut side-slope requirements.
    - Characterize sediment dredgeability.

[6] The Survey QAPP Addendum will be developed in parallel with the PDI QAPP Addendum for Phase II in 2023 and will be submitted to EPA with the draft Phase I DER.

    - Support sediment consolidation assessment for cap design.
    - Support contractor's selection of dredge equipment.
    - Support design of sediment handling, transport, dewatering, treatment systems, and disposal requirements.
  - Specialized surveys as appropriate to characterize utilities and/or debris (as described in the Survey QAPP Addendum) and to measure thickness of sediment overlying bank armoring (as will be described in the PDI QAPP Addendum for Phase II) (DQO 14)

All data collection and sampling activities will be conducted in conformance with the health and safety plan (HSP) (Appendix A) and the Archaeological Monitoring and Inadvertent Discovery Plan (Appendix B). This information will be collected and reported per the following schedule, as outlined in the RDWP (Anchor QEA and Windward 2022b).

Upon approval of the QAPP or QAPP Addendum, PDI field work is expected to be completed in accordance with the schedule provided in the PDIWP, unless otherwise approved by EPA. Phase I field work is anticipated to begin in late 2022.

Two tiers of analytical chemistry are planned for Phase I of the PDI (see Section 4.1.1). In Phase II, the work will focus on geotechnical and vertical sampling and refinement of Phase I RAL exceedance areas. The refinement will include chemical analysis and toxicity testing, primarily in Tier 1. Phase III will focus on filling any remaining design data gaps. Significant toxicity testing is not expected in Phase III. To minimize the schedule impact of tiering in any of the phases, working meetings will be held with EPA following receipt of unvalidated analytical results from Tier 1 to determine which archive samples will be analyzed in Tier 2. Most of the Phase I samples will be analyzed in Tier 1. A data package will be submitted to EPA 10 days after validated data from Tiers 1 and 2 (for Phase II PDI, this will include all toxicity results) have been received.

PDI DERs will be submitted to EPA following Phases I and II data submittals. The PDI DERs will present and interpret the data (including existing data), define interpolated RAL exceedance area boundaries, assign preliminary remedial technologies to these areas, and identify remaining general data needs. The Phase I PDI DER and PDI QAPP Addendum for Phase II are scheduled to be submitted to EPA 80 days after submittal of the Phase I PDI data package; this date is estimated to be in December 2023. The Phase II PDI DER is scheduled to be submitted to EPA 60 days after submittal of the Phase II PDI data package. The Phase I and II data will be incorporated into the 30% design. If Phase III design sampling is conducted, a Phase III data package will be submitted to EPA and the Phase III results will be incorporated into and appended to the 90% design document.

The 2021 bathymetry data, summarized in PDIWP Attachment B, have been incorporated into all of the maps in this QAPP to aid in determining sampling locations. In addition, these data were used to propose changes to recovery categories from RM 1.6 to RM 3.0, as summarized in PDIWP Attachment C. Any proposed final revisions to the recovery categories will be documented in the Phase II DER. This timing will allow for consideration of Phase I and II sediment data in establishing the final recovery category boundaries.

The 2021 bathymetric survey was not able to cover the entire middle reach because of access restrictions (e.g., moored barges). These data gaps will be addressed by completion of the Phase I sampling event.

3 Project Organization and Responsibilities

Figure 3-1 shows the overall project organization and the individuals responsible for the various tasks required for PDI sampling and analysis. The following sections describe the responsibilities of project team members, as well as laboratory project managers (PMs).

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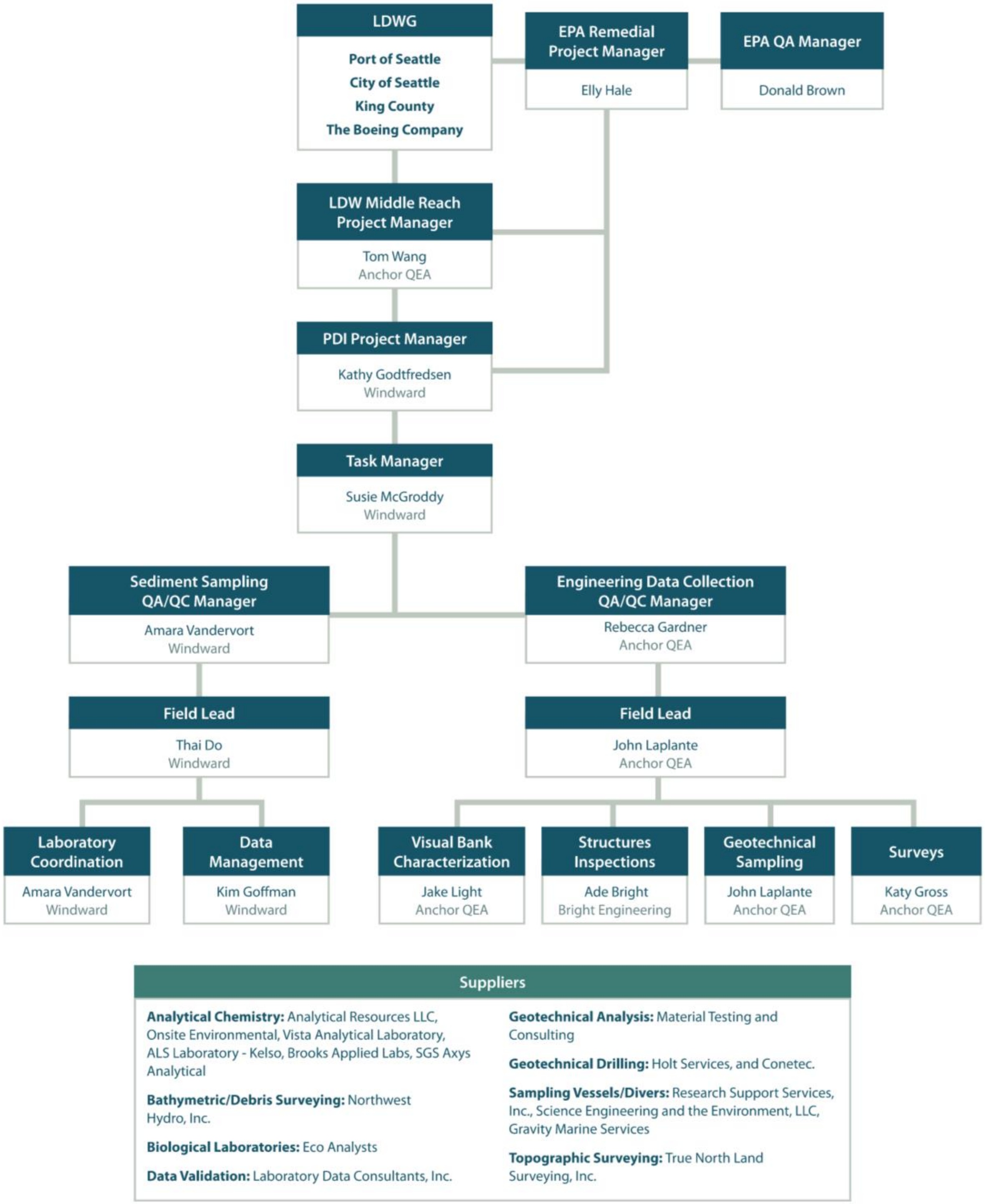
Figure 3-1
Project Organization and Team Responsibilities



3.1 Project Management

Both the Lower Duwamish Waterway Group (LDWG) and EPA are involved in all aspects of this project, including discussion, review, and approval of this QAPP and interpretation of the results of the investigation. Elly Hale is the EPA remedial project manager for the PDI and RD for the middle reach.

Tom Wang is the Anchor QEA LLC (Anchor QEA) PM for the middle reach RD. In this capacity, he will be responsible for providing oversight for planning and coordination, work plans, all project deliverables, and performance of the administrative tasks needed to provide timely and successful completion of the project. He will also be responsible for coordinating with LDWG and EPA on schedule, deliverables, and other administrative details. Mr. Wang can be reached as follows:

Mr. Tom Wang
Anchor QEA LLC
1201 3rd Avenue, Suite 2600
Seattle, WA 98101
Telephone: 206.903.3314
Email: twang@anchorqea.com

Kathy Godtfredsen is the Windward Environmental LLC (Windward) PM for the middle reach PDI. In this capacity, she will be responsible for PDI project coordination, and for providing oversight for planning and coordination, PDI-related project deliverables, and performance of the administrative tasks needed to provide timely and successful completion of the PDI. She will also be responsible for coordinating with LDWG and EPA on PDI-related details. Dr. Godtfredsen can be reached as follows:

Dr. Kathy Godtfredsen
Windward Environmental LLC
200 First Avenue West, Suite 500
Seattle, WA 98119
Telephone: 206.577.1283
Email: kathyg@windwardenv.com

Susan McGroddy (Windward) is the task manager (TM) for the PDI. As such, she will be responsible for communicating with the Windward PM on the progress of project tasks, conducting detailed planning and coordination, and monitoring and communicating to the Windward PM any deviations from the QAPP. Significant deviations from the QAPP will be further reported to representatives of LDWG and EPA. Dr. McGroddy can be reached as follows:

Dr. Susan McGroddy
Windward Environmental LLC
200 First Avenue West, Suite 500
Seattle, WA 98119
Telephone: 206.812.5421
Email: susanm@windwardenv.com

3.2 Field Coordination

Thai Do is the field coordinator and health and safety officer (FC/HSO) for Windward and will be responsible for managing field sampling activities and general field and QA/quality control (QC) oversight. He will oversee sample collection, preservation, and holding times, and he will coordinate delivery of environmental samples to the designated laboratories for chemical analyses. Mr. Do will familiarize field staff with the field SOPs attached to the QAPP, including any updates, if needed. Mr. Do will report deviations from this QAPP to the TM and PMs for consultation. Windward will report significant deviations from the QAPP to representatives of LDWG and EPA. Mr. Do can be reached as follows:

Mr. Thai Do
Windward Environmental LLC
200 First Avenue West, Suite 500
Seattle, WA 98119
Telephone: 206.812.5407[7]
Email: thaid@windwardenv.com

John Laplante is the engineering FC for Anchor QEA, overseeing engineering field leaders for the geotechnical, engineering field inspection, and surveying work. In this capacity, he will be responsible for managing geotechnical sampling, engineering field inspections (including visual bank characterization and structure inspection efforts), and surveys (as described in Section 5 and in the Survey QAPP Addendum). Mr. Laplante, working closely with other engineering field leads, will oversee geotechnical sample collection, processing, and delivery to the designated laboratories for geotechnical analyses, and he will familiarize the field staff with the field SOPs attached to the QAPP, including any updates, if needed. Mr. Laplante will report deviations from QAPPs to the TM and PM for consultation. Windward will report significant deviations from the QAPPs to representatives of LDWG and EPA. Mr. Laplante can be reached as follows:

[7] This is Mr. Do's office phone number. A mobile phone number will be provided prior to field sampling.

Mr. John Laplante
Anchor QEA LLC
1201 3rd Avenue, Suite 2600
Seattle, WA 98101
Telephone: 206.903.3323
Email: jlaplante@anchorqea.com

Mr. Laplante will work with Ade Bright with Bright Engineering Inc. on the structures inspections. Mr. Bright can be reached as follows:

Mr. Ade Bright
Bright Engineering Inc.
1809 7th Avenue, Suite 1100
Seattle, WA 98101
Telephone: 206.625.3777
Email: ab@brighteng.com

Eric Parker, Shawn Hinz, and Tim Thompson will provide vessel support. They will be responsible for operating their boats and will coordinate closely with the FC to collect samples in accordance with the methods and procedures presented in this QAPP. They can be reached as follows:

Mr. Eric Parker
Research Support Services
321 Northeast High School Road, Suite D3/563
Bainbridge Island, WA 98110
Mobile: 206.550.5202
Email: eparker@rssincorporated.com

Mr. Shawn Hinz
Gravity Consulting LLC
32617 Southeast 44th Street
Fall City, WA 98024
Mobile: 425.281.1471
Email: shawn@gravity.com

Mr. Tim Thompson
Science Engineering and the Environment LLC
4401 Latona Avenue Northeast
Seattle WA, 98105
Mobile: 206.418.6173
Email: tthompson@seellc.com

3.3 Quality Assurance/Quality Control

Amara Vandervort is the Windward QA/QC coordinator. In this capacity, she will oversee coordination of the field sampling and laboratory programs, and she will supervise data validation and project QA coordination, including coordination with the analytical laboratories and the EPA QA chemist, Don Matheny. Mr. Matheny is the EPA contact for AOC5 and works on behalf of the QA manager, Donald Brown. Ms. Vandervort will also maintain the official approved QAPP and coordinate the distribution of any updated versions of the QAPP to EPA. Ms. Vandervort can be reached as follows:

Ms. Amara Vandervort
Windward Environmental LLC
200 First Avenue West, Suite 500
Seattle, WA 98119
Telephone: 206.812.5415
Email: amarav@windwardenv.com

Mr. Matheny can be reached as follows:

Mr. Don Matheny
US Environmental Protection Agency, Region 10
1200 6th Avenue
Seattle, WA 98101
Telephone: 206.553.2599
Email: matheny.don@epa.gov

Rebecca Gardner is the Anchor QEA QA/QC coordinator for engineering PDI data collection and management. In this capacity, she will oversee coordination of the engineering data collection programs. Ms. Gardner can be reached as follows:

Ms. Rebecca Gardner
Anchor QEA LLC
1201 3rd Avenue, Suite 2600
Seattle, WA 98101
Telephone: 206.903.3332
Email: rgardner@anchorqea.com

Laboratory Data Consultants, Inc. (LDC) will provide independent third-party chemical data review and validation. The PM at LDC can be reached as follows:

Ms. Pei Geng
Laboratory Data Consultants, Inc.
2701 Loker Avenue West, Suite 220

Carlsbad, CA 92010
760.827.1100 (ext. 141)
Email: pgeng@lab-data.com

3.4 Laboratory Responsibilities

Amara Vandervort of Windward is the laboratory coordinator for the analytical chemistry and toxicity testing laboratories. John Laplante of Anchor QEA is the geotechnical laboratory coordinator for geotechnical testing. Analytical Resources LLC (ARL) will perform all chemical analyses on the sediment samples. Backup laboratories include: OnSite Environmental Inc. (OnSite), Vista Analytical Laboratory, ALS Environmental, Brooks Applied Laboratory, and SGS Axys Analytical Services Ltd. EcoAnalysts, Inc. (EcoAnalysts) will perform the toxicity testing. Materials Testing and Consulting, Inc. (MTC) will perform geotechnical testing and grain size analysis.

The laboratory PM at ARL can be reached as follows:

Ms. Susan Dunnihoo
Analytical Resources LLC
4611 South 134th Place
Tukwila, WA 98168-3240
Telephone: 206.695.6207
Email: limsadm@arilabs.com

The laboratory PM at EcoAnalysts can be reached as follows:

Mr. Jay Word
EcoAnalysts, Inc.
4729 Northeast View Drive
PO Box 216
Port Gamble, WA 98364
Telephone: 206.779.9500
Email: jword@ecoanalysts.com

The geotechnical laboratory PM at MTC can be reached as follows:

Mr. Alex Eifreg
Materials Testing & Consulting, Inc.
77 Chrysler Drive
Burlington, WA 98233
Telephone: 360.755.1990 Ext. 1114
Email: alex.eifrig@mtc-inc.net

The laboratories will meet the following requirements:

- Adhere to the methods outlined in this QAPP, including those methods referenced for each procedure.
- Adhere to documentation, custody, and sample logbook procedures.
- Implement QA/QC procedures defined in this QAPP.
- Meet all reporting requirements.
- Deliver electronic data files as specified in this QAPP.
- Meet turnaround times for deliverables as described in this QAPP.
- Allow EPA and the QA/QC manager, or a representative, to perform laboratory and data audits.

3.5 Data Management

Kim Goffman of Windward will oversee all environmental and geotechnical data management and will confirm that analytical data are incorporated into the LDW database with appropriate qualifiers following acceptance of the data validation. QA/QC of the database entries will provide accuracy for use in the Pre-Design Studies. Ms. Goffman can be reached as follows:

Ms. Kim Goffman
Windward Environmental LLC
200 First Avenue West, Suite 500
Seattle, WA 98119
Telephone: 206.812.5414
Email: kimg@windwardenv.com

3.6 Special Training/Certification

The Superfund Amendments and Reauthorization Act of 1986 required the Secretary of Labor to issue regulations through the Occupational Safety and Health Administration (OSHA) providing health and safety standards and guidelines for workers engaged in hazardous waste operations. Accordingly, 29 Code of Federal Regulations (CFR) 1910.120 requires that employees be given the training necessary to provide them with the knowledge and skills to enable them to perform their jobs safely and with minimum risk to their personal health. All sampling personnel will have completed the 40-hour HAZWOPER training and 8-hour refresher courses, as necessary, to meet OSHA regulations. The FC/HSO will also have completed the eight-hour HAZWOPER supervisor training.

Also, all analytical laboratories have current environmental laboratory accreditation from the Washington State Department of Ecology (Ecology) and other accreditation agencies for the analytical methods to be used. Geotechnical laboratories are not accredited; MTC is a qualified geotechnical laboratory that has 20 years' experience conducting American Society for Testing and Materials (ASTM) procedures for geotechnical testing.

3.7 Documentation and Records

All field activities and laboratory analyses will be documented following the protocols described in this section. In addition, this section provides data reduction rules and data report formats.

3.7.1 Field Observations

All field activities will be recorded in a field logbook maintained by the FC or designee. The field logbook will provide a description of all sampling activities, conferences between the FC and EPA oversight personnel associated with field sampling activities, sampling personnel, and weather conditions, as well as a record of all modifications to the procedures and plans identified in this QAPP and the HSP (Appendix A). The field logbook will consist of bound, numbered pages, and all entries will be made in indelible ink. Photographs, taken with a digital camera, will provide additional documentation of the surface sediment collection activities and all bank sediment sampling areas. The field logbook is intended to provide sufficient data and observations to enable participants to reconstruct events that occurred during the sampling period.

The project team will use the following field forms, included as Appendix C, to record pertinent information after sample collection:

- Surface sediment collection form
- Sediment core collection form
- Sediment core processing log
- Shoreline visual inspection form
- Facilities condition assessment report including photo log and concrete, wood, and steel materials visual inspection checklists
- Soil boring form
- Vane shear form
- Dynamic cone penetrometer (DCP) field form
- Protocol modification form
- Chain of custody form

The project team will document information regarding equipment calibration and other sampling activities in the field logbook.

3.7.2 Laboratory Records

3.7.2.1 Chemistry Records

The analytical laboratories will be responsible for internal checks and data verification on sample handling and analytical data reporting and will correct errors identified during the QA review. The analytical laboratories will submit data packages electronically, including the following as applicable:

- **Project narrative**: This summary, in the form of a cover letter, will present any problems encountered during any aspect of sample analyses. The summary will include, but not be limited to, discussion of QC, sample shipment, sample storage, and analytical difficulties. The project narrative will document any problems encountered by the laboratory and their resolutions. In addition, the summary will provide operating conditions for instruments used for the analysis of each suite of analytes and definitions of laboratory qualifiers.
- **Records**: The data package will include legible copies of the chain of custody forms. This documentation will include the time of receipt and the condition of each sample received by the laboratory. These records will also document additional internal tracking of sample custody by the laboratory.
- **Sample results**: The data package will summarize the results for each sample analyzed. The summary will include the following information, as applicable:
  - Field sample identification (ID) code and the corresponding laboratory ID code
  - Sample matrix
  - Date of sample extraction/digestion
  - Date and time of analysis
  - Weight used for analysis
  - Final dilution volumes or concentration factor for the sample
  - Percent solids in the samples
  - Identification of the instruments used for analysis
  - Method detection limits (MDLs)[8] and RLs[9]
  - All data qualifiers and their definitions
- **QA/QC summaries**: These summaries will contain the results of all QA/QC procedures. Each QA/QC sample analysis will document the same information required for the sample results (see above). The laboratory will make no recovery or blank corrections, except for

[8] The term MDL includes other types of detection limits (DLs), such as estimated detection limit (EDL) values calculated for dioxin/furan congeners.
[9] RL values are consistent with the lower limit of quantitation LLOQ values required under EPA-846.

isotope dilution method corrections prescribed by EPA. The required summaries will include the following information, as applicable:

- The calibration data summary will contain the concentrations of the initial calibration and daily calibration standards and the date and time of analysis. This summary will also list the response factor, percent relative standard deviation (%RSD), relative percent difference (RPD), and retention time for each analyte, as appropriate, as well as standards analyzed to indicate instrument sensitivity.
- The internal standard area summary will report the internal standard areas, as appropriate.
- The method blank analysis summary will report the method blank analysis associated with each sample and the concentrations of all compounds of interest identified in these blanks.
- The surrogate spike recovery summary will report all surrogate spike recovery data for organic analyses, and it will list the names and concentrations of all compounds added, percent recoveries, and QC limits.
- The labeled compound recovery summary will report all labeled compound recovery data for EPA method 1613b, and it will list the names and concentrations of all compounds added, percent recovery, and QC limits.
- The matrix spike (MS) recovery summary will report the MS or MS/matrix spike duplicate (MSD) recovery data for analyses, as appropriate, including the names and concentrations of all compounds added, percent recoveries, and QC limits. The MS recovery summary will also report the RPD for all MS and MSD analyses.
- The matrix duplicate summary will report the RPD for all matrix duplicate analyses and will list the QC limits for each compound or analyte.
- The certified reference material (CRM) analysis[10] summary will report the results of the CRM analyses and compare these results with published concentration ranges for the CRMs.
- The LCS analysis summary will report the results of the analyses of LCSs, including the QC limits for each compound or analyte.
- The relative retention time summary will report the relative retention times for the primary and confirmational columns of each analyte detected in the samples and the percent difference between the columns, as appropriate.

[10] CRMs will be analyzed for polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyl (PCB) Aroclors, and dioxins/furans. All other analyses will include a laboratory control sample (LCS). Specific information is listed in Section 4.10.

  - The ion abundance ratio summary for samples analyzed by EPA method 1613b will report computed ion abundance ratios compared to theoretical ratios listed in the applicable method.
- **Original data**: The data package will include legible copies of the original data generated by the laboratory, including the following:
  - Sample extraction/digestion, preparation, and cleanup logs
  - Instrument specifications and analysis logs for all instruments used on days of calibration and analysis
  - Reconstructed ion chromatograms for all samples, standards, blanks, calibrations, spikes, replicates, LCSs, and CRMs
  - Enhanced and unenhanced spectra of target compounds detected in field samples and method blanks, with associated best-match spectra and background-subtracted spectra, for all gas chromatography/mass spectrometry (GC/MS) analyses
  - Enhanced and unenhanced spectra of target performance reference compounds detected in field samples, day-zero blanks, field blanks, and method blanks, with associated best-match spectra and background-subtracted spectra, for all GC/MS analyses
  - Quantitation reports for each instrument used, including reports for all samples, blanks, calibrations, MSs/MSDs, laboratory replicates, LCSs, and CRMs

The analytical laboratories will submit data electronically, in EarthSoft EQuIS® standard four-file or EZ_EDD format. Guidelines for electronic data deliverables for chemical data will be communicated to the analytical laboratories by the project QA/QC coordinator or data manager. All electronic data submittals must be tab-delimited text files that include all results, MDLs (as applicable), and RLs consistent with those provided in the laboratory report. If laboratory replicate analyses are conducted on a single submitted field sample, the laboratory sample identifier must distinguish among the replicate analyses.

3.7.2.2 Toxicity Testing Records

The bioassay laboratory, EcoAnalysts, will be responsible for internal checks on sample handling and toxicity test data reporting and will correct errors identified during the QA review. EcoAnalysts will submit its laboratory data packages electronically, including the following as applicable:

- **Project narrative**: This summary, in the form of a cover letter, will present any problems encountered during any aspect of sample analyses. The summary will include, but not be limited to, summary of test methods, discussion of QC, sample shipment, sample storage, and analytical difficulties. This summary will document any problems encountered by the laboratory and their resolutions, and it will provide definitions of laboratory qualifiers.

- **Records**: The data package will include legible copies of the chain of custody forms. This documentation will include the time of receipt and the condition of each sample received by the laboratory, as well as additional internal tracking of sample custody by the laboratory.
- **Sample results**: The data package will summarize the bioassay results and replicate data for each sample analyzed. The summary will include the following information, as applicable:
  - Field sample ID code and the corresponding laboratory ID code
  - Toxicity test and test species
  - Bioassay start and end date and time
  - Weight of a representative subsample of organisms at the start of sediment exposures
  - Test acceptability requirements and discussion of any deviations from these requirements
- **QA/QC summaries**: These summaries will contain the results of all QA/QC checks, including the following as applicable:
  - Serial dilutions
  - LCS and reference toxicant tests
  - Any additional QC procedures required by applicable method protocols and laboratory SOPs
- **Original data**: The data package will include legible copies of the original data generated by the laboratory, including the following:
  - Source of control sediment and associated measurements
  - Water quality monitoring results
  - Measured light intensity during testing
  - Laboratory worksheets

EcoAnalysts will submit data electronically, in a Microsoft™ Excel spreadsheet format to be provided by Windward.

3.7.2.3 Geotechnical Testing Records

The geotechnical laboratory, MTC, will be responsible for internal checks on sample handling and geotechnical data reporting. MTC will submit laboratory data packages as electronic reports that include the following, as applicable:

- **Project narrative**: This summary, in the form of a cover letter, will present any problems encountered during any aspect of geotechnical testing. The summary will include, but not be limited to, summary of test methods, discussion of QC, sample shipment, sample storage, and testing difficulties as applicable. This summary will document any problems encountered by the laboratory and their resolutions.
- **Records**: The data package will provide legible copies of the chain of custody forms. This documentation will include the time of receipt and the condition of each geotechnical sample received by the laboratory.
- **Sample results**: The geotechnical data report will summarize the geotechnical testing results for each sample analyzed. The summary will include the following information, as applicable:
  - Field sample ID code and the corresponding laboratory ID code
  - Geotechnical data for each type of testing performed
  - Test acceptability requirements and discussion of any deviations from these requirements
- **Original data**: The data package will include legible copies of the original data generated by the laboratory.

MTC will submit data electronically, in PDF report and Excel format, where applicable.

3.7.3 Data Reduction

Data reduction is the process by which original data (i.e., analytical measurements) are converted or reduced to a specified format or unit to facilitate analysis of the data. Data reduction requires that all aspects of sample preparation that could affect the test result, such as sample volume analyzed or dilutions required, be taken into account in the final result. It is the laboratory analyst's responsibility to reduce the data, which the laboratory PM, the Windward TM, the QA/QC coordinator, and independent reviewers then subject to further review and reduction. The laboratory will generate the data in a format amenable to review and evaluation. Data reduction may be performed manually or electronically.

3.7.4 Data Storage and Backup

All electronic files related to the project will be stored on a secure server on Windward's network. The server contents are backed up on an hourly basis, and a copy of the backup is uploaded nightly to a secure off-site facility.

4 Data Generation and Acquisition for Sediment and Bank-area Sediment Samples

This section presents details of the PDI data generation and acquisition of chemistry data for the middle reach, and it addresses how samples will be collected, processed, and analyzed, including QA/QC, instrument maintenance and calibration, and data management requirements. PDI sampling includes the following elements that involve the sampling and analysis of sediment samples to address DQOs 1 through 7, 9, 10, and 11:

- Sediment collection and analysis of 0- to 10-cm, 0- to 45-cm, 0- to 60-cm, FNC shoal, and vertical extent core samples collected at locations below mean higher high water (MHHW)[11]
- Toxicity testing of sediment samples as needed[12]

Other PDI elements associated with engineering design elements are discussed in Section 5.

4.1 Sampling Design for Sediment Samples

This section discusses the sampling design for sediment and under-structure sampling, including approaches and rationale for depth intervals, analytes, tiering, sampling locations, and toxicity testing.

4.1.1 Sediment Sample Depth Intervals

The ROD defines which sediment depth intervals will be sampled to delineate RAL exceedances in PDI samples. Most locations will be sampled at two depth intervals. Some locations will require only one interval of sampling, depending on existing data and RAL applicability in certain areas. In the intertidal area, 0- to 10-cm and 0- to 45-cm samples will be collected as needed. In the subtidal areas, 0- to 10-cm and 0- to 60-cm samples (or FNC shoaling intervals) will be collected as needed. In subtidal areas outside of both Recovery Category 1 areas and potential vessel scour areas,[13] there are no subsurface RALs, and thus, no subsurface samples will be collected. Sampling intervals for Phase I are summarized in Table 4-1.

[11] Per Section 4.3 of the ROD (EPA 2014a), "The Selected Remedy addresses, to the extent practicable, contaminated sediments and surface water below the MHHW level (in the LDW, MHHW is 11.3 ft above the mean lower low water [MLLW] level) that are expected to remain after the EAA cleanup work (component 1) is completed."

[12] As discussed in Section 4.1.7, toxicity testing may be conducted in Phase II or III at locations with only benthic RAL exceedances and where the results would affect remedial action area boundaries if they were to pass the benthic toxicity tests.

[13] Potential vessel scour areas are defined in Table 28 of the ROD as subtidal areas (i.e., below -4 ft MLLW) that are above -24 ft MLLW north of the 1st Ave South Bridge and above -18 ft MLLW south of the 1st Ave South Bridge.

Table 4-1
Sample Depth Intervals for Phase I

Area Type	Applicable RAL Intervals	
	Surface	Subsurface
Intertidal	0–10 cm	0–45 cm
Subtidal	0–10 cm	0–60 cm (in Recovery Category 1 and potential vessel scour areas[1])
Shoaled areas in the FNC	0–10 cm	shoaled material (depth and number of samples varies, depending on the depth of shoal)[2]
		2 ft of overdredge

Notes:

1. The only segment of the FNC with the potential for vessel scour is RM 2.8 to RM 3.0, with an authorized navigation depth of -15 ft MLLW, which is shallower than the vessel scour depth of -18 ft MLLW. Between RM 1.6 and RM 2.8, the authorized depths (-20 ft MLLW and -30 ft MLLW) are deeper than the corresponding potential vessel scour depths (-18 ft MLLW and -24 ft MLLW, respectively).
2. The depth intervals for the shoaled material are shown in Table 4-2 and on Figure 4-1. One 2-ft Z-sample will also be collected in shoaling cores below the overdredge interval (Inouye and DMMP 2010). The Z-sample represents the post-dredge sediment conditions following maintenance dredging (DMMP 2021).

FNC: Federal Navigation Channel
MLLW: mean lower low water
RAL: remedial action level
RM: river mile

Sampling intervals in shoaling areas of the FNC are dependent on the depth of the shoal and the authorized navigation depth. In the middle reach, there are three different authorized navigation depths (Table 4-2), which dictate the depths of the samples to be taken for comparison to RALs. In FNC areas with shoals (i.e., areas in which the current elevation is shallower than the authorized depth), the 0- to 10-cm interval will be sampled, and other intervals will be sampled depending on the thickness of the shoal material, as shown in Figure 4-1 for the three FNC segments.

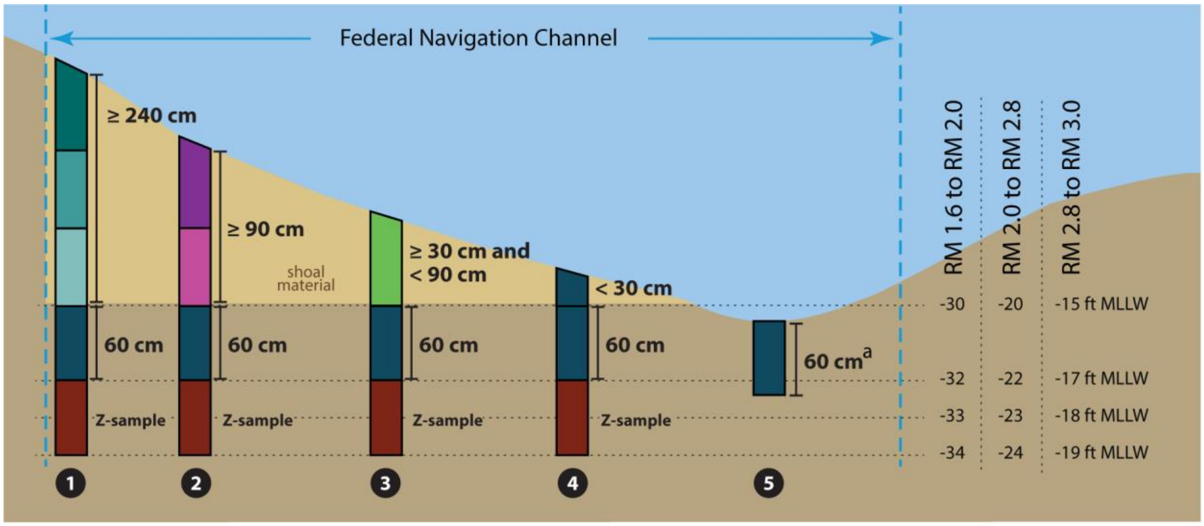
Table 4-2
Authorized FNC Depths and Associated Sample Intervals for Shoaled Areas in the Middle Reach

FNC Segment[1]	Authorized Navigation Depth (ft MLLW)	Sample Intervals in Shoaled Areas (ft MLLW)		
		Shoal (1–3 samples)[1]	Overdredge (1 sample)[2]	Z-Layer (1 sample)
RM 1.6 to RM 2.0	-30	surface to -30	-30 to -32	-32 to -34
RM 2.0 to RM 2.8	-20	surface to -20	-20 to -22	-22 to -24
RM 2.8 to RM 3.0	-15	surface to -15	-15 to -17	-17 to -19

Notes:
1. The USACE stations for these segments are provided in Table 2-1 of the PDIWP (Windward and Anchor QEA 2022).
2. When less than 30 cm of shoal material is present, the shoal material and overdredge material will be combined into a single sample (see Figure 4-1).

FNC: Federal Navigation Channel
MLLW: mean lower low water
RM: river mile

Figure 4-1
Shoal Design Sampling Approach RM 1.6 to RM 3.0



[a] The 0 - 60 cm RAL interval applies in recovery category 1 or potential vessel scour areas (RM 2.8 to RM 3.0)

1. When the thickness of shoal material is ≥ 240 cm, the shoal material will be characterized in three equal intervals.
2. When the thickness of the shoal material is ≥ 90 cm and < 240 cm, the shoal material will be characterized in two equal intervals.
3. When the thickness of the shoal material is ≥ 30 cm and < 90 cm, the shoal material will be characterized as one interval.
4. When the thickness of the shoal material is < 30 cm, the shoal material will be characterized as one interval by analyzing a combined sample with the shoal material and the 60 cm overdredge interval.
5. Between RM 2.8 and RM 3.0, a 0-60 cm sample will be analyzed in areas that are not shoaled and are shallower than the potential vessel scour elevation of -18 ft MLLW. Samples from these areas will not be characterized as a shoaling locations because they have no shoaling material.

Note: The interval between the authorized navigation depth and the overdredge depth will be characterized as a separate interval whenever the shoal interval is greater than or equal to 30 cm. In addition, a 0-10 cm sample and a 60 cm Z-sample will be collected at all shoaling core locations.

4.1.2 Tiered Analysis and Analytes

The PDI sediment sampling design involves the collection of two tiers of samples:

- Tier 1 – Locations sampled for immediate analysis
- Tier 2 – Locations sampled for sample archival with analysis dependent on the results of Tier 1 analyses

Tier 1 and Tier 2 samples will be collected during the same sampling effort. The majority of the Phase I samples will be analyzed in Tier 1. Tier 2 locations will be selected for analysis in consultation with EPA based on the general principles discussed in the PDIWP (Windward and Anchor QEA 2022). Specifically, some samples in Phase I may be analyzed as Tier 2 because they have been added to the gridded design as re-occupation or bounding samples (see Section 4.1.3).

In addition, some of the Phase I shoaling intervals will be analyzed in Tier 2. In the FNC, the overdredge core interval samples (the 2 ft below the authorized depth) will be analyzed as a Tier 1 in all locations with more than 30 cm of shoal material. When the thickness of shoal material is 30 cm or less, the shoal material and the overdredge interval will be analyzed as one sample in Tier 1. The remaining subsurface intervals will be archived as Tier 2 samples and analyzed using the following guidelines.

- When the overdredge core interval in a shoaling core does not have any RAL exceedances, then the archived shoal intervals above the overdredge interval will be analyzed to determine if all intervals are below the RAL.
- When the overdredge core interval in a shoaling core has a RAL exceedance, then archived intervals will be analyzed as needed for design purposes. For example, the analysis of the Z-sample interval would provide additional vertical delineation, and the analysis of interval(s) to characterize the uppermost 0- to 2-ft core interval could provide helpful information in determining if dredging may be deferred if USACE determines that shoaled sediment is not an impediment to navigation (per footnote 23 of the ROD).

Grain size archive samples will be collected for each interval in each shoaling core in Phase I. Shoaling samples will be analyzed for grain size in Tier 2 if Tier 1 results at a given location indicate RAL exceedances. The interval(s) (or composited intervals) to be analyzed at these locations will be determined by the engineer to meet design needs. All remaining grain size analyses will be conducted in Phase II as needed in vertical extent samples (see Section 4.2.5) or for toxicity testing (see Section 4.2.7).

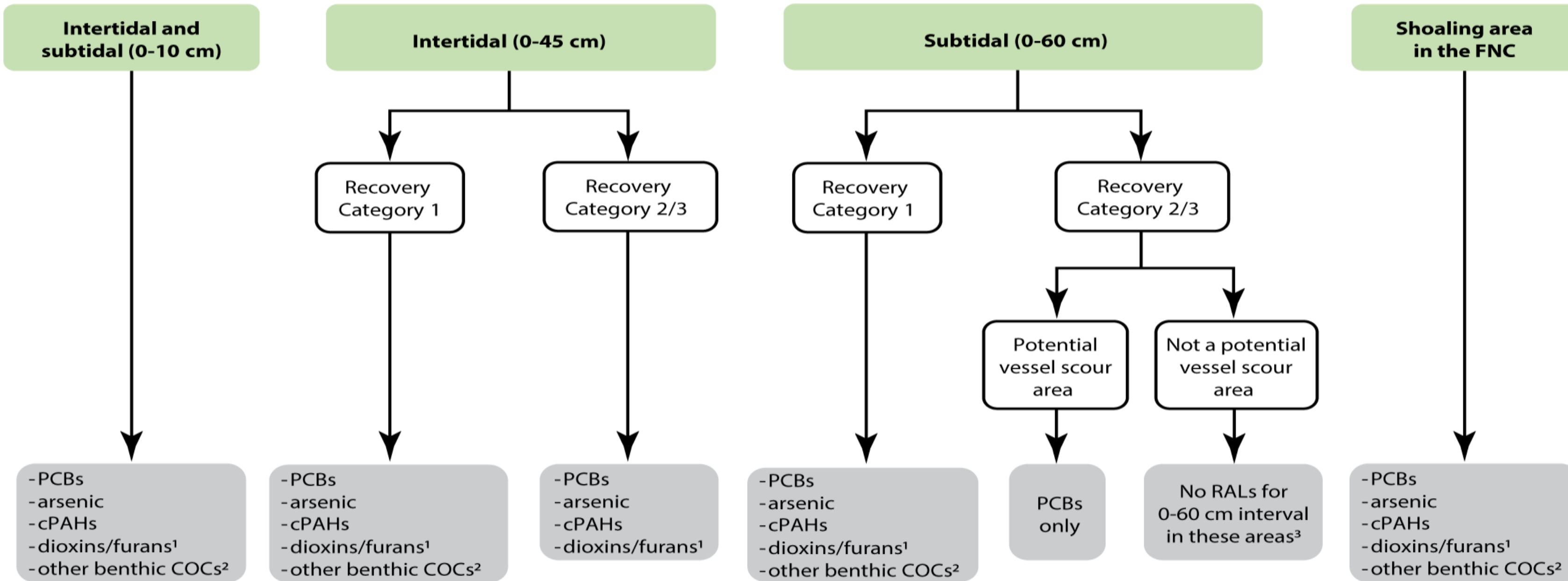
The analyte list for each Phase I sediment sample will differ depending on which RALs are applicable. RAL applicability is determined based on the sample type (i.e., intertidal or subtidal), sample interval, recovery category, and other location-specific factors. RAL applicability is summarized in Figure 4-2 and Map 2 according to the RALs presented in ROD Tables 27 and 28 (EPA 2014b) and the ESD (EPA 2021b) for cPAHs.[14]

In general, Tier 1 samples in Phase I will be analyzed for all contaminants of concern (COCs) with an applicable RAL for that sample, with the exception of dioxins/furans. Dioxins/furans will be analyzed in a subset of Phase I Tier 1 samples, as described in Section 4.1.3.

The analyte list for each Tier 2 (archive) sample will be determined based on unvalidated Tier 1 data in a meeting with EPA. COC(s) with RAL exceedance(s) in a Tier 1 sample will be analyzed in the adjacent Tier 2 samples. In addition, other COCs may be selected for Tier 2 analysis based on area-specific Tier 1 results and other existing sediment and nearby upland source data.

[14] LDWG will voluntarily evaluate any additional RAL exceedance areas using the 2014 ROD RALs for cPAHs in the DER.

Figure 4-2
Required analytes per ROD Tables 27 and 28



Notes:

Sediment will be archived to allow for potential analysis of additional RC1 analytes at all locations that may be affected by the recovery category review following the resolution of the bathymetry data gaps.

1. A subset of samples will be analyzed for dioxins/furans.
2. Other benthic COCs are the benthic risk drivers in ROD Table 27 (see Table 4-10); while PCBs, arsenic. and the seven individual PAHs in cPAHs are also benthic COCs, they are addressed by the human health RALs because they are also human health COCs.
3. Disturbance of sediment by anthropogenic sources (e.g., vessels) is not expected in these areas, so sediment deeper than 10 cm would not be exposed.

4.1.3 Phase I Sediment Sampling Design (Excluding Areas Under Structures)

This section defines the guidelines followed in identifying specific sediment sampling locations and intervals and the number of PDI samples that will be collected and analyzed to support the interpolation of RAL exceedances areas (DQOs 1 through 7). Based on these guidelines, details for each location are summarized in Appendix D. The sampling design for samples to be collected under structures (DQO 9) is discussed in Section 4.1.5.

To support the interpolation of RAL exceedance areas, a gridded design was selected to serve as the basis for Phase I sampling; this approach provides a relatively even distribution of data points. This approach differs from that used in Phase I in the upper reach, because RI/FS data used to develop the ROD indicated that the upper reach had larger areas without RAL exceedances compared to the middle reach.

For this design, a total of 243 grid cells have been identified (Maps 3a, 3b, and 3c); individual grid cells are referred by to row and column (e.g., 41C). Grid cells are rectangular (100 × 200 ft) and oriented with water flow direction along the FNC and along slips. Grid cells were altered where necessary to adapt to the geometry of the middle reach and to result in a transect-like data distribution from one side of LDW to the other (or bank to bank), because transects are often helpful in design. Within each grid cell, a centroid (center of the grid) with a 50-ft radius around it were identified to aid in the sampling design.

Maps 4a, 4b, and 4c show the data in the design dataset within the grid cell design, including exceedance factors (EFs) relative to RALs for locations with EFs > 0.9. The design dataset, as discussed in Section 3.1 and Attachment D of the PDIWP (Windward and Anchor QEA 2022), includes the data that will be used to design the remedy (i.e., to define RAL exceedance areas and the vertical extent of contamination). The design dataset includes surface sediment data collected from 2011 to the present (post-FS data[15]), as well as subsurface sediment data (both RI/FS[16] and post-FS data). A small subset of data from areas with > 1.5 ft of deepening since 2003 was not included in the design dataset because the degree of deepening indicates that previously analyzed interval(s) may no longer exist at those locations, creating uncertainty regarding representativeness.

Maps 5a and 5b show the PDI sampling locations within the gridded cells. These locations have been placed according to the steps and guidelines discussed below.

The first step was to determine if the default position of the PDI sampling location within a grid should be moved from the centroid to a new location (within 50 ft of the centroid when

[15] The post-FS dataset includes available data from January 2011 to October 2021.
[16] The surface and subsurface RI/FS dataset includes data collected from 1990 to January 2010.

possible). The default sampling location was moved from the centroid of the cell in the following circumstances.

- **RAL-applicable areas** – In grid cells with more than one RAL-applicable area (e.g., intertidal, potential vessel scour, shoal, Recovery Category 1 area), the default PDI sampling location was shifted from the centroid to a sampling location in the grid that occupies the majority of the grid cell or is the area with the lowest RALs. For example, in grid cell 41C on Map 4b, the sampling location was shifted to the southwest to be within the Recovery Category 1 area.
- **Sampleability** – In areas with steep banks, structures, or riprap, centroid locations may not be sampleable. In these places, sampling locations within grid cells were moved to an area anticipated to be sampleable. For example, the centroid in grid cell 23A on Map 4a is on riprap, so the default PDI sampling location was shifted to the north. The new locations in some grid cells with centroids near the MHHW line are more than 50 ft from the centroid (e.g., 13A, 14A, 15G, and 26A).
- **Beach play and clamming areas** – In grid cells that include intertidal areas listed as potential beach play or clamming areas, the default PDI sampling locations were sometimes moved into locations that target these intertidal areas of interest to ensure adequate coverage. For example, in grid cell 41B on Map 4b, the sampling location was shifted north to better target the intertidal area that includes beach play area 5.

Once a default PDI sampling location was established in each grid cell, the next step was to assess whether each grid cell needs to be sampled. Key considerations included: 1) what RALs apply at each location, 2) whether all or part of a grid cell is likely to be remediated, and 3) whether representative data in the design dataset already exist. The relevant guidelines are listed below.

- **Applicability of subsurface RALs** – Some grid cells are in locations that do not have an applicable subsurface RAL. In these grid cells, no subsurface sample will be collected in Phase I.[17] For example, a 0- to 60-cm sample will not be collected in grid cell 23D on Map 4a, because there is no subsurface RAL at this location.
- **Likely active remediation area** – Some grid cells have existing data in the design dataset that indicate that a remedy is likely needed in this area. In these cases, bounding through the sampling of a PDI location outside the centroid or re-occupation of an existing location may be more appropriate. For example, the sampling location in grid cell 25A was shifted north to help bound the exceedances in the inlet at RM 2.2W. In addition, an active

[17] For these locations, if the Phase I 0 to 10-cm surface sample has RAL exceedances, sediment cores will be collected at representative locations in those areas during Phase II to determine the vertical extent of contamination.

remedy is assumed for Beach 6 (grid cells 38F and 39F), with bounding samples being collected in Phase 1.

- **Coverage with existing data** – If design dataset data already exist within the grid cell, PDI sampling may not be necessary because the existing data may represent that grid cell. In order for an existing sample to substitute for a PDI sample, it must have been collected within 50 ft of the centroid, to maintain a relatively even sample distribution, and it must have been analyzed for most if not all of the analytes listed in Section 4.8.2. For example, samples analyzed for only PCBs or samples without PCBs analyses (e.g., grid cell 9A) do not qualify.

Once a PDI sampling location for each grid has been established (or substitute data have been identified), some of the existing data locations may be re-occupied as additional samples if they have an EF of ≥ 0.9. For example, in grid cells 31E and 43D, locations with EFs of 1.3 to 1.0, respectively, are being re-occupied because these EFs are close to 1. The decision to analyze these re-occupation samples, many of which are Tier 2, will be based on the results of the adjacent Tier 1 samples. For example, if concentrations in adjacent samples are below RALs, a Tier 2 sample may be analyzed to see if the sample location is also below applicable RALs. Conversely, if concentrations in adjacent samples are above RALs, the analysis of the Tier 2 sample may be unnecessary, because the Phase I results indicate that an active remedy is needed in this area (potentially with additional horizontal/vertical delineation of the area in Phase II). As discussed in Attachment D to the PDIWP (Windward and Anchor QEA 2022), when newer data are collected at a location, these data replace the older data in the design dataset if the sample is collected within 10 ft of the original location.

In addition, although remedial investigation/feasibility study (RI/FS) surface sediment data were excluded from the design dataset due to their age and the conceptual site model, these data were reviewed to determine if any RI/FS locations had EFs > 4. If so, they were re-occupied to determine if exceedances still exist in that area and to improve understanding of how concentrations are changing in the area. For example, a PDI sampling location was placed in grid cell 36E to re-occupy a 2005 surface sediment sampling location with a PCB EF of 29.

Sampling in the Slip 4 area (grid cells 40G, 42ABC) will be addressed using a tiered approach, with potentially two sampling events during Phase I (which has a multi-month sampling period). This area has received more than 2 ft of depositional material, based on differences in bathymetric surveys between 2003 and 2021. In addition, dredging was conducted in the southern part of Slip 4 in three construction seasons from 2013 to 2015 as part of the Boeing Plant 2 Early Action Area (see Attachment A of the PDIWP). As part of this action, perimeter samples were collected in this area and analyzed yearly from 2012 through 2015 (see Table A-4 in the PDIWP). Many of these perimeter locations had PCB concentrations above the applicable

RAL at least once in the last three years (see Table A-3 in the PDIWP). No data have been collected in this area since 2015.

To assess current conditions north of the dredging area, 10 perimeter monitoring stations (508, 509, 510, 511, 513, 514, 515, 516, 517, and 518) will be re-occupied early in the Phase I field effort (Map 4c). At these stations, 0- to 10-cm samples will be collected and analyzed for PCBs.[18] Based on the results, either additional Phase I sampling and analysis will be conducted in these four grid cells, or the area will be designated as a remedy area for further characterization (e.g., bounding and vertical extent of contamination) during Phase II. If additional sampling and analysis is conducted during Phase I, a 0- to 60-cm subsurface sample would be collected from each of the four grid cells, and archived PDI samples from these perimeter monitoring locations would be analyzed for the full analyte list. Additional surface sediment samples, such as re-occupations of past RAL exceedance locations, may also be collected.

Based on the above guidelines, a total of 278 sampling locations (excluding areas under structures)[19] have been identified in the 243 grids for Phase I sampling in the middle reach; most of the locations have both a surface and subsurface interval. Table 4-3 summarizes Phase I surface and subsurface sampling locations. The location of each of the Phase I sampling locations, along with other relevant data, is shown on Maps 4a, 4b and 4c (relative to RAL application areas), Map 5a and 5b (relative to the isopach analysis results), and Maps 6a and 6b (relative to the aerials). In addition, the rationale for the placement of each sampling location, the intervals collected at each location, and applicable analytes (as described in Figure 4-2 and Section 4.1.2) are presented in Appendix D. Approximately 95% of the Phase I PDI sampling locations will be analyzed in Tier 1, including 221 of the 237 surface sediment locations and at least 1 interval from all 218 subsurface sediment locations.

Table 4-3
Summary of Middle Reach Phase I PDI Sampling Locations

Grid Category	Count by Sample Type	
	Surface	**Subsurface**
Total number of grids (excludes the under-structure grids and grids where there is not an applicable RAL)	237	220
Count of grids with PDI sample	198 (84% of grids)	204 (93% of grids)
Count of grids with no PDI sample (either because of existing data, assumed active remedy, or analysis of upper reach archive sample)	39	16

[18] All samples will also be analyzed for total organic carbon (TOC) and total solids.
[19] Sampling location counts do not include under-structure sampling locations, which are discussed in Section 4.5.1.

Grid Category	Count by Sample Type	
	Surface	Subsurface
Total number of sampling locations		
Count of locations to satisfy grid coverage	191[1]	202[2]
Count of additional re-occupation samples, bounding or bank area samples, or samples adjacent to potential upland sources	46[3] (16 are Tier 2)	16
Total Phase I PDI Sampling Locations[4]	**237 (221 are Tier 1; 16 are Tier 2)**	**218[5] (all 218 are Tier 1)**

Notes:

1. This count (191 samples) includes 7 re-occupation samples that are also being used for grid coverage. This is less than the count of 198 grids where a PDI sample is being collected, because of the 4 grids in Slip 4 (40G and 42ABC) where PCB trends are being evaluated and the bounding samples in Slip 3 (grid 18D) and Beach 6 (grids 37F and 38F). These seven grids are not included in the count of locations to satisfy grid coverage because there are existing data in these grids.
2. This count (202) is less than the 204 grids where a PDI sample is being collected, because of the bounding samples in Slip 3 (grid 18D) and in Beach 6 (grid 38F) that are not also used to satisfy grid coverage.
3. This count includes only additional re-occupation/bounding samples, as well as samples adjacent to potential upland sources that were added per Ecology request. The seven re-occupation samples that are also being used for grid coverage are not included in this count.
4. Counts do not include the 21 under-structure sampling locations, which are discussed in Section 4.1.5.
5. Of the 218 subsurface locations, 65 are 0–45-cm intertidal locations, 114 are 0–60-cm subtidal locations, and 39 are shoaling locations. For the 39 shoaling locations, one interval at each location will be analyzed in Tier 1 (see Section 4.1.2).

PDI: pre-design investigation

A subset of the Tier 1 samples has been identified for dioxin/furan analysis; 44 surface and 45 subsurface sampling locations (Maps 7a and 7b). The PDI locations identified for Tier 1 dioxin/furan analysis were determined based on all existing surface and subsurface sediment data, including RI/FS surface sediment data. The selected Tier 1 samples are intended to target areas that have had dioxin/furan TEQs greater than 20 ng/kg dry weight [dw], collect subsurface data in areas with elevated surface sediment dioxin/furan TEQs, and provide spatial coverage of dioxin/furan data near outfalls where higher dioxin/furan TEQs have been reported. Archive samples from locations not analyzed for dioxins/furans in Tier 1 (surface and subsurface samples) will be retained for potential analysis of dioxins/furans in Tier 2.

The Phase I PDI Tier 1 and Tier 2 results will be included in the design dataset, as defined in the PDIWP (Windward and Anchor QEA 2022), and used to define the interpolated preliminary RAL exceedance areas in the Phase I DER. Phase II PDI data, which will also be tiered, will be used in the Phase II DER to refine the RAL exceedance area boundaries through updated data interpolations. Phase II data will also be used to define the depths of contamination in dredge or capped remedial action areas.

In addition, a probability analysis will be presented in the Phase I DER regarding the size of a contiguous area with concentrations exceeding the RAL that would be detected with a specified level of confidence, if such an area were to exist. This type of analysis is best conducted once the PDI Phase I data can be included. The results of this analysis will be considered in identifying Phase II data gaps.

4.1.4 Phase I Sampling Design Under Structures

In Phase I, sediment sampling will also be conducted under over-water structures that are at least 50 ft wide (perpendicular to the bank) and 50 ft long with safe access (DQO 9). The density of sampling locations under structures was designed to loosely conform to the grid sampling density established in Section 4.1.3, with one sample targeted for each approximately 200 linear ft of structure.[20] This work may require the use of a diver.

Prior to initiating investigations under structures, a reconnaissance inspection will be made by the Dive Supervisor and the engineering team, including the structural engineer, to verify the stability of each structure and whether or not the areas beneath them can be accessed safely. Sediment probing and sampling will not occur under any structures that are found to be unsafe to access. At this time, only one structure has been identified as unsafe to sample beneath—the southern Seattle Iron and Metals wharf at RM 2.55E. Samples will be collected from four locations immediately adjacent to this structure. If any other structures are determined to be unsafe, LDWG will coordinate with EPA to determine if sampling adjacent to the structure will be required in addition to standard grid sampling. Factors to be considered in that discussion will include the results of the analysis of the surrounding sediment data, proximity to an upland source or outfall, and visual observations.

Depending on the nature of the substrate under the structure, the first step in under-structure sediment sampling may include sediment probing to determine the horizontal limits of slope armoring (e.g., riprap) and the thickness of sediment overlying armor materials. Bathymetric elevations will also be verified during the probing effort.

When safe and feasible to collect sediment, under-structure sampling will target a surface and subsurface sediment sample at each location, if sufficient sediment is present. The specific sediment intervals collected will depend on whether the observed elevations are intertidal or subtidal. If both intertidal and subtidal conditions are present and sufficient sediment exists to collect samples, preference will be given to collecting samples within the intertidal area. Maps 8a and 8b identify 21 understructure locations. All samples will be analyzed for the Tier 1 analyte list at applicable RAL locations,[21] as discussed in Section 4.1.2. Surface sediment samples from five locations will also be analyzed for dioxins/furans: one surface sample each from under

[20] A minimum of one sample would be collected for each targeted structure less than 200 ft long.

[21] Note, the applicable RALs under many structures are not currently known because of bathymetry data gaps, which are to be filled during Phase I sampling.

structures at Terminal 115 (RM 1.65W) and Pacific Pile and Marine (RM 2.75W), and one surface sample each from three locations under the structure at the 8th Avenue Terminal (RM 2.85E).

It is expected that some sampling locations may require location adjustments based on field conditions and the results of the sediment probing. An under-structure sampling SOP describing the details of the approach for determining the final location is included in Appendix E.
Table 4-4 provides an overview of the structures and conditions at each location that will be targeted during Phase I. The locations of each of the Phase I under-structure sampling locations, along with other relevant data, are shown on Maps 4 through 8. Maps 8a and 8b best show the locations relative to the structures in the aerial photo. All structures will be assessed for potential safety concerns prior to sampling, and unsafe conditions will be documented and reported to EPA if they prohibit under-structure sampling in specific locations. Table 4-4 also lists five structures that will not be sampled during Phase I due to their small size and proximity to a grid sample. Depending on the Phase I results, sampling may be recommended at these locations for Phase II.

Table 4-4
Identified Over-water Structures in the Middle Reach and Targeted Phase I Sampling

Approximate RM (side)	Overwater Structure Name	Description[1]	Targeted Phase I Sampling[2]	Notes
1.65 (east)	Certainteed Pier	50-ft-wide T-head pier supported on steel pipe piles at approximately 10×10-ft spacing with horizontal bracing.	1 intertidal location (0–10-cm and 0–45-cm samples if possible)	Several composite samples predating 2011 have been collected around the structure. Based on current understanding of conditions that indicate the presence of soft sediment, no sediment probing on armoring or diver inspection is anticipated.
1.7 (east)	Glacier Northwest Slip 2 Pier	Small 20-ft-wide timber pier	No Phase I sampling	Structure is smaller than minimum target width for Phase I sampling. The need for sampling will be re-evaluated during Phase II. PDI samples that are located near the structure will be collected during Phase I.
1.6–1.75 (west)	Northland North Wharf (Terminal 115)	Concrete pile-supported wharf (90 ft wide and 860 ft long within the study area).	5 subtidal locations (0–10-cm and 0–60-cm samples if possible)	Conduct sediment probing on armoring to identify five locations for sediment sampling, targeting -15 feet MLLW. Due to the presence of hard armoring, diving will likely be required to facilitate probing and sampling.
1.8 (west)	Northland South Pier (Terminal 115)	Two timber finger piers (30 ft wide each).	No Phase I sampling	Structure is smaller than minimum target width for Phase I sampling. The need for sampling will be re-evaluated during Phase II. PDI samples that are located near the structure will be collected during Phase I.
1.9 (west)	Seafreeze Pier (Terminal 115)	<20-ft-wide concrete pile-supported pier.	No Phase I sampling	Structure is smaller than minimum target width for Phase I sampling. The need for sampling will be re-evaluated during Phase II. PDI samples that are located near the structure will be collected during Phase I.

Table 4-4
Identified Over-water Structures in the Middle Reach and Targeted Phase I Sampling

Approximate RM (side)	Overwater Structure Name	Description[1]	Targeted Phase I Sampling[2]	Notes
1.8–1.9 (east)	Samson Tug	The facility is composed of three waterfront structures: one 75-ft wide T-head pier (on the mouth of Slip 2) and two single-span piers (25 ft wide each).	1 intertidal location at main pier (0–10-cm and 0–45-cm samples if possible); smaller piers are below size threshold	Several surface samples predating 2011 have been collected around the structure. Based on current understanding of conditions that indicate the presence of soft sediment, no sediment probing on armoring or diver inspection is anticipated.
1.9–2.0 (east)	Duwamish Marine Center	The central structure is a floating dock with several integrated boat houses.	Sampling will occur as part of the primary grid plan described in Section 4.1.3	Structures are floating and can be accessed via boat like other main areas of the waterway.
2.05 (east)	Muckleshoot Tribe Marina	230-ft-long wharf and floating structures	1 intertidal location (0–10-cm and 0–45-cm samples, if possible)	Based on preliminary reconnaissance, only a short distance along the wharf is not armored; therefore, only one sample will be collected. Sampling may occur by foot at low tide.
2.1 (west)	Alaska Marine Lines Yard No. 2	95-ft-wide concrete wharf.	1 subtidal location (0–10-cm and 0–60-cm samples if possible)	Conduct sediment probing on armoring to identify location for sediment sampling. Diving may be required to facilitate probing and sampling.
2.1–2.2 (east)	SeaTac Marine	On Slip 3, a configuration of concrete wharfs, aprons, and a long finger pier (600 ft long and 40 ft wide) make up a vessel slip. On the main waterway, a 400-ft-long wharf exists.	3 locations under main waterway wharf; targeting intertidal, but may be subtidal; collect 0–10-cm and subsurface (0–45- or 0–60-cm) samples if possible	At concrete wharf, conduct sediment probing on armoring to identify locations for sediment sampling. Diving may be required to facilitate probing and sampling. The finger pier is narrow and adjacent samples collected as part of the primary sampling grid will be representative of conditions under this structure.

Table 4-4
Identified Over-water Structures in the Middle Reach and Targeted Phase I Sampling

Approximate RM (side)	Overwater Structure Name	Description[1]	Targeted Phase I Sampling[2]	Notes
2.35 (west)	Boyer Alaska Barge Line North Lay Berth	Plastic float system (less than 10 feet wide) with steel raised decking and timber guide piles.	No Phase I sampling	Structure is smaller than minimum target width for Phase I sampling. The need for sampling will be re-evaluated during Phase II. PDI samples that are located near the structure will be collected during Phase I.
2.45 (west)	Boyer Alaska Barge Line Seattle Main Wharf	Timber pile-supported wharf structure (125 ft wide) with concrete cap and deck.	1 subtidal location (0–10-cm and 0–60-cm samples if possible)	Several surface and composite samples predating 2011 have been collected around and beneath the structure. Based on current understanding of conditions that indicate the presence of soft sediment, no sediment probing on armoring or diver inspection is anticipated.
2.4–2.55 (east)	Seattle Iron & Metals Wharves	Two timber wharves are present at the facility (one 135 ft long and one 315 ft long). The south structure is not in use and unsafe to conduct investigations below.	2 locations under the north wharf; targeting intertidal, but may be subtidal; collect 0–10-cm and subsurface (0–45- or 0–60-cm) samples if possible	Conduct sediment probing on armoring to identify locations for sediment sampling. Target water depth is within the intertidal; however, water is likely deeper. Due to the presence of hard armoring, diving is likely to be required to facilitate probing and sampling.
2.6 (west)	Pacific Pile and Marine Mooring	One 25-ft-wide timber pier.	No Phase I sampling	Structure is smaller than minimum target width for Phase I sampling. The need for sampling will be re-evaluated during Phase II. PDI samples that are located near the structure will be collected during Phase I.
2.75 (west)	Pacific Pile and Marine Wharf	Triangular timber pile wharf (265 ft long and <10 ft deep along waterway and 125 ft wide and >10 ft deep towards shore).	1 subtidal location; collect 0–10-cm and 0–60-cm samples	Based on preliminary reconnaissance, only a short distance along the wharf is not armored; therefore, only one sample will be collected. Conduct sediment probing on armoring to identify final location for sediment sampling. Diving may be required to facilitate probing and sampling.

Table 4-4
Identified Over-water Structures in the Middle Reach and Targeted Phase I Sampling

Approximate RM (side)	Overwater Structure Name	Description[1]	Targeted Phase I Sampling[2]	Notes
2.8 (east)	8th Avenue Terminal Wharf	Segmented concrete pile-supported wharf (600 ft long in total).	4 subtidal locations; collect 0–10-cm and 0–60-cm samples if possible	Conduct sediment probing on armoring to identify locations for sediment sampling. Diving may be required to facilitate probing and sampling.
2.9 (west)	Silver Bay Logging Wharf	Pier (115 ft wide) and apron with steel pile and steel superstructure.	1 location targeting intertidal; collect 0–10-cm and 0–45-cm samples if possible	Conduct sediment probing on armoring to identify location for sediment sampling. Diving may be required to facilitate probing and sampling.

Notes:

1. Description modified from the *Waterway User Survey and Assessment of In-Water Structures – Data Report* (Integral et al. 2018). Only structures with notable overwater coverage are included in this table. Other structures (e.g., bridge abutments, mooring dolphins, private docks and floats) were omitted since sampling would occur adjacent to those structure types (i.e., no proposed under-structure sampling). General dimensions of structures are approximate.
2. Details regarding these samples are presented in Appendix D (Table D-5).

MLLW: mean lower low water
RM: river mile

4.1.5 Phase II Sediment Sampling to Refine RAL exceedance area delineation

Following Phase I PDI sampling, a PDI QAPP Addendum for Phase II will be prepared to address Phase II DQOs (Table 2-1) and any other identified data gaps based on the interpretation of the results in the Phase I DER.

Phase II surface and subsurface sediment samples will be collected[22] to further refine the interpolated boundaries of RAL exceedance areas (DQOs 10 and 11). Sampling will target locations near RAL exceedance areas and address areas with greater data interpolation uncertainty to further refine RAL exceedance areas. For DQO 11, sediment samples will be collected where needed to refine the horizontal extent of potential contamination in bank areas[23] up to the MHHW that are within and adjacent to Phase I RAL exceedance areas. All Phase II sediment sampling locations, intervals, and analytes will be described in detail in a PDI QAPP Addendum. Topographical surveys and other characterization will also be conducted in these bank areas as needed and will be described in the Survey QAPP Addendum.

4.1.6 Phase II Vertical Extent Delineation

Sediment cores deeper than 60 cm (referred to herein as vertical extent cores) will be collected to determine the depth of contamination in dredging or partial dredging and capping remediation areas (DQO 12). Details of sampling to determine vertical extent of contamination in different types of areas are described below.

4.1.6.1 Vertical Extent Delineation within the FNC

For vertical extent delineation within the FNC, the target elevation for the vertical extent of the cores is tied to the elevation of the top of an engineered cap. The ROD (Section 13.2.1.1) states: *All post-remedy surfaces within the FNC will be maintained at or below their current authorized depths. In order to avoid damage to a cap or ENR layer during federal maintenance dredging, the top of any ENR layer will be at least 2 ft and the top of any cap will be at least 4 ft below the authorized federal navigation channel depth* (EPA 2014b). The ROD assumed a cap thickness of 3 ft in subtidal areas, a reasonable average thickness for an engineered cap. However, because a typical cap may be designed to be 2 to 3.5 ft thick, the final constructed cap thickness can vary from an anticipated minimum thickness of 2 ft to an anticipated maximum thickness of less than 5 ft (accounting for construction tolerances). In addition, because the top of the cap elevation must be 4 ft below the authorized depth within the FNC, the bottom elevation of an engineered cap, if constructed, may vary depending on authorized depth, with an assumed maximum thickness of 5 ft (Figure 4-3).

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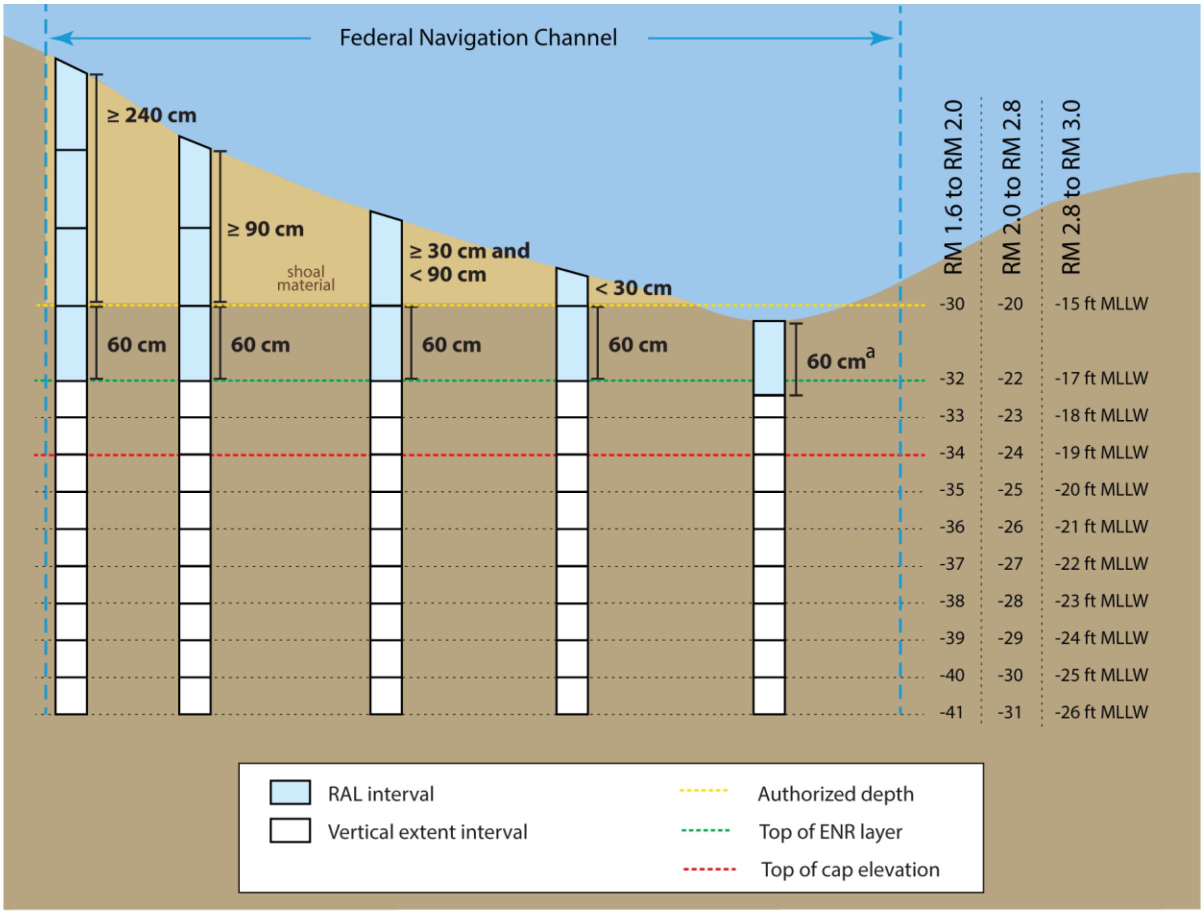
22 If some Phase I data gaps can be satisfied through the analysis of archived Phase I locations (or intervals) that were not analyzed as part of Tier 2 in Phase I, these samples could be analyzed in Phase II.
23 See Map 9 in the PDIWP for the locations of bank area data collected to date.

Figure 4-3
FNC Design Sampling for Vertical Extent



[a] The 0 - 60 cm RAL interval applies in recovery category 1 or potential vessel scour areas (RM 2.8 to RM 3.0)

Therefore, within the FNC, the vertical extent cores will be collected to target elevations of -26 ft MLLW (between RM 2.8 and RM 3.0), -31 ft MLLW (between RM 2.0 and RM 2.8), and -41 ft MLLW (between RM 1.6 and RM 2.0), allowing for characterization of at least 2 ft of sediment below the anticipated maximum cap thickness. In addition, any sediment collected below the target elevation (or depth) will be archived in 30-cm (approximately 1-ft) intervals, as described in Appendix E. The target elevations will apply to cores collected within the FNC and within a 10-ft buffer on either side of the channel boundary.

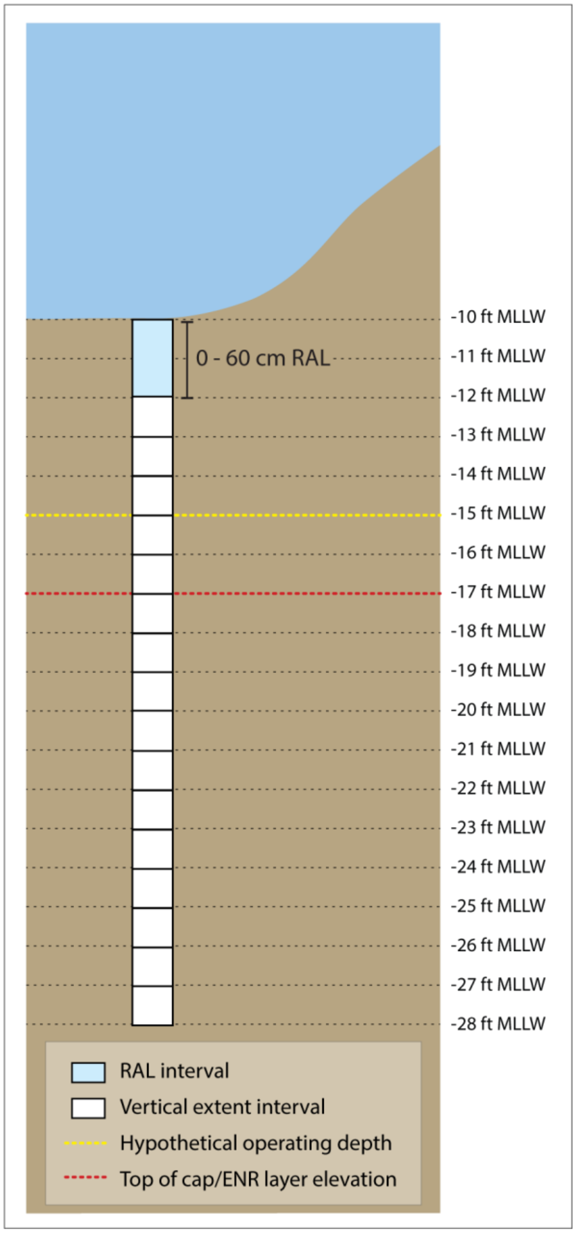
Section 2.5 of the LDW RI (Windward 2010) summarizes the geologic conditions below the LDW. In general, recently deposited sediments are underlain by alluvium consisting of silts and sands with silt interbeds of varied thicknesses. These native layers are encountered between elevations -20 ft MLLW and -25 ft MLLW, depending on the location within the middle reach. Therefore, the minimum target depths for vertical cores will be sufficient to characterize potential contamination within the FNC. If contamination does extend to the target depths, dredging more than 7 ft below the maximum top of cap elevation will need to be carefully considered, due to potential impacts on side slope stability in areas outside of the FNC, including habitat areas.

4.1.6.2 Vertical Extent Delineation in Berthing Areas

Outside of the FNC, the ROD (Section 13.2.1.1) states: *For areas outside the FNC where depths are maintained by private or public entities (called berthing areas in this ROD, but could include slips, entrance channels, or restorations areas) the top of any cap or ENR layer will be a minimum of 2 ft below the operating depth* (EPA 2014b). Thus, where vertical extent delineation is required within a berthing area outside of the FNC, vertical extent cores are targeted to extend at least 9 ft below the operating depth (i.e., obtaining 7 ft of vertical extent below the 2-ft overdredge buffer below the operating depth) in order to accommodate an anticipated maximum cap thickness of 5 ft (Figure 4-4). Berthing depths will be presented in the PDI QAPP Addendum once it has been determined where vertical extent cores will be collected based on Phase I RAL exceedance areas.

Figure 4-4
Berthing Area Outside the FNC Design Sampling

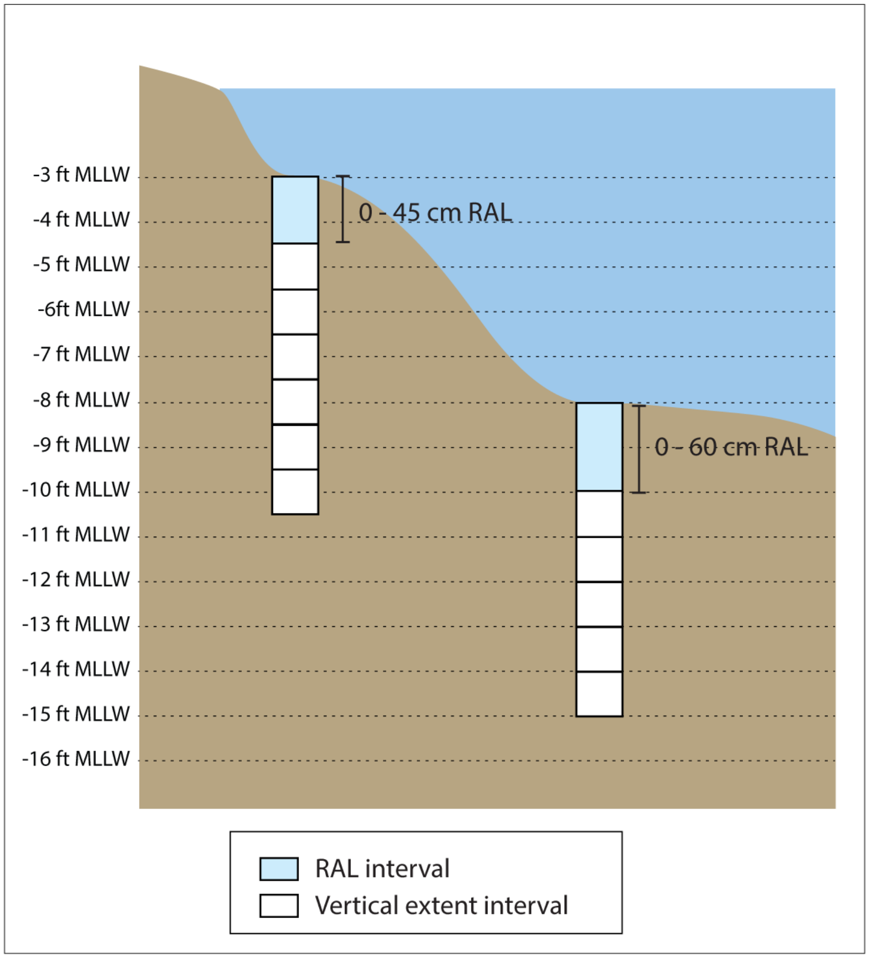
Example Berthing Area



4.1.6.3 Vertical Extent Delineation in Habitat Areas and Areas Outside of the FNC or Berthing Areas

Within habitat areas (defined as areas above -10 ft MLLW in the ROD), the ROD states: *Post-remedy surfaces will be maintained at their current depth and backfilled or capped with suitable habitat materials* (EPA 2014b). Thus, vertical extent cores in these areas will not include any buffer depth below the existing grade, and a targeted 7-ft core will provide sufficient vertical extent delineation to design a cap with habitat substrate on top (Figure 4-5). The ROD does not require any specific elevation limits when placing enhanced natural recovery or caps in areas that are not within the FNC, berthing areas, or habitat areas (EPA 2014b). Backfilling to grade is not required for non-habitat areas. However, some backfilling of a dredge area may be needed for slope stability, to avoid morphological changes, or for other reasons.

Figure 4-5
Sampling Design for Habitat Areas and Areas Outside of the FNC or Berthing Areas



4.1.7 Phases II and III Toxicity Testing Design

Toxicity testing can be used to help delineate remedial action area boundaries (DQOs 1 and 2). If sediment is not toxic at a location based on benthic toxicity tests, then the toxicity result will override the benthic RAL chemistry result[24] in areas without human health RAL exceedances.

In Phase II or III, toxicity testing may be conducted at locations with only benthic RAL exceedances and at locations where the results would affect remedial action area boundaries if they were to pass the benthic toxicity tests. Toxicity testing will not be done at locations with human health COC RAL exceedances. The specific locations to be tested, sample collection protocols, and timing considerations will be identified in QAPP addenda.

It is anticipated that most of the locations for toxicity testing will be identified in the Phase I DER. These locations will be re-occupied in Tier 1 of Phase II, and toxicity testing will be conducted. The results of the Phase II toxicity testing will be included in the Phase II DER, wherein Phase I RAL exceedance area boundaries and technologies will be refined, and remaining data gaps based on Phase II data will be identified. If the need for additional toxicity testing is identified as a data gap in the Phase II DER, the locations and timing for additional toxicity testing in Phase III will be considered. Options to expedite the testing will be investigated. Testing results may refine the 30% RD areas defined based on Phase I and II results. If significant changes to these areas are possible, LDWG will work with EPA to update stakeholders in a timely manner.

4.2 Sediment Sampling Methods

This section provides methods to locate and collect surface and subsurface sediment samples as part of PDI sampling efforts. Detailed sediment sampling methods are included as SOPs in Appendix E.

Sampling activities will be coordinated with other activities occurring within the middle reach. These activities include tribal fishing, waterfront operations at active facilities, and potential construction activities.

4.2.1 Sediment Sampling Sequencing and Logistics

Phase I sediment sampling is anticipated to begin in November 2022. For sampling locations where both a surface (i.e., 0- to 10-cm) and subsurface sediment (i.e., 0- to 45-cm, 0- to 60-cm, or deeper shoaling area cores) sample will be collected, the subsurface sediment sample will be collected first when possible to ensure that an acceptable core can be collected at a given

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24 Per the note to ROD Table 20.

location.[25] The coordinates from the actual core location (or surface location if the surface sample is collected first) will be used as the target sample coordinates, unless the location is a re-occupation, in which case the sample will be collected at the original target coordinates.

LDWG notified property owners in February 2022 regarding upcoming sampling, including the need for coordination of access to locations that will be accessed via adjacent uplands or samples that will be collected from privately owned aquatic lands. LDWG will obtain access agreements where needed (see RDWP Map 4-1) (Anchor QEA and Windward 2022b). LDWG will notify property owners well in advance of sampling to coordinate access; property owners will notify their tenants as necessary. In the event that LDWG or EPA cannot obtain timely access, alternative locations, a later phase of sampling, or a reasonable assumption regarding potential RAL exceedances will be considered in consultation with EPA.

4.2.2 Target Sampling Locations

Target sampling locations are presented in Maps 4a, 4b, and 4c and listed in Appendix D. For all sampling locations, the field crew will confirm the sampling area type (i.e., within or outside of the FNC and subtidal vs. intertidal) in real-time during sample collection. This confirmation will be particularly important for locations without existing bathymetry information at the time of sampling (i.e., in bathymetry data gap locations).

For samples intended to re-occupy previous sampling locations, sample collection will be attempted as close as possible to and no further than 3 m (10 ft) from the target coordinates. The field crew will have field sheets (based on information in Appendix D) that will provide all relevant information for each location, including which locations are re-occupations.

For samples not intended to re-occupy a previous sampling location, more flexibility is permitted. First, sample collection will be attempted within 3 m (10 ft) of the target coordinates. If this is not possible (e.g., due to an obstruction or because the location is too shallow to sample from a boat), the field crew will either move the sampling location (within a maximum distance of 10 m [32 ft]) or, in the case of shallow water, attempt to manually collect the sample on foot during a low tide. To minimize the need to move the sampling location, property owners with barges will be notified prior to the sampling event, and samples will be collected from shallow areas during higher tide levels.

If the sample cannot be collected due to difficult substrate (e.g., presence of riprap or other obstruction) or after up to three subsequent attempts within 10 m (32 ft), the closest sampleable

[25] Surface sediment samples cannot be collected from the cores because insufficient volume for analysis would be available in the 0- to 10-cm section of the core.

location meeting the needs of the location will be sampled. If no sample can be collected meeting the location needs, EPA and LDWG will be consulted.

When the sample is moved, the sample ID will be assigned the coordinates of the revised location. Sampling locations positioned under known structures will remain under structures if it is safe to sample in these locations. Safety concerns will be documented in field forms, and EPA and LDWG will be notified to discuss options for these locations.

4.2.3 Surface Sediment Collection

Surface sediment samples (0- to 10-cm) will be collected from a boat, or from land by manually collecting the sample on foot during a low tide. Based on the Phase I bank visual inspection, any locations that are determined to be inaccessible by boat or land may be deferred for collection by a diver if it is safe to do so (Section 4.3). Under-structure surface sediment sampling may be conducted from a boat, from land, or by diver, depending upon site access considerations. Surface sediment grab sample collection and processing will follow standardized procedures described in Ecology's Sediment Cleanup User's Manual (SCUM) (Ecology 2021). SOPs for the collection of surface sediment by boat and from land are presented in Appendix E. Sediment volumes are discussed in Section 4.10.

4.2.4 Subsurface Sediment Collection

Subsurface sediment core samples will be collected primarily using a vibracorer deployed from a sampling vessel. However, conditions may arise in the intertidal area where sampling from a vessel is not possible; in these cases, the core must be manually collected from shore during low tide. The SOPs for collecting and processing intertidal (0- to 45-cm), subtidal (0- to 60-cm), and shoaling location sediment cores are presented in Appendix E. Sediment volumes are discussed in Section 4.9. Based on the Phase I visual bank characterization, any intertidal locations determined to be inaccessible from a boat or from land may be deferred for collection by a diver if the sample can be safely collected (Section 4.3). Under-structure subsurface sediment sampling may be conducted from a boat, from land, or by diver, depending upon site access considerations.

4.2.5 Processing Vertical Extent Cores

The procedures for processing sample intervals in vertical extent cores are provided in detail in the subsurface sample collection SOP included in Appendix E. All intervals will be recovery corrected following the procedures in the subsurface sample collection SOP (Appendix E). The RAL intervals in the vertical extent cores will be processed following the same methods used for subsurface sediment (Section 4.2.4). The deeper sample intervals will be processed as separate 30-cm (approximately 1-ft) intervals for archival or analysis. If any of the sediment cores contain at least 15 cm of sediment below the targeted depth, that sediment will also be archived. If more than 30 cm of sediment is collected in a core below the targeted depth, the sediment will be archived in 30-cm intervals (Appendix E).

In general, first two 30-cm sample intervals below the depth interval where RALs apply will be analyzed; then, each subsequent alternating interval will be archived or analyzed, until reaching the end of the core, native sediment,[26] or the target depth. Any native sediment identified will not be composited with non-native sediment. If the boundary with native sediment falls on an even 30-cm increment, starting at the top of the native sediment boundary, 30-cm interval archive samples will be collected. If the boundary does not fall at an even 30-cm increment, the 15-cm rule for material at the end of a core (described above) will be used to determine intervals. For example, if native material is encountered at 265 cm (8.7 ft) in a 366-cm (12-ft) subtidal core, the intervals would be as follows: Interval A would represent the 0- to 60-cm interval, intervals B through G would represent 30-cm intervals of non-native material, interval H would represent material 240 to 265 cm (i.e., the bottom of the non-native material), and intervals I through K would represent native material (intervals I and J would each be 30 cm, and interval K would be 41 cm because less than 15 cm would remain if a 30-cm interval was used). The proposed analysis and archive intervals for each vertical core will be provided in the PDI QAPP Addendum for Phase II with the vertical core locations.

Core interval delineation and Tier 2 assignments may be affected by stratigraphy. If a sample interval is changed to reflect a change in geologic unit, the decision will be made in the field during core processing and documented on the Sediment Core Processing Log (Appendix C). An experienced[27] field geologist or geotechnical engineer will either directly oversee or coordinate with the field geologist or geotechnical engineer during the sediment core logging process in order to identify major stratigraphic boundaries in vertical extent cores, and to determine if native material is present in the core. Any changes to Tier 2 analysis assignments will require EPA approval.

Grain size analyses will be performed on approximately 10% to 25% of the cores to help the project engineer understand the dredgeability of the sediment. One or more composite samples representing the full length of the core above any native material layer encountered will be selected for analysis. Grain size data will also be collected for native materials. The compositing interval(s) will be determined when the core is examined during sediment core logging. The field geologist or geotechnical engineer will identify spatially representative cores from which to obtain the grain size composite(s).

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[26] The LDW Upper Reach Phase II DER (Anchor QEA and Windward 2022a) defines native as an alluvial unit that is composed primarily of sand with varying amounts of silt, as well as interbedded lenses of silt, clay, and poorly graded sand throughout. The upper 2 to 17 ft may contain significant wood and sometimes anthropogenic debris, as well as laminations of shell hash.

[27] An "experienced" geologist or engineer has at least five years of field experience that includes geologic interpretation of sediment or soil cores.

4.2.6 Special Considerations for Sampling Sediment on Banks

Banks, which are defined as the transition areas from the LDW subtidal or intertidal bed to MHHW (Anchor QEA and Windward 2019), can be more challenging to sample than the other waterway sediments. Banks can be steeply sloped, covered by hard materials, or difficult to access due to limited water depth. Before the sampling program begins, the field crew will inspect the banks to determine how areas could be accessed. If a target location listed in Appendix D is not accessible, the field crew will move the sampling location to a nearby area within the same bank, as described in the SOP (Appendix E). In addition to the proposed samples, additional samples will be collected at any location within an interpolated RAL exceedance area that appears to be a unique potential source (i.e., area with discoloration or visible seepage of material).

If the global positioning system (GPS) does not work in a bank area (e.g., due to poor reception caused by structures obstructing satellite signals), sediment samples will be collected as close to the target location as possible, using zoomed-in aerial photo maps as guidance. Sampling locations will be recorded using distances measured from landmarks (e.g., pier structures and pilings). Additional photographs will be taken as needed in order to record the sampling location.

Vertical extent cores on the banks will be collected by boat wherever possible, following protocols in the SOP (Appendix E). However, water depths may limit the ability of the sampling boat to get close enough to a bank to collect samples on the bank below MHHW, and bank physical conditions (e.g., debris, riprap) may limit the effectiveness of vibracoring or drill rig equipment. Drilling methods for vertical extent delineation sampling will be the same as those described in Section 5.3.2 for barge-based geotechnical drilling. The drill rig may be deployed from a barge, or from the top of the bank, set back to provide a flat surface. The approach to be used will be determined prior to the field effort in consultation with EPA and the drilling company, based on site access and safety considerations. Where necessary, a probe rig may be deployed to collect vertical extent cores on the bank. Sample collection using a probe rig is described in Appendix E.

If neither vibracoring nor collection using a drill rig or probe rig is feasible, it may be necessary to use hand auger sampling methods for vertical extent cores. The practical depth of hand augering is typically 2 to 3 ft. The use of hand augers, if needed, will be discussed with EPA during the field effort.

4.2.7 Sediment Collection for Toxicity Testing

4.2.7.1 LDW Sediment

For locations identified for toxicity testing, additional sediment will be collected during the collection of surface sediment grabs (Section 4.2.3). A total of 200 oz (6 L) of sediment will be collected at these locations. Thus, multiple grabs will be collected from the same location until sufficient volume has been obtained. Sediment from all grabs will be thoroughly homogenized prior to distribution into the appropriate sample containers for both conventionals analysis and toxicity testing. The sediment from locations identified for toxicity testing will be submitted for expedited analysis of grain size and TOC to identify appropriate reference sediments. The expedited data will be available within 2 weeks of sample collection in order to initiate the bioassays within the holding time (56 days). In addition, ammonia and sulfide will be analyzed due to the short holding time (seven days) for those parameters.

4.2.7.2 Reference Area Sediment

Reference area sediment will be collected by EcoAnalysts from locations in Carr Inlet such that the grain size and TOC are similar to those of the LDW samples being tested. In order to obtain a suitable reference sample and to best match the LDW samples, five locations will be sampled from the reference area following the reference area sediment sampling protocols in SCUM (Ecology 2021) and the Dredged Material Management Program (DMMP) User Manual (DMMP 2021). Field measurements of grain size will be used to inform the selection of the five sampling locations.

At each reference area location, multiple grab samples will be combined and homogenized thoroughly to create a composite sample with sufficient volume for toxicity testing and analysis of TOC, grain size, ammonia, and total sulfides. Additional sediment from the reference sites will be archived in case chemical analyses are needed at a later date.

In order to review reference area grain size and TOC data prior to initiating the bioassay testing, these analyses will be expedited. The grain size and TOC data for the five composite reference samples will be reviewed, and the toxicity test reference will be selected. The reference sediment percent fines should be within 20% of the test sediment percent fines and the TOC should be similar. If there is no single sample with TOC and grain size comparable to those of the LDW samples, then combining reference area samples to create a composite reference sample will be considered.

4.3 Diver-related Activities

Based on the field conditions, any sediment sampling locations that are determined to be inaccessible by boat or from land may be accessed by a diver. A dive plan (including health and safety requirements) is included in Appendix F.

4.4 Sample Identification

Unique alphanumeric IDs will be assigned to each sample and recorded on the collection and processing forms (Appendix C).

The sample IDs for individual sediment samples will include the following:

- Project area ID (i.e., LDW) and two-digit year (i.e., 22 will be used for all Phase I samples to indicate that sample collection for this phase began in 2022[28])
- Sample type:
  - SS – surface sediment (0 to 10 cm)
  - IT – intertidal sediment (0 to 45 cm)
  - SC – subsurface core (depths variable)
  - GT – geotechnical sample
- Location number (which will begin with 1,000 outside structures and 1,800 under structures)
- For all subsurface cores (SC), a sequential letter (e.g., A, B, etc.) will be used to identify the interval. The letter A will be used to indicate the targeted surface interval, with B, C, etc. used to indicate each subsequent interval.

For example, a surface sediment sample from location 1027 would be labeled LDW22-SS1027. The subtidal sediment core samples from that location would be labeled LDW22-SC1027A for the first core interval (e.g., the 0- to 60-cm sample) and LDW22-SC1027B for the next core interval sample (if applicable), and so forth.

The number of RAL intervals at shoaling locations is dependent on the depth of the shoal material (Figure 4-1). In a shoaling core with more than 90 cm of shoal material, the surface-most three intervals are all RAL intervals, and these intervals would be labelled A, B, and C. In a shoaling core with less than 30 cm of shoal material, the surface-most interval is the only RAL interval; it would be labelled as the A interval. Z-samples would also be labelled using this approach. For example, for a shoaling core with more than 30 cm and less than 60 cm of shoal material, the shoal material would be the A interval, the overdredge interval would be the B interval, and the Z-sample would be the C interval.

Any field duplicate sample collected will have the same sample ID as its parent sample but will be appended with "-FD" to identify it as a field duplicate.

4.5 Sample Custody and Shipping Requirements

Sample custody is a critical aspect of environmental investigations. Sample possession and handling must be traceable from the time of sample collection, through laboratory and data analyses, to delivery of the sample results to the recipient. Procedures to be followed for sample custody and shipping are detailed in this section.

[28] The sample IDs for all Phase I samples (even if some are collected in 2023) will begin with LDW22 to indicate the initiation of the Phase I sampling effort.

4.5.1 Sample Custody Procedures

Samples are considered to be in custody if they are: 1) in the custodian's possession or view; 2) in a secured place (under lock) with restricted access; or 3) in a container and secured with an official seal(s) such that the sample cannot be reached without breaking the seal(s). Custody procedures, described below, will be used for all samples throughout the collection, transportation, and analytical processes, and for all data and data documentation, whether in hard copy or electronic format. Custody procedures will be initiated during sample collection.

A chain of custody form will accompany all samples to the analytical laboratory. Each person who has custody of the samples will sign the chain of custody form and ensure that the samples are not left unattended unless properly secured. Minimum documentation of sample handling and custody will include:

- Sampling location, project name, and unique sample ID
- Sample collection date and time
- Any special notations on sample characteristics or problems
- Name of the person who initially collected the sample
- Date sample was sent to the laboratory
- Shipping company name and waybill number (if applicable)

In the field, the FC or a designee will be responsible for all sample tracking and custody procedures. The FC will also be responsible for final sample inventory and will maintain sample custody documentation. The FC or a designee will complete chain of custody forms prior to transporting samples. At the end of each day, and prior to sample transfer, chain of custody entries will be made for all samples. Information on the sample labels will be checked against sample log entries, and sample tracking forms and samples will be recounted. Chain of custody forms, which will accompany all samples, will be signed at each point of transfer. Copies of all chain of custody forms will be retained and included as appendices to the data reports. Samples will be shipped in sealed coolers.

The analytical laboratories will ensure that chain of custody forms are properly signed upon receipt of the samples and will note any questions or observations concerning sample integrity on the chain of custody forms. The analytical laboratories will contact the FC and project QA/QC coordinator immediately if discrepancies are discovered between the chain of custody forms and the sample shipment upon receipt.

4.5.2 Shipping Requirements

Sediment chemistry samples will be transported directly to ARI (i.e., by lab courier or field staff) and will be shipped or transported via courier to EcoAnalysts. Geotechnical samples will be transported via courier or shipped to MTC. Prior to shipping, containers with sediment samples will be wrapped in bubble wrap and securely packed inside a cooler with ice packs. The original signed chain of custody forms will be placed in a sealed plastic bag and taped to the inside lid of the cooler. Fiber tape will be wrapped completely around the cooler. On each side of the cooler, a *This Side Up* arrow label will be attached; a *Handle with Care* label will be attached to the top of the cooler, and the cooler will be sealed with a custody seal in two locations.

The temperature inside the cooler(s) containing the sediment samples will be checked by the laboratory upon receipt of the samples. The laboratory will specifically note any coolers that do not contain ice packs or that are not sufficiently cold[29] upon receipt. All samples will be handled in a manner to prevent contamination or sample loss. Any remaining sediment samples will be disposed of upon receipt of written notification by the Windward PM. Holding times will vary by analysis and are summarized in Section 4.8.2.

4.6 Decontamination Procedures

Sampling requires strict measures to prevent contamination. Sources of extraneous contamination can include sampling gear, grease from ship winches or cables, spilled engine fuel (gasoline or diesel), engine exhaust, dust, ice chests, and ice used for cooling. All potential sources of contamination in the field will be identified by the FC, and appropriate steps will be taken to minimize or eliminate contamination. For example, during retrieval of sampling gear, the boat will be positioned, when feasible, so that engine exhaust does not fall on the deck. Ice chests will be scrubbed clean with Alconox® detergent and rinsed with distilled water after use to prevent potential cross contamination. To avoid contamination from melting ice, the wet ice will be placed in separate plastic bags.

All sediment sampling and homogenizing equipment, including the mixing bowl and stainless steel implements, will be decontaminated between sampling locations per Ecology guidelines (2021) and the following procedures:

1. Rinse with site water and wash with a scrub brush until free of sediment.
2. Wash with phosphate-free detergent.
3. Rinse with site water.
4. Rinse with distilled water.

Acid or solvent washes will not be used in the field because of safety considerations and problems associated with rinsate disposal and sample integrity, specifically:

- Use of acids or organic solvents may pose a safety hazard to the field crew.
- Disposal and spillage of acids and solvents during field activities pose an environmental concern.

[29] As stated in validation guidance documents, sample shipping coolers should arrive at the laboratory with an internal temperature of ≤ 6ºC; however, due to the short transit distance and time from the site to ARL, not all samples may have reached this temperature by the time they arrive at the laboratory.

- Residues of solvents and acids on sampling equipment may affect sample integrity for chemical testing.

Any sampling equipment that cannot be cleaned to the satisfaction of the FC will not be used for further sampling activities.

4.7 Field-generated Waste Disposal

Excess surface sediment will be returned to each sampling location after sampling has been completed for that location. Excess subsurface sediment will be containerized (e.g., in steel drums) as non-hazardous waste, labelled, and secured for off-site disposal via a licensed waste disposal company. Decontamination water will not be contained.[30] All disposable sampling materials and personal protective equipment used in sample processing, such as disposable coveralls, gloves, and paper towels, will be placed in heavyweight garbage bags or other appropriate containers. Disposable supplies will be removed from the site by sampling personnel and placed in a normal refuse container for disposal as solid waste.

4.8 Laboratory Methods for Sediment Samples

At each laboratory, a unique sample identifier (termed either project ID or laboratory ID) will be assigned to each sample. The laboratory will ensure that a sample tracking record follows each sample through all stages of laboratory processing. The sample tracking record must contain, at a minimum, the name/initials of individuals responsible for performing the analyses, dates of sample extraction/preparation and analysis, and types of analyses being performed.

The analytical laboratories will meet the sample handling requirements and follow the procedures described in this section. In addition, analytical methods and data quality indicator (DQI) criteria are provided herein. Laboratory methods for geotechnical testing are discussed in Section 5.3.3.

4.8.1 Laboratory Sample Handling

Samples will be stored initially at ARL in accordance with the conditions specified in the methods. Samples for the other laboratories will be packed in coolers on ice and delivered via courier service or shipped in coolers on ice. Bioassay sediments will be stored, refrigerated, after nitrogen purging of the headspaces in the jars at ARL. Archive samples will be stored, frozen, at ARL. The analytical laboratories will preserve and store samples as described in Section 4.8.2. Samples will be disposed of after hold times expire, following written authorization from the Windward PM.

[30] Because decontamination water is an Alconox®/water solution (i.e., phosphate-free), it does not require containment.

4.8.2 Analytical Methods

The analyte list for each Phase I sediment sample is summarized in Appendix D by sample type. Chemical analysis of the sediment samples will be conducted by ARL, grain size analyses will be conducted by MTC, and toxicity testing will be conducted by EcoAnalysts (Table 4-5). Analytical methods, toxicity test methods, and laboratory sample handling requirements for all measurement parameters are presented in Table 4-6. Geotechnical testing methods are presented in Section 5.3.3.

Table 4-5
Sediment Analyses to be Conducted at each Analytical Laboratory

Laboratory	Analyte Group	Individual Analytes
ARL	conventionals	TOC, percent solids, ammonia, and sulfides
	metals	arsenic, cadmium, chromium, copper, lead, silver, zinc, mercury
	PAHs	acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(j)fluoranthene, benzo(k)fluoranthene, benzo(g,h,i)perylene, chrysene, dibenzo(a,h)anthracene, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, 2-methylnaphthalene, naphthalene, phenanthrene, and pyrene
	PCB Aroclors	Aroclor 1016, Aroclor 1221, Aroclor 1232, Aroclor 1242, Aroclor 1248, Aroclor 1254, Aroclor 1260
	SVOCs	1,2-dichlorobenzene, 1,2,4-trichlorobenzene, 1,4-dichlorobenzene, 2,4-dimethylphenol, 4-methylphenol, benzoic acid, benzyl alcohol,[1] bis(2-ethylhexyl)phthalate, butyl benzyl phthalate, dibenzofuran, dimethyl phthalate, hexachlorobenzene, n-nitrosodiphenylamine, pentachlorophenol, and phenol
	dioxin/furan congeners	2,3,7,8-TCDD, 1,2,3,7,8-PeCDD, 1,2,3,4,7,8-HxCDD, 1,2,3,6,7,8-HxCDD, 1,2,3,7,8,9-HxCDD, 1,2,3,4,6,7,8-HpCDD, OCDD, 2,3,7,8-TCDF, 1,2,3,7,8-PeCDF, 2,3,4,7,8-PeCDF, 1,2,3,4,7,8-HxCDF, 1,2,3,6,7,8-HxCDF, 1,2,3,7,8,9-HxCDF, 2,3,4,6,7,8-HxCDF, 1,2,3,4,6,7,8-HpCDF, 1,2,3,4,7,8,9-HpCDF, and OCDF
MTC	conventionals	grain size[2]
EcoAnalysts	toxicity testing	acute amphipod 10-day mortality test, acute 48-hr bivalve larvae combined mortality and abnormality test, and chronic 20-day juvenile polychaete survival and growth test

Notes:

1. Because benzyl alcohol is not a CERCLA hazardous substance, benzyl alcohol data will not be included in the DERs. Benzyl alcohol data obtained through routine SVOC analysis of the PDI sediment samples will be provided to EPA.
2. For engineering-related tests, ASTM methods D6913 and D7928 will be used. For toxicity-related tests, the PSEP method will be used.

ARL: Analytical Resources LLC

ASTM: American Society for Testing and Materials
CERCLA: Comprehensive Environmental Response, Compensation, and Liability Act
DER: data evaluation report
EcoAnalysts: EcoAnalysts, Inc.
EPA: US Environmental Protection Agency
HpCDD: heptachlorodibenzo-*p*-dioxin
HpCDF: heptachlorodibenzofuran
HxCDD: hexachlorodibenzo-*p*-dioxin
HxCDF: hexachlorodibenzofuran
MTC: Materials & Testing Consulting, Inc.
OCDD: octachlorodibenzo-*p*-dioxin
OCDF: octachlorodibenzofuran
PAH: polycyclic aromatic hydrocarbon
PCB: polychlorinated biphenyl
PDI: Pre-Design Investigation
PeCDD: pentachlorodibenzo-*p*-dioxin
PeCDF: pentachlorodibenzofuran
PSEP: Puget Sound Estuary Program
SVOC: semivolatile organic compound
TCDD: tetrachlorodibenzo-*p*-dioxin
TCDF: tetrachlorodibenzofuran
TOC: total organic carbon

Table 4-6
Analytical Methods and Sample Handling Requirements for Sediment Samples

Parameter[1]	Method	Reference[2]	Extraction Solvent	Cleanup	Laboratory	Container	Preservative	Sample Holding Time
Chemistry								
TOC	high-temperature combustion	EPA 9060A	na	na	ARL	4-oz glass jar	cool to ≤ 6°C; freeze to ≤ -18°C	28 days 6 months if frozen
Percent solids	drying oven	SM 2540G	na	na	ARL		cool to 4 ± 2°C	6 months
Metals	ICP-MS	EPA 3050B EPA 6020B UCT-KED	na	na	ARL	4-oz glass jar	cool to ≤ 6°C; freeze to ≤ -18°C	6 months 2 years if frozen
Mercury	cold vapor-atomic fluorescence spectroscopy	EPA 7471B	na	na	ARL			28 days 1 year if frozen
Grain size	sieve/hydrometer	ASTM D7913 and D7928	na	na	MTC	16-oz plastic jar	cool to 4 ± 2°C	6 months
cPAHs[3,4]	GC/MS-SIM	EPA 3546/ EPA 8270E-SIM	dichloromethane/ acetone	Silica gel	ARL	16-oz glass jar	cool to 0–6°C; freeze to ≤ -18°C	1 year to extraction if frozen; 14 days to extraction if refrigerated; when thawed, 40 days after extraction; store extracts at ≤ 6°C and in the dark

Table 4-6
Analytical Methods and Sample Handling Requirements for Sediment Samples

Parameter[1]	Method	Reference[2]	Extraction Solvent	Cleanup	Laboratory	Container	Preservative	Sample Holding Time
PAHs[4]/SVOCs[5]	GC/MS	EPA 3546/ EPA 8270E/EPA 8270E-SIM	dichloromethane/ acetone	GPC (optional)	ARL		cool to 0–6°C; freeze to ≤ -18°C	1 year to extraction if frozen; 14 days to extraction if refrigerated; when thawed, 40 days after extraction; store extracts at ≤ 6°C and in the dark
PCB Aroclors	gas chromatography/electron capture detection	EPA 3546 Mod EPA 8082A	Hexane/ acetone	Silica gel, sulfuric acid/ permanganate sulfur, or acid/ base partition (optional)	ARL		cool to 0–6°C; freeze to ≤ -18°C	1 year to extraction if frozen; 14 days to extraction if refrigerated; when thawed, 40 days after extraction; store extracts at ≤ 6°C and in the dark
Hexachloro-benzene	gas chromatography/electron capture detection	EPA 3546/EPA 8081B	Hexane/ acetone	Silica gel, sulfur removal, GPC (optional)	ARL		cool to 0–6°C; freeze to ≤ -18°C	1 year to extraction if frozen; 14 days to extraction if refrigerated; when thawed, 40 days after extraction; store extracts at ≤ 6°C and in the dark
Ammonia[6]	Flow injection	SM 4500-NH3 H-97	na	na	ARL	4-oz glass jar	cool to 4 ± 2°C	7 days
Total sulfide[6]	Colorimetric	SM 4500-S2 D-0 PSEP prep	na	na	ARL	4-oz glass jar	2 mL 2 Normal zinc acetate; cool 4 ± 2°C	7 days

Table 4-6
Analytical Methods and Sample Handling Requirements for Sediment Samples

Parameter[1]	Method	Reference[2]	Extraction Solvent	Cleanup	Laboratory	Container	Preservative	Sample Holding Time
Dioxins/furans	HRGC/HRMS	EPA 1613b	Toluene	Florisil, silica gel, sulfuric acid	ARL	8-oz amber glass jar	cool to ≤ 4°C; freeze to ≤ -18°C	1 year until extraction and 1 year after extraction if stored in the dark at ≤ -18°C
Toxicity Testing								
Amphipod and polychaete toxicity testing	na	PSEP 1995/ Ecology 2021	na	na	EcoAnalysts	32-oz HDPE wide-mouth jars	cool to 4 ± 2°C nitrogen purge of headspace	56 days until test initiation
Bivalve larvae toxicity testing								

Notes:

1. Individual analytes are listed in Table 4-5.
2. Laboratory SOPs are confidential and are available upon EPA request.
3. Per the ROD (EPA 2014a), cPAHs consist of a subset of seven PAHs that EPA has classified as probable human carcinogens: benz[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, benzo[k]fluoranthene, chrysene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene.
4. cPAHs will be analyzed by 8270E-SIM in samples that require only cPAH analysis (i.e., 0- to 45-cm samples in Recovery Category 2/3) and not the full SVOC list.
5. In the analysis of the full SVOC list, 2,4-dimethylphenol, benzoic acid, benzyl alcohol, n-Nitrosodiphenylamine, pentachlorophenol, 1,2,4-trichlorobenzene, 1,2-dichlorobenzene, and 1,4-dichlorobenzene will be analyzed by 8270-SIM.
6. Ammonia and total sulfide analyses will only be conducted on the sediment locations targeted for possible toxicity testing

ARL: Analytical Resources LLC
ASTM: American Society for Testing and Materials
cPAH: carcinogenic polycyclic aromatic hydrocarbon
EcoAnalysts: EcoAnalysts, Inc.
EPA: US Environmental Protection Agency
GC/MS: gas chromatography/mass spectrometry
GPC: gel permeation chromatography
HDPE: high-density polyethylene
HRGC/HRMS: high-resolution gas chromatography/high-resolution mass spectrometry
ICP-MS: inductively coupled plasma-mass spectrometry

MTC: Materials & Testing Consulting, Inc.
na: not applicable or not available
PAH: polycyclic aromatic hydrocarbon
PCB: polychlorinated biphenyl
PSEP: Puget Sound Estuary Program
ROD: Record of Decision
SIM: selected ion monitoring
SM: Standard Method
SOP: standard operating procedure
SVOC: semivolatile organic compound
TOC: total organic carbon
UCT-KED: universal cell technology-kinetic energy discrimination

4.9 Sediment Chemistry Analytical Data Quality Objective and Criteria

The analytical DQO for sediment samples is to develop and implement procedures that will ensure the collection of representative data of known, acceptable, and defensible quality. Parameters used to assess data quality are precision, accuracy, representativeness, completeness, comparability, and sensitivity (PARCCS). These parameters are discussed below.

Precision is the measure of reproducibility among individual measurements of the same property, usually under similar conditions, such as multiple measurements of the same sample. Precision is assessed by performing multiple analyses on a sample; it is expressed as an RPD when duplicate analyses are performed, and as a %RSD when more than two analyses are performed on the same sample (e.g., triplicates). Precision is assessed by laboratory duplicate analyses (e.g., duplicate samples, MSDs, and LCS duplicates) for all parameters. Precision measurements can be affected by the nearness of a chemical concentration to the DL, whereby the percent error (expressed as either %RSD or RPD) increases. The DQI for precision varies depending on the analyte. The equations used to express precision are as follows:

$$\%\text{ Recovery} = \frac{(\text{measured conc - measured duplicate conc})}{(\text{measured conc + measured duplicate conc}) \div 2} \times 100$$ **Equation 1a**

$$\%\text{ RSD} = {}^{SD}/_{D_{ave}} \times 100$$

Where:

$$SD = \sqrt{\left(\frac{\sum (D_n - D_{ave})^2}{(n-1)}\right)}$$

Equation 1b

D	=	sample concentration
D_{ave}	=	average sample concentration
n	=	number of samples
SD	=	standard deviation

Accuracy is an expression of the degree to which a measured or computed value represents the true value. Accuracy may be expressed as a percentage recovery for MS, LCS, or CRM analyses. The DQI for accuracy varies depending on the analyte. The equation used to express accuracy for spiked samples is as follows:

$$\%\text{ Recovery} = \frac{\text{spike sample results - unspiked sample results}}{\text{amount of spike added}} \times 100$$ **Equation 2**

Representativeness is an expression of the degree to which data accurately and precisely represent an environmental condition. The sampling approach was designed to address the specific objectives described in Section 2.1. Assuming those objectives are met, the samples collected should be considered adequately representative of the environmental conditions they are intended to characterize.

Comparability is an expression of the confidence with which one dataset can be evaluated in relation to another dataset. Therefore, sample collection and chemical and physical testing will adhere to the most recent Puget Sound Estuary Program (PSEP) and SCUM QA/QC procedures (PSEP 1997; Ecology 2021) and EPA and Standard Methods (SMs) analysis protocols.

Completeness is a measure of the amount of data that is determined to be valid in proportion to the amount of data collected. The equation used to calculate completeness is as follows:

$$\text{Completeness} = \frac{\text{number of valid measurements}}{\text{total number of data points planned}} \times \mathbf{100} \qquad \textbf{Equation 3}$$

The DQI for completeness for all components of this project is 90%. Data that have been qualified as estimated because the QC criteria were not met will be considered valid for the purpose of assessing completeness. Data that have been qualified as rejected will not be considered valid for the purpose of assessing completeness.

Analytical sensitivity is the minimum concentration of an analyte above which a data user can be reasonably confident that the analyte was reliably detected and quantified. For this study, the MDL[31] or the lower limit of quantitation will be used as the measure of sensitivity for each analyte.

Table 4-7 lists specific DQIs for laboratory analyses of sediment samples.

Table 4-7
DQIs for Laboratory Analyses

Parameter[1]	Unit	Precision[2]	Accuracy[2]		Completeness
			CRM/LCS[3]	Spiked Samples	
TOC	%	± 20%	80-120%	75/125%	90%
Percent solids	%	± 20%	na	na	90%
Grain size	%	± 20%	na	na	90%
Metals	mg/kg dw	± 20%	80–120%	75–125%	90%

31 The term MDL includes other types of DLs, such as EDL values calculated for dioxin/furan congeners. Recent revisions to EPA SW846 methods no longer require the calculation of MDLs.

Table 4-7
DQIs for Laboratory Analyses

Parameter[1]	Unit	Precision[2]	Accuracy[2]		Completeness
			CRM/LCS[3]	Spiked Samples	
Mercury	mg/kg dw	± 20%	80–120%	75–125%	90%
PAHs[4]	µg/kg dw	± 35%	44–203%/ 30–160%	30–160%	90%
cPAHs[5]	µg/kg dw	± 35%	45–155%/ 35–129%	35–129%	90%
PCB Aroclors	µg/kg dw	± 35%	50–150%/ 56–120%	56–120%	90%
SVOCs	µg/kg dw	± 35%	10–160%	10–160%	90%
Hexachlorobenzene	µg/kg dw	± 35%	50–120%	50–120%	90%
Ammonia	mg/kg dw	± 20%	90-110%	75–125%	90%
Total sulfides	mg/kg dw	± 20%	75–125%	75–125%	90%
Dioxins/furans	ng/kg dw	± 25%	50–150%/ 63–170%	63–170%[6]	90%

Notes:

1. Individual analytes are listed in Table 4-5.
2. Values listed are method limits provided by ARL. The percentages provided represent the recovery range for each parameter. Individual compound recoveries for PAHs and SVOCs are provided in Appendix G.
3. An LCS may be used to assess accuracy when CRM is unavailable. CRMs will be analyzed for PAHs, PCB Aroclors, and dioxins/furans only. The satisfactory acceptance limit for CRM recovery will include the uncertainty range around the CRM mean as well as the uncertainty of the method measurement
4. PAHs analyzed by EPA 8270E.
5. cPAHs analyzed by EPA 8270E-SIM.
6. Labelled compound percent recovery range.

ARL: Analytical Resources LLC
cPAH: carcinogenic polycyclic aromatic hydrocarbon
CRM: certified reference material
DQI: data quality indicator
dw: dry weight
EPA: US Environmental Protection Agency
LCS: laboratory control sample
na: not applicable
PAH: polycyclic aromatic hydrocarbon
PCB: polychlorinated biphenyl
SIM: selected ion monitoring
SVOC: semivolatile organic compound
TOC: total organic carbon

The laboratory MDL and RL goals for each analytical method are compared to their respective minimum sediment RALs in Tables 4-8 and 4-9. All the analytical methods are sufficiently sensitive.

Table 4-8
RAO 1, 2, and 4 COCs and Associated RL Goals and RALs for Sediment Samples

COC	Method	Unit	RL	RAL[1]
PCBs	EPA 8082A (Aroclors)[2]	µg/kg dw	4	240[2]
Arsenic	EPA 6020B	mg/kg dw	0.500	28
cPAH[3]	EPA 8270E	µg TEQ/kg dw	18.1[4]	900[5]
cPAH[3,6]	EPA 8270E SIM	µg TEQ/kg dw	4.5[4]	900[5]
Dioxins/ furans	EPA 1613b	ng TEQ/kg dw	1.59[7]	25

Notes:

1. RAL is the minimum value for a COC listed in the ROD Table 28 (EPA 2014b) or cPAH ESD (EPA 2021b).
2. The OC-normalized RAL was converted for this table to dry weight values using 2% TOC based on average LDW TOC. The RAL is 12 mg/kg OC; sample results will be compared to the RAL based on the sample-specific TOC value.
3. Per the ROD (EPA 2014a), cPAHs consist of a subset of seven PAHs that EPA has classified as probable human carcinogens: benz[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, benzo[k]fluoranthene, chrysene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene.
4. The RL for the cPAH TEQ value was calculated using one-half the RL for each of the cPAH compounds and the appropriate toxic equivalency factor values (California EPA 2009). Individual compound RLs are listed in Appendix G.
5. The 2014 ROD RAL is based on a benzo(a)pyrene slope factor that has since been updated. The updated value from the cPAH ESD (EPA 2021b) is listed in this table.
6. cPAHs will be analyzed by 8270E-SIM in samples that require only cPAH analysis and not the full SVOC list (i.e., 0- to 45-cm sediments in Recovery Category 2/3 and beach play areas).
7. The RL for the dioxin/furan TEQ value is based on the laboratory minimum calibration level from ARL; the dioxin/furan mammalian TEQ value was calculated using one-half the RL for each dioxin/furan compound and appropriate mammal toxic equivalency factor values (Van den Berg et al. 2006). Individual congener LOQs are listed in Appendix G.

ARL: Analytical Resources LLC
COC: contaminant of concern
cPAH: carcinogenic polycyclic aromatic hydrocarbon
dw: dry weight
EPA: US Environmental Protection Agency
ESD: Explanation of Significant Differences
LDW: Lower Duwamish Waterway
LOQ: limit of quantitation
OC: organic carbon
PAH: polycyclic aromatic hydrocarbon
PCB: polychlorinated biphenyl
RAL: remedial action level
RAO: remedial action objective
RL: reporting limit
ROD: Record of Decision
SIM: selected ion monitoring
SVOC: semi-volatile organic compound
TEQ: toxic equivalent
TOC: total organic carbon

Table 4-9
RAO 3 COCs and Associated RL Goals and RALs for Individual 0–10-cm Sediment Samples

COC	Method	RL	Lowest RAL (Benthic SCO)
Metals (mg/kg dw)			
Arsenic	EPA 6020B	0.2	57
Cadmium	EPA 6020B	0.1	5.1
Chromium	EPA 6020B	0.5	260
Copper	EPA 6020B	0.5	390
Lead	EPA 6020B	0.1	450
Silver	EPA 6020B	0.2	6.1
Zinc	EPA 6020B	6	410
Mercury	EPA 7471B	0.025	0.41
PAHs and SVOCs (µg/kg dw)			
Benzo(a)anthracene	EPA 8270E	20.0	2,200[1]
Benzo(a)pyrene	EPA 8270E	20.0	1,980[1]
Total benzofluoranthenes	EPA 8270E	40.0	4,600[1]
Chrysene	EPA 8270E	20.0	2,200[1]
Dibenzo(a,h)anthracene	EPA 8270E	20.0	240[1]
Indeno(1,2,3-cd)pyrene	EPA 8270E	20.0	680[1]
Anthracene	EPA 8270E	20.0	4,400[1]
Acenaphthene	EPA 8270E	20.0	320[1]
Acenapthylene	EPA 8270E	20.0	1,320[1]
Benzo(g,h,i)perylene	EPA 8270E	20.0	620[1]
Fluoranthene	EPA 8270E	20.0	3,200[1]
Fluorene	EPA 8270E	20.0	460[1]
Naphthalene	EPA 8270E	20.0	1,980[1]
Phenanthrene	EPA 8270E	20.0	2,000[1]
Pyrene	EPA 8270E	20.0	20,000[1]
Total HPAHs[2]	EPA 8270E	40.0	19,200[1]
Total LPAHs[3]	EPA 8270E	20.0	7,400[1]
2,4-dimethylphenol	EPA 8270E-SIM	20.0	29
2-methylnaphthalene	EPA 8270E	20.0	760[1]
4-methylphenol	EPA 8270E	20.0	670
Benzoic acid	EPA 8270E-SIM	100	650
Benzyl alcohol[4]	EPA 8270E-SIM	20.0	57

Table 4-9
RAO 3 COCs and Associated RL Goals and RALs for Individual 0–10-cm Sediment Samples

COC	Method	RL	Lowest RAL (Benthic SCO)
Bis(2-ethylhexyl)phthalate	EPA 8270E	50.0	940[1]
Butyl benzyl phthalate	EPA 8270E	20.0	98[1]
Dibenzofuran	EPA 8270E	20.0	300[1]
Dimethyl phthalate	EPA 8270E	20.0	1,060[1]
Hexachlorobenzene	EPA 8081B	0.5	7.6[1]
n-Nitrosodiphenylamine	EPA 8270E-SIM	5.0	220[1]
Pentachlorophenol	EPA 8270E-SIM	20.0	360
Phenol	EPA 8270E	20.0	420
1,2,4-trichlorobenzene	EPA 8270E-SIM	5.0	16.2[1]
1,2-dichlorobenzene	EPA 8270E-SIM	5.0	46.0[1]
1,4-dichlorobenzene	EPA 8270E-SIM	5.0	62.0[1]
PCBs (µg/kg dw)			
PCBs	EPA 8082A (Aroclors)	4.0	240[1]

Notes:

1. OC-normalized RAL was converted to dry weight value for this table using 2% TOC (average LDW sediment TOC). This value, which is below the dry weight AETs in Table 8-1 of SCUM (Ecology 2021), is presented herein as a dry weight value only for the purpose of comparison to RLs.
2. HPAH compounds include fluoranthene, pyrene, benzo(a)anthracene, chrysene, total benzofluoranthenes, benzo(a)pyrene, indeno(1,2,3 cd)pyrene, dibenzo(a,h)anthracene, and benzo(g,h,i)perylene.
3. LPAH compounds include naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, anthracene, and 2-methylnaphthalene.
4. Because benzyl alcohol is not a CERCLA hazardous substance (Windward and Anchor QEA 2020), benzyl alcohol data will not be included in the DERs. Benzyl alcohol data obtained through routine SVOC analysis of the PDI sediment samples will be provided to EPA.

AET: apparent effects threshold
CERCLA: Comprehensive Environmental Response, Compensation, and Liability Act
COC: contaminant of concern
DER: data evaluation report
dw: dry weight
EPA: US Environmental Protection Agency
HPAH: high-molecular-weight polycyclic aromatic hydrocarbon
LDW: Lower Duwamish Waterway
LPAH: low-molecular-weight polycyclic aromatic hydrocarbon
na: not applicable
OC: organic carbon
PAH: polycyclic aromatic hydrocarbon
PCB: polychlorinated biphenyl
PDI: Pre-Design Investigation
RAL: remedial action level
RAO: remedial action objective

RL: reporting limit
SCO: sediment cleanup objective
SCUM: Sediment Cleanup User's Manual
SIM: selective ion monitoring
SVOC: semivolatile organic compound
TOC: total organic carbon

Standard mass requirements are specified to meet RL goals for each particular analytical method. Table 4-10 summarizes the sample volume needed for each sample type. The masses listed include those required for QC samples.

Table 4-10
Sample Mass Required per Analysis

Analyte	Sediment Mass (ww)	Container Size
Chemistry samples		
TOC	6 g	4-oz jar
Percent solids	45 g	
Metals	3 g	4-oz jar
Mercury	1 g	
Grain size	600 g	16-oz jar
PAHs	60 g	16-oz jar
PCB Aroclors	75 g	
Hexachlorobenzene	60 g	
SVOCs	60 g	
Dioxins/furan congeners[1]	40 g	8-oz jar
Archive	na	8-oz jar
All chemical analyses	950 g	56 oz
Toxicity samples		
Toxicity testing	2,400 g	6 32-oz jars
Toxicity chemistry samples		
Ammonia[2]	25 g	4-oz jar
Total sulfides[2]	25 g	4-oz jar

Notes:
1. This 8-oz jar will be collected at all locations and intervals and either analyzed for dioxins/furans in Tier 1 or archived.
2. Ammonia and total sulfide samples will be collected only at the sediment locations targeted for possible toxicity testing.

na: not applicable
PAH: polycyclic aromatic hydrocarbon
PCB: polychlorinated biphenyl
SVOC: semivolatile organic compound
TOC: total organic carbon
ww: wet weight

For all locations and intervals, following homogenization in the field, sediment for chemistry analysis will be dispensed into two 4-oz, two 8-oz, and two 16-oz jars.

Of the two 8-oz jars (from all locations and intervals), one will be archived in the event that issues arise (e.g., jar is lost or broken). The other will either be analyzed in Tier 1 for dioxins/furans or be archived for potential Tier 2 analysis. All jars for potential chemistry analysis will remain archived until the analytical holding times expire (one year following collection).

For Phase II locations for which toxicity testing is planned (see Section 4.1.8), two additional 4-oz jars and six additional 32-oz jars will be collected.

4.10 Sediment Chemistry Quality Assurance/Quality Control

The types of samples to be analyzed and the procedures to be conducted for QA/QC in the field and laboratory are described in this section.

4.10.1 Field Quality Control Samples

Field QA/QC samples, such as field duplicate samples, are generally used to evaluate the variability attributable to sample handling and processing. For Tier 1 surface and subsurface samples, a minimum of 1 duplicate sample[32] for every 20 samples will be collected. Field duplicate samples will be analyzed for the same analytes as the parent sample. Grain size will be analyzed in duplicates as mass allows.

4.10.2 Laboratory Quality Control

Before analyzing the samples, the laboratory must provide written protocols for the analytical methods to be used, calculate RLs for each analyte in each matrix of interest as applicable, and establish an initial calibration curve for all analytes. The laboratory must also demonstrate its continued proficiency by participation in inter-laboratory comparison studies, and by repeated analysis of CRMs, calibration checks, laboratory reagent blanks, and spiked samples.

4.10.2.1 Sample Delivery Group

Project- and/or method-specific QC measures, such as MSs and MSDs or laboratory duplicates, will be used per sample delivery group (SDG) preparatory batch or per analytical batch, as specified in Table 4-11. An SDG is defined as no more than 20 samples or a group of samples received at the laboratory within a 2-week period. Although an SDG may span two weeks, all holding times specific to each analytical method will be met for each sample in the SDG.

[32] Field duplicates are defined as samples for which twice as much volume as necessary to fill the sample containers has been collected. Following homogenization, aliquots of this sample are equally distributed in two sets of sample containers. Field duplicate results are used to measure and document the repeatability of sample handling procedures and heterogeneity of the sample matrix (PSEP 1997).

Table 4-11
Laboratory QC Sample Analysis Summary

Analysis Type	Method	Initial Calibration	Initial Calibration Verification (2nd source) and Calibration Blank	Continuing Calibration Verification and Calibration Blank	CRM or LCS[1]	Laboratory Replicates	MS	MSD	Method Blanks	Internal Standards/ Surrogate Spikes
TOC	EPA 9060A	Prior to analysis	After initial calibration	Every 10 samples	1 per 20 samples or per batch	1 per 20 samples or per batch	1 per 20 samples or per batch	na	1 per 20 samples or per batch	na
Percent solids	SM 2540G	na	na	na	na	1 per 20 samples or per batch	na	na	na	na
Grain size	ASTM D7913 and D7928	na	na	na	na	Triplicate per 20 samples	na	na	na	na
Metals	EPA 6020A UCT-KED	Daily, prior to analysis	After initial calibration; interference check standard and spectral interference check at beginning of analytical run; spectral interference check every 12 hours	Every 10 samples and at end of analytical sequence	1 per prep batch	1 per batch or SDG	1 per batch or SDG	na	1 per prep batch	Each sample (internal standard only)

Analysis Type	Method	Initial Calibration	Initial Calibration Verification (2nd source) and Calibration Blank	Continuing Calibration Verification and Calibration Blank	CRM or LCS[1]	Laboratory Replicates	MS	MSD	Method Blanks	Internal Standards/ Surrogate Spikes
Mercury	EPA 7471B	Prior to analysis	After initial calibration	Every 10 samples and at end of analytical sequence	1 per prep batch	1 per batch or SDG	1 per batch or SDG	na	1 per prep batch	na
PAHs/ cPAHs	EPA 8270E/ EPA 8270E-SIM	Prior to analysis	After initial calibration	Before and after sample analysis, and every 12 hours	1 per prep batch[2]	na	1 per batch or SDG	1 per batch or SDG	1 per prep batch	Each sample
PCB Aroclors	Mod EPA 8082A	Prior to analysis	After initial calibration	Before and after sample analysis, every 10–20 analyses or 12 hours	1 per prep batch[3]	na	1 per batch or SDG	1 per batch or SDG	1 per prep batch	Each sample
Hexachlor obenzene[4]	EPA 8081B	Prior to analysis	After initial calibration	Before and after sample analysis, every 10–20 analyses or 12 hours	1 per prep batch	na	1 per batch or SDG	1 per batch or SDG	1 per prep batch	Each sample
SVOCs	EPA 8270E/ EPA 8270E-SIM	Prior to analysis	After initial calibration	Before and after sample analysis and every 12 hours	1 per prep batch	na	1 per batch or SDG	1 per batch or SDG	1 per prep batch	Each sample
Ammonia	SM 4500-NH3 H-97	Prior to analysis	After initial calibration	Every 10 samples	1 per prep batch	1 per batch or SDG	1 per batch or SDG	na	1 per prep batch	na
Total sulfides	SM 4500-S2 D-0 PSEP prep	Prior to analysis	After initial calibration	Every 10 samples	1 per prep batch	1 per prep batch or SDG	1 per batch or SDG	na	1 per prep batch	na

Analysis Type	Method	Initial Calibration	Initial Calibration Verification (2nd source) and Calibration Blank	Continuing Calibration Verification and Calibration Blank	CRM or LCS[1]	Laboratory Replicates	MS	MSD	Method Blanks	Internal Standards/ Surrogate Spikes
Dioxins/ furans	EPA 1613b	Prior to analysis	After initial calibration	Before and after sample analysis and every 12 hours	1 CRM and LCS/LCSD per prep batch[3]	na	na	na	1 per prep batch	Each sample

Notes:

A batch is a group of samples of the same matrix analyzed or prepared at the same time, not exceeding 20 samples.

1. An LCS may be used to assess accuracy when CRM is unavailable.
2. Sigma-Aldrich SQC017-40G and CRM 143 BNA will be used to assess accuracy for cPAHs and PAHs.
3. Puget Sound sediment reference material will be used to assess accuracy for PCB Aroclors and dioxins/furans.
4. Hexachlorobenzene will be analyzed separately from the other SVOCs following EPA method 8081B.

ASTM: American Society for Testing and Materials
cPAH: carcinogenic polycyclic aromatic hydrocarbon
CRM: certified reference material
EPA: US Environmental Protection Agency LCS: laboratory control sample
LCS: laboratory control sample
LCSD: laboratory control sample duplicate
MS: matrix spike
MSD: matrix spike duplicate
na: not applicable or not available
PAH: polycyclic aromatic hydrocarbon
PCB: polychlorinated biphenyl
PSEP: Puget Sound Estuary Program
QC: quality control
SDG: sample delivery group
SIM: selected ion monitoring
SM: Standard Method
SVOC: semivolatile organic compound
TOC: total organic carbon
UCT-KED: universal cell technology-kinetic energy discrimination

4.10.2.2 Laboratory Quality Control Samples

The analyst will review the results of QC analyses from each sample group immediately after a sample group has been analyzed. The QC sample results will then be evaluated to determine whether control limits have been exceeded.

If control limits have been exceeded, then appropriate corrective action, such as recalibration followed by reprocessing of the affected samples, must be initiated before a subsequent group of samples is processed. The project QA/QC coordinator must be contacted immediately by the laboratory PM if satisfactory corrective action to achieve the DQIs outlined in this QAPP is not possible. All laboratory corrective action reports relevant to the analysis of project samples must be included in the data deliverable packages.

All primary chemical standards and standard solutions used in this project will be traceable to the National Institute of Standards and Technology, Environmental Resource Associates, National Research Council of Canada, or other documented, reliable, commercial sources. Standards will be validated to determine their accuracy by comparing them to independent standards. Laboratory QC standards are verified in a multitude of ways: Second-source calibration verifications (i.e., same standard, two different vendors) are analyzed to verify initial calibrations; new working standard mixes (e.g., calibrations, spikes, etc.) are verified against the results of the original solution and must be within 10% of the true value; newly purchased standards are verified against current data. Any impurities found in the standard will be documented.

The following sections summarize the procedures that will be used to assess data quality throughout sample analysis. Table 4-11 summarizes the QC procedures to be performed by the laboratory. The associated control limits for precision and accuracy are listed in Table 4-7.

4.10.2.3 Method Blanks

Method blanks are analyzed to assess possible laboratory contamination at all stages of sample preparation and analysis. A minimum of 1 method blank will be analyzed for each SDG or for every 20 samples, whichever is more frequent.

4.10.2.4 Certified Reference Material

CRMs are samples of similar matrices and known analyte concentrations, processed through the entire analytical procedure and used as an indicator of method accuracy. A minimum of 1 CRM will be analyzed for each SDG or for every 20 samples, whichever is more frequent. CRMs will be analyzed for PAHs, PCB Aroclors, and dioxins/furans. An LCS sample can be used to assess accuracy if appropriate CRM is not available. An LCS will be analyzed for conventional, metals, and semivolatile organic compound (SVOC) analyses.

4.10.2.5 Laboratory Control Samples

LCSs are prepared from a clean matrix using the same process as the project samples that are spiked with known amounts of the target compounds. The recoveries of the compounds are used as a measure of the accuracy of the test methods. A laboratory control duplicate will be analyzed for dioxins/furans.

4.10.2.6 Laboratory Replicate Samples

Laboratory replicate samples provide information on the precision of the analysis and are useful in assessing potential sample heterogeneity and matrix effects. Laboratory replicates are subsamples of the original sample that are prepared and analyzed as separate samples, assuming sufficient sample matrix is available. A minimum of 1 laboratory replicate sample will be analyzed for each SDG or for every 20 samples, whichever is more frequent, for metals and conventional parameters.

4.10.2.7 Matrix Spikes and Matrix Spike Duplicates

The analysis of MS samples provides information on the extraction efficiency of the method on the sample matrix. By performing MSD analyses, information on the precision of the method is also provided for organic analyses. For organic analyses, a minimum of 1 MS/MSD pair will be analyzed for each SDG or for every 20 samples, whichever is more frequent, when sufficient sample volume is available, with the exception of dioxins/furans. For inorganic analyses (i.e., metals), a minimum of one MS sample will be analyzed for each SDG, when sufficient sample volume is available.

4.10.2.8 Surrogate Spikes

All project samples analyzed for organic compounds will be spiked with appropriate surrogate compounds, as defined in the analytical methods. Surrogate recoveries will be reported by the analytical laboratories; however, no sample results will be corrected for recovery using these values.

4.10.2.9 Isotope Dilution Quantitation

All project samples analyzed for dioxin/furan congeners will be spiked with a known amount of surrogate compounds, as defined in the analytical methods. The labeled surrogate compounds will respond similarly to the effects of extraction, concentration, and gas chromatography. Data will be corrected for the recovery of the surrogates used for quantification.

4.10.2.10 Internal Standard Spikes

Internal standards may be used for calibrating and quantifying organic compounds and metals using MSs. If internal standards are required by the method, all calibration, QC, and project samples will be spiked with the same concentration of the selected internal standard(s). Internal standard recoveries and retention times must be within method and/or laboratory criteria.

4.11 Sediment Toxicity Testing Quality Objectives and Quality Assurance/Quality Control

4.11.1 Laboratory Sediment Handling

Sediment submitted for toxicity testing will be obtained from the same field homogenate as the sediment submitted for chemical analyses. The homogenized sediment will be placed into six I-Chem™ 32-oz high-density polyethylene (HDPE) wide-mouth jars with zero headspace. These samples will be refrigerated after nitrogen purging of the headspaces in the jars at ARL, after which they will be shipped to EcoAnalysts, as needed. The sediment samples will be stored in the dark at 4 ± 2°C . The toxicity tests will be initiated within eight weeks of sample collection.

Three standard PSEP sediment toxicity tests will be conducted on each sample collected from the locations identified for toxicity testing. These tests are:

- Acute 10-day amphipod mortality test (*Ampelisca abdita* or *Eohaustorius estuarius*)
- Acute 48-hr larval-embryo combined mortality and abnormality test (*Mytilus galloprovincialis* or *Dendraster excentricus*)
- Chronic 20-day juvenile polychaete survival and growth test (*Neanthes arenaceodentata*)

Toxicity testing will be conducted according to *Recommended Guidelines for Conducting Laboratory Bioassays on Puget Sound Sediments* (PSEP 1995), and consistent with the updated protocols presented at the Seattle US Army Corps of Engineers District Sediment Management Annual Review Meeting. Data interpretation will follow recommended guidance (Ecology 2021). The laboratory SOPs for the sediment toxicity tests are provided in Appendix E.

4.11.1.1 Acute 10-day Amphipod Mortality Test

Short-term adverse effects of sediments will be evaluated by measuring the survival of adult amphipods. The appropriate test species will be selected based on sediment grain size data (Table 4-12). Amphipods will be exposed to LDW sediment and reference sediment from Carr Inlet for a 10-day period. The test will be performed according to the procedures and QA/QC performance standards described in (Ecology 2021) with survival as the endpoint.

Table 4-12
Sediment Conditions and Preferred Amphipod Test Species

Sediment Condition	Grain Size	Preferred Amphipod Test Species
Coarse, sand, or silty sand	<60% fines	*E. estuarius*
Fine-grained	>60% fines	*A. abdita or E. estuarius*
High clay	>20% clay	*A. abdita*

4.11.1.2 Acute Larval- Embryo Combined Mortality and Abnormality Test

The endpoint assessed in bivalve larvae after a 48- to 60-hr exposure period is normal survivorship, which is a combined assessment of mortality and abnormality. Larvae of the mussel species *M. galloprovincialis* are the preferred test organisms for this study. If *M. galloprovincialis* in spawning condition are unavailable, the sand dollar echinoderm *D. excentricus* will be used (test duration 48 to 96 hours). Test protocols and QA/QC performance standards will be in accordance with guidance (USACE et al. 2018; Ecology 2021).

4.11.1.3 Chronic 20-day Juvenile Polychaete Survival and Growth

The juvenile polychaete sublethal bioassay is used to characterize the toxicity of marine sediments based on polychaete worm survival and growth. The target initial worm weight for test organisms will be between 0.25 and 1.0 mg. Parameters measured after 20-day sediment exposure are survival and growth in juvenile polychaetes (*N. arenaceodentata*). The test will be performed according to the procedures described in PSEP protocols (1995) and Johns et al. (1990), as well as the most recent *N. arenaceodentata* protocol adjustments presented in the 2013 clarification paper regarding the use of ash-free dry weights (AFDWs) (DMMP 2013) and the QA/QC guidance provided by (Ecology 2021).

4.11.2 Toxicity Test Evaluation Criteria

The results of the toxicity tests will be evaluated relative to the marine biological criteria in SCUM (Ecology 2021). The evaluation criteria are provided in Table 4-13. Per ROD Table 20, benthic sediment cleanup objective (SCO) biological criteria (Ecology 2013) may be used to override benthic SCO chemical criteria where human health-based RALs are not also exceeded.

Table 4-13
SMS Marine Biological Criteria

Toxicity Test	Test Endpoint	SCO/Sediment Quality Standards	Cleanup Screening Level
Amphipod	10-day mortality	Test mortality >25% and statistical difference between test mortality and reference mortality ($p<0.05$)	Test mortality – reference mortality ≥30% and statistical difference between test mortality and reference mortality ($p<0.05$)
Larval	Bivalve or echinoderm abnormality/ mortality	Test normal survivorship/reference normal survivorship < 0.85 and statistical difference between test and reference response ($p<0.10$)	Test normal survivorship/ reference normal survivorship < 0.70 and statistical difference between test and reference response ($p<0.10$)

Table 4-13
SMS Marine Biological Criteria

Toxicity Test	Test Endpoint	SCO/Sediment Quality Standards	Cleanup Screening Level
Polychaete	Neanthes 20-day growth (AFDW)	Test mean individual growth/reference mean individual growth <0.70 and statistical difference between test response and reference response (p<0.05)	Test mean individual growth/reference mean individual growth <0.50 and statistical difference between test response and reference response (p<0.05)

Notes:
AFDW: ash-free dry weight
SCO: sediment cleanup objective
SMS: Washington State Sediment Management Standards

4.11.3 Data Quality Indicators

DQIs for sediment toxicity tests (Table 4-14) are based on guidelines provided in Ecology (2021). Compliance with these indicators will be confirmed by EcoAnalysts and Windward.

Table 4-14
DQIs for Sediment Toxicity Testing

Toxicity Test	DQI
Acute 10-day amphipod mortality test with *R. abronius, E. estuarius,* and *A. abdita*	• Mean mortality in the negative control is ≤10%. • Mean mortality in reference sediments is ≤ 25% • All organisms in a test must be from the same source. • The mean of the daily test temperature must be within ± 1°C of 15°C (20°C for *A. abdita*) • Test must be conducted under continuous light. • DO, pH, and salinity must be within the acceptable ranges established by the protocol. • Test chambers must be identical and contain the same volume of sediment and overlying water. • The LC50 for a positive control test should be within the mean LC50 ± 2 standard deviations of the control chart.

Table 4-14
DQIs for Sediment Toxicity Testing

Toxicity Test	DQI
Acute 48-hr bivalve larvae combined mortality and abnormality test with *M. galloprovincialis*	• Normal survivorship expressed as actual counts is ≥ 0.70 for the control sediment and ≥ 0.65 for the reference sediment. • All organisms in a test must be from the same source. • The mean of the daily test temperature must be within ± 1°C of 16°C (15°C for echinoderm *D. excentricus*). • Test must be conducted under a light cycle of 14 hrs light to 10 hrs dark. • DO, pH, and salinity must be within the acceptable ranges established by the protocol. • Test chambers must be identical and contain the same volume of sediment and overlying water. • The EC50 for a positive control test should be within the mean EC50 ± 2 standard deviations of the control chart.
Chronic 20-day juvenile polychaete survival and growth test with *N. arenaceodentata*	• Mean juvenile polychaete weight must be between 0.25 and 1.0 mg dw at test initiation. • Mean mortality in the negative control must be ≤ 10%. • Mean individual growth rate must be ≥ 0.38 mg/individual/day AFDW in the control. • Mean individual growth rate in reference sediment divided by mean individual growth rate in negative control must be ≥ 0.80 as AFDW. • All organisms in a test must be from the same source. • The mean of the daily test temperature must be within ± 1°C of 20°C. • Test must be conducted under continuous light. • DO, pH, and salinity must be within the acceptable ranges established by the protocol. • Test chambers must be identical and contain the same volume of sediment and overlying water. • The EC50 for a positive control test should be within the mean EC50 ± 2 standard deviations of the control chart.

Notes:

AFDW: ash-free dry weight
DO: dissolved oxygen
DQI: data quality indicator
dw: dry weight
EC50: concentration that causes a non-lethal effect in 50% of an exposed population
LC50: concentration that is lethal to 50% of an exposed population

4.11.4 Sediment Toxicity Testing Quality Control Criteria

All three sediment toxicity tests will incorporate standard QA/QC procedures to ensure that the test results are valid. Standard QA/QC procedures include the use of a negative control, a positive control, and reference sediment samples, as well as the measurement of water quality during testing.

The negative control will be a test using a clean, inert material and the same diluent seawater used in testing sediment toxicity. For the amphipod and polychaete tests, the negative control will be native sediment from the organism collection site (Appendix E). For the polychaete test, the negative control will be sand collected from Yaquina Bay (*Eohaustorius* home sediment) or other clean amphipod control sediment. For the bivalve larvae test, the negative control seawater will be ambient seawater from North Hood Canal.

For the positive control, a reference toxicant will be used to establish the relative sensitivity of the test organism. The positive control for sediment tests is typically conducted with diluent seawater and without sediment. Reference toxicants are often used in positive controls. In addition to the positive controls with reference toxicants, positive controls using ammonia (water exposure only) will be performed.

Reference sediment will also be included with each toxicity test series. Reference sediments provide toxicity data that can be used to separate toxicant effects from unrelated effects, such as those of sediment grain size. Reference sediments are also used in statistical comparisons to determine whether test sediments are toxic. Sediment samples selected to be test reference sediment should represent the range of important natural, physical, and chemical characteristics of the test sediments, specifically sediment grain size and TOC. Sediments to be used as reference sediment for the three bioassays will be collected from Carr Inlet (PSEP 1995).

Bioassays require that proper water quality conditions be maintained to ensure that organisms survive and do not experience undue stress unrelated to test sediments. Salinity, dissolved oxygen (DO), pH, ammonia, total sulfides, and temperature will be regularly measured during testing. Temperature, salinity, DO, and pH will be measured daily for all three tests.

Interstitial porewater will be analyzed for ammonia and total sulfides at test initiation and termination for both the amphipod and polychaete tests. Ammonia and total sulfides will be measured in overlying water in all three tests at test initiation and test termination.

DMMP (USACE et al. 2018) protocols will be followed for samples with unacceptable ammonia, sulfides, wood waste, or grain size.

4.12 Instrument/Equipment Testing, Inspection, and Maintenance

Prior to each field event, measures will be taken to test, inspect, and maintain all field equipment. All equipment used, including the differential GPS unit and digital camera, will be tested for accuracy before leaving for the field event.

The FC will be responsible for overseeing the testing, inspection, and maintenance of all field equipment.

Laboratory instrument testing, inspection, and maintenance procedures are described in the laboratory SOPs.[33] The laboratory PM will be responsible for ensuring laboratory equipment testing, inspection, and maintenance requirements are met.

4.13 Instrument/Equipment Calibration and Frequency

Multipoint initial calibration will be performed on each analytical instrument at the start of the project, after each major interruption to the instrument, and when any continuing calibration does not meet the specified criteria. The number of points used in the initial calibration is defined in each analytical method. Continuing calibrations will be performed daily for organic analyses, every 10 samples for inorganic analyses, and with every sample batch for conventional parameters to ensure proper instrument performance.

Gel permeation chromatography (GPC) calibration verifications will be performed at least once every seven days, and corresponding raw data will be submitted by the laboratory with the data package. In addition, florisil performance checks will be performed for every florisil lot, and the resulting raw data will be submitted with the data package.

Calibration of analytical equipment used for chemical analyses includes the use of instrument blanks or continuing calibration blanks, which provide information on the stability of the baseline established. Continuing calibration blanks will be analyzed immediately after the continuing calibration verification, at a frequency of 1 blank for every 10 samples analyzed for inorganic analyses, and 1 blank every 12 hours for organic analyses. If the continuing calibration does not meet the specified criteria, the analysis must stop. Analysis may resume after corrective actions have been taken to meet the method specifications. All project samples analyzed by an instrument found to be out of compliance must be reanalyzed.

4.14 Inspection/Acceptance of Supplies and Consumables

The FC will gather and check field supplies daily for satisfactory conditions before each field event. Batteries used in the digital camera will be checked daily and recharged as necessary.

[33] Laboratory SOPs are confidential and can be provided upon EPA request.

Supplies and consumables for the field sampling effort will be inspected upon delivery and accepted if the condition of the supplies is satisfactory.

4.15 Analytical Data Management

All field data will be recorded on field forms, which the FC will check for missing information at the end of each field day and amend as necessary. A QC check will be done to ensure that all data have been transferred accurately from the field forms to the database. Field forms will be archived in the Windward library.

Analytical laboratories are required to submit data in an electronic format, as described in Section 3.7.2. The laboratory PM will contact the project QA/QC coordinator prior to data delivery to discuss specific format requirements.

A library of routines will be used to translate typical electronic output from laboratory analytical systems and to generate data analysis reports. The use of automated routines will ensure that all data are consistently converted to the desired data structures, and that operator time is kept to a minimum. In addition, routines and methods for quality checks will be used to ensure such translations are correctly applied.

Written documentation will be used to clarify how field and analytical laboratory duplicates and QA/QC samples were recorded in the data tables, and to provide explanations of other issues that may arise. The data management task will include keeping accurate records of field and laboratory QA/QC samples so that project team members who use the data will have appropriate documentation. All data management files will be secured on the Windward network. Data management procedures outlined in Attachment D of the PDIWP will be followed (Windward and Anchor QEA 2022).

5 Data Generation and Acquisition of Engineering PDI Elements

This section discusses the study design and procedures for collecting, handling, and managing data that will be acquired in support of the engineering PDI elements. This section presents methods for the following key elements:

- Bank visual inspection (DQO 8) and focused topographic surveys (DQO 11)
- Inspections and evaluations of existing structures within or adjacent to active remedial action areas to develop design criteria for remedial activities that may impact existing structures (DQO 14)
- Collection of geotechnical data for use in RD; assessing material behavior; and conducting stability modeling for banks, structures, and dredge or capping areas (DQO 13)
- Specialized surveys (e.g., utilities, debris characterization, sediment thickness overlying armoring in bank areas) as necessary to adequately characterize site conditions for engineering design and construction bid documents (DQO 14)

Certain details for engineering data needs will be defined using the results of Phase I data collection. For example, determining geotechnical sampling locations will require initial horizontal RAL exceedances to have been delineated (i.e., DQOs 1 through 7 to have been addressed). Specifics regarding locations and methods for the tasks in this section will be provided in the PDI QAPP Addendum for Phase II based on the analyses presented in the Phase I DER. Methods specified in the PDI QAPP Addendum for Phase II for geotechnical data collection will use the SOPs provided in Appendix E; these SOPs are not anticipated to require modification for the PDI QAPP Addendum for Phase II.

5.1 Banks

5.1.1 Phase I Visual Inspection of Banks

To address DQO 8, a visual survey and inspection of shoreline conditions in bank areas located within the middle reach will be performed during the Phase I PDI to document overall bank conditions that will inform RD (i.e., presence/absence of bank armoring, evidence of significant erosion, presence of structures, presence of vegetation, visual observation of potential stormwater discharge pathways or groundwater seeps along shoreline). This effort will build upon the existing *Waterway User Survey and Assessment of In-Water Structures – Data Report* (hereafter referred to as the Waterway User Survey) (Integral et al. 2018)—which focused on existing structures by adding additional detail to support engineering design—and will update the information gathered, as appropriate, for areas where conditions have changed.

Bank areas may be armored or unarmored. The presence of armoring will be documented, as will the nature of any armoring (e.g., concrete blocks, mats, riprap, bulkheads) and its superficial condition. For unarmored banks, factors that may affect bank stability or indicate erosion will be noted, including: bank steepness, surface material type, observed bank undermining, and presence and stability of vegetation (e.g., trees and exposed tree roots). Vegetation located on bank areas will be documented to establish existing conditions so that decisions can be made during RD regarding any need for clearing, protection, and/or replacement.

The Phase I DER will identify bank areas that may require remedial actions (i.e., banks that are located within or adjacent to Phase I RAL exceedance areas) and additional detailed inspection during Phase II. Phase II results will be presented in the Phase II DER, as described in Section 7.3.

The Phase I bank inspection will be conducted primarily by boat. It will be completed for all bank areas within the middle reach within approximately four hours around a daytime low tide (two hours before, two hours after), depending on weather conditions.

The Phase I bank area visual inspection results will supplement information gathered during the Waterway User Survey (Integral et al. 2018). The Waterway User Survey included general descriptions of bank areas in some locations, with more information on banks near structures, as well as maps presenting four different types of bank conditions: armored slope, vertical bulkhead, exposed bank, and dock face. The crew performing the bank area visual inspection will review the Waterway User Survey before commencing work and will refer to existing information as needed while performing the Phase I visual inspection.

The following activities will be completed prior to the visual inspection:

- Review the Waterway User Survey (Integral et al. 2018) for existing information relevant to bank conditions.
- Check tide charts to develop a schedule for the visual inspection.
- Prepare a daily float plan that includes locations to be observed each day (and existing drawings) and communication protocols for use among the field team.

Documentation will be developed for representative sections of banks and will exclude EAAs. High-resolution photographs will be taken with a camera and DGPS receiver (to tag the photograph location). Visual observations will also be documented for representative sections of banks, providing descriptive attributes of bank area features, which may include:

- Armored (e.g., riprap, bulkhead) and un-armored banks
- Presence of sediment accumulated on armored slopes
- Observed bank erosion
- Observed utility crossings
- Observed outfalls/pipes

- Locations with discharge flowing from outfalls
- Navigational obstructions
- Access points (including nature and condition)
- Vegetation
- Other features of note

For armored banks, the following information will be noted:

- Type of armor material (e.g., riprap, concrete, grout mat, bulkhead)
- Estimated slope/grade
- Presence of nearby structures that may indicate waterway traffic patterns that could affect the armoring

For unarmored banks, the following information will be noted:

- Qualitative observation of unarmored bank steepness
- Presence and condition of vegetation that may stabilize the slope (note if vegetation obscures observation of the condition of the underlying slope; note if roots that may indicate bank erosion are visible)
- Evidence of erosion (e.g., over-steepened bank, collapsed bank) or conditions (e.g., surface runoff) that may promote erosion
- Presence of nearby structures that may indicate waterway traffic or current flow patterns that could affect the stability of the bank

Bank conditions, vegetation, and features will be described on the shoreline visual inspection form (Appendix C), or in an electronic data dictionary capable of recording the same information and will be used to develop the Phase I DER described in Section 7.3. Features will be photographed, and location data, photographs, and descriptions will be recorded on the shoreline visual inspection form. If a bank feature is not approachable by boat due to bathymetric conditions, safety concerns, or obstructions, a DGPS offset or digitized location will be collected instead.

5.1.2 Phase II Focused Topographic Surveys

Following completion of Phase I PDI activities, the Phase I DER will identify bank areas adjacent to or within interpolated RAL exceedance areas. The Survey QAPP Addendum will identify survey DQOs and the bank areas that will be targeted for the collection of focused topographic survey data to support RD.

The proposed topographic survey methods and timing will be detailed in an addendum to the Survey QAPP that will be prepared at the same time as the PDI QAPP Addendum for Phase II.

These topographic survey methods could include traditional ground point elevation data collection, the use of aerial or boat-mounted light detection and ranging equipment, aerial photogrammetry, or a combination of methods, depending on site access limitations, presence of vegetation, and data accuracy and density requirements informing engineering design. Additional topographic data collection locations and methods will be evaluated in coordination with EPA.

5.2 Structure Inspections

Structures within the middle reach of the LDW will be visually inspected during Phase I. Structure inspections will be planned and conducted in cooperation with structure owners/operators to ensure information is up to date. Phase I inspection efforts will include a review of available information, comprised in the Waterway User Survey (Integral et al. 2018), to inform the scope of additional visual inspections and supplement existing information. Structures identified in the Waterway User Survey included bridge foundations and wingwalls, piers, docks, fender pilings, dolphin piles, bulkheads, and outfalls.

For structures located within or adjacent to the Phase I RAL exceedance areas, available as-built information will be obtained from facility owners and reviewed in Phase II. Detailed condition inspections (via land access, vessel, and/or dive inspections) will be conducted as needed after Phase I. Structure inspections will be completed in accordance with the American Society of Civil Engineers manual of practice No. 130 regarding waterfront facilities inspection and assessment.

Specific Phase I visual inspection activities will include:

- Making general observations of structure condition, visible physical damage, and surface deterioration or defects of structure component materials. An example structure inspection form is included in Appendix C. Documentation of structure engineering assessments will be included in the RD.
- Collecting information to supplement existing data in the Waterway User Survey (Integral et al. 2018), including structure ID numbers, physical descriptions of the structures observed, and notations of any discrepancies or changed conditions.
- Visually assessing access or safety concerns that may be important considerations for chemistry or geotechnical sampling in the vicinity of or beneath the structure during the Phase I and II PDI. If access conditions are deemed unsafe, then only a general visual inspection of the structure will be performed, subject to EPA agreement. Key issues for safety include visible damage to or decay of overhead structures, dangerous gaps or space between supports, cables or other entanglement hazards, excessive height above slopes (fall hazards), and slippery, sharp, or unstable slope armoring.

Inspections will be documented using the Facilities Condition Assessment Report template forms (Appendix C), which will include written observations, photographs, and detailed checklists for the materials used in the structure (concrete, wood, and/or steel).

Following completion of the Phase I visual inspections, a summary of findings will be provided in the Phase I DER. The Phase I DER information will add to the existing Waterway User Survey (Integral et al. 2018) information; the Phase I DER will present structures' location information and relevant background information.

Following the Phase I DER, Phase II inspection and evaluation activities will be conducted for structures that may be impacted by remedial activities. Because unsound structures may fail or be repaired or replaced, areas with such structures will be evaluated for construction accessibility during follow-up inspections to be conducted during Phase II data collection. These evaluations may include more detailed condition inspections, potential structure materials sampling, and additional evaluation of equipment accessibility. Phase II inspection activities will be conducted in accordance with American Society of Civil Engineers manual of practice No. 130. The results of these inspections will be documented in the Phase II DER.

5.3 Geotechnical Investigation

To address DQO 13, geotechnical sediment samples (surface and subsurface) will be collected in locations that take into account the middle reach's Phase I RAL exceedance areas, as identified in the Phase I DER, as part of Phase II investigation efforts. These samples will be tested to identify *in situ* and *ex situ* sediment strength characteristics to support engineering design and address sediment management/disposal considerations. The data collection efforts will be completed using different sampling equipment than that used to collect the environmental samples described in Section 4. A summary of the proposed geotechnical sampling and testing program is provided in the following sections. Based on preliminary reconnaissance, geotechnical sampling is anticipated to be conducted during Phase II. In the event that new site access challenges are identified and require geotechnical work during Phase I, the proposed geotechnical sampling location(s) will be provided in a separate map for EPA approval that will be developed after such locations have been identified. Otherwise, details on proposed geotechnical field and laboratory testing and geotechnical sampling locations will be provided in the PDI QAPP Addendum for Phase II.

Geotechnical explorations will be completed using barge-mounted or land-based exploration equipment and handheld testing equipment to collect surface and subsurface geotechnical data. Sampling locations will be in the general vicinity of the Phase I RAL exceedance areas (as defined in the Phase I DER). Where appropriate, explorations will be conducted adjacent to bank areas and existing structures to collect engineering data that will inform structural engineering evaluations in design.

5.3.1 Geotechnical Investigation Design

The specific locations, numbers, and types (surface vs. subsurface) of geotechnical samples will be presented in the PDI QAPP Addendum for Phase II following evaluation of Phase I data and interpolation of RAL exceedance areas in the Phase I DER. Specific types of *in situ* geotechnical testing that may be performed include:

- Standard penetration testing (SPT) performed at regular depth intervals within select borings to identify subsurface sediment density with depth and to assess dredgeability, as described in Appendix E
- Thin-walled, undisturbed sample collection for consolidation testing to evaluate settlement as part of engineered sediment cap design, as described in Appendix E
- Cone penetration testing (CPT) at select locations to provide a continuous subsurface profile of sediment density and strength to assess dredgeability, as described in Appendix E. As appropriate, the CPT testing setup may be supplemented with a full-flow penetrometer (FFP) capable of measuring the shear strength of soft sediments at a higher resolution than can conventional CPT. FFP, if used, will generally follow procedures described in DeJong et al. (2011).
- Vane shear testing (VST) to measure sediment shear strength and for use in the design of engineered sediment caps, as described in Appendix E
- Handheld DCP testing at select locations, if appropriate, to provide *in situ* soil or sediment density and augment SPT and CPT data to assess dredgeability, as described in Appendix E

Geotechnical explorations may also be advanced to deeper elevations than those used to collect samples to be tested for chemistry. These deeper elevations will yield data to support the evaluation of slope stability and sediment-bearing capacity, and to identify contacts between different lithologic units (i.e., locations of previously undisturbed native sediments).

Ex situ geotechnical testing will also be performed on a subset of geotechnical locations, and the method to determine which locations and samples will be subject to *ex situ* geotechnical testing will be described in the PDI QAPP Addendum for Phase II. Sample identification for *ex situ* geotechnical testing will be numbered as described in Section 4.4.

Testing requirements, as identified in Section 5.3.3, will be used to characterize variations in sediment physical properties both laterally and vertically. The characterization tests to be conducted *ex situ* at the geotechnical testing laboratory are likely to include:

- Moisture content
- Grain size distribution (sieve and hydrometer) and percent fines (percent passing the U.S. No. 200 sieve)

- Specific gravity
- Atterberg limits
- Unit weight
- One-dimensional consolidation
- Direct shear
- Triaxial compression (unconsolidated-undrained and consolidated-undrained)

The data from this *ex situ* testing program will be evaluated to assess the variability of sediment physical properties in each active remedial action area. The results will support the assessment of dredgeability, evaluations of sediment stability, evaluations of slope stability for temporary and permanent slopes, development of design criteria for structural stability, and potential options for dewatering, treatment, and disposal during RD.

5.3.2 Geotechnical Field Methods

Collecting geotechnical samples and data during implementation of Phase II activities will generally require the use of a hollow-stem auger, mud rotary, or rotosonic drill rig and *in situ* testing equipment, such as a cone penetrometer rig, vane shear device, and potentially a handheld DCP. Requirements for the collection of geotechnical samples and data are described in the following sections. Decontamination procedures and field-generated waste procedures are described in Sections 4.6 and 4.7, respectively.

5.3.2.1 Station Location Positioning Control

To meet the goals of the pre-design sampling activities, appropriate positioning control at geotechnical station locations is required. Both absolute accuracy (i.e., ability to define position) and repeatable accuracy (i.e., ability to return to a sampling station) are important. The process for station location positioning is the same as used during sediment sampling and is described in Appendix E.

5.3.2.2 Geotechnical Boring Procedures and Sample Collection

A general SOP for geotechnical borehole sampling is provided in Appendix E. It contains the procedures for SPT testing and split-spoon sampling. SOPs may be modified as necessary to complete geotechnical borings within bank areas based on access considerations, type of equipment to be utilized, water depth, and other factors. Identification of location-specific methods for collecting geotechnical data within bank areas will be documented in the PDI QAPP Addendum for Phase II.

Upon positioning the drilling vessel at the proposed location, the coordinates and other field notes regarding the sampling location will be entered onto the soil boring form (Appendix C). A water depth reading will be taken using appropriate equipment (e.g., survey rod or weighted tape) to measure the depth of water to the sediment-water interface. The water depth will be recorded on the soil boring form.

SPT blow counts will be recorded for each interval sampled, in accordance with ASTM method D1586. Disturbed samples for ex situ geotechnical testing will be collected by split-spoon sampling techniques, in accordance with ASTM method D1586. Samples will be contained in air-tight glass or plastic jars or double-sealed in Ziploc® bags for transport to the geotechnical laboratory. Each sample jar or bag will be labeled with appropriate sample ID information prior to sample collection (see Section 4.4).

In addition to the split-spoon samples, undisturbed, thin-walled tube samples may be collected during geotechnical drilling, in accordance with ASTM method D1587 and as described in Appendix E. Once collected, the thin-walled tube will be capped and sealed at both ends, serving as the container for that sample during transport to the laboratory. Similar labeling practices will be followed for these samples.

5.3.2.3 Cone Penetration Testing Procedures

An SOP for CPT is provided in Appendix E of this QAPP. CPT tests will be conducted in accordance with ASTM method D3441. CPT field data will be recorded electronically by the CPT contractor, so there is no specific field data collection form for CPT. For soft sediments, the CPT instrument may be outfitted with an FFP to record higher-resolution shear strength data, as described in DeJong et al. (2011). FFP data will also be recorded electronically by the CPT contractor and therefore also do not utilize a specific field data collection form. Results of CPT and FFP testing will be provided in the contractor's data report and included in the Phase II DER.

5.3.2.4 In situ Vane Shear Testing Procedures

An SOP for *in situ* VST using a handheld device is provided in Appendix E. *In situ* VST may be performed from the same vessel as the geotechnical drilling or from a separate data-collection vessel. *In situ* VST will be performed in general accordance with ASTM method D2573. VST field data collected with a handheld device will be recorded on the vane shear field form, provided in Appendix C. Alternately, VST data will be included with a contractor-prepared data report when the VST is advanced using the contractor's equipment.

5.3.2.5 Dynamic Cone Penetrometer Testing Procedures

An SOP for DCP testing is provided in Appendix E. DCP testing may be performed in difficult-to-access bank areas to obtain a subsurface profile of soil or sediment density for use in engineering evaluations. DCP testing field data will be recorded on the DCP field form, provided in Appendix C.

5.3.3 Geotechnical Laboratory Methods

Samples for laboratory analyses will be transported or shipped to MTC for geotechnical laboratory testing. MTC will follow the sample handling and custody procedures described in Section 4.5 and perform testing on a subset of samples (determined by the geotechnical engineer). Table 5-1 summarizes standards, laboratory methods, sample container requirements, preservation methods, and holding time limitations for geotechnical samples. Geotechnical sampling is not anticipated to occur during the Phase I PDI. Results of geotechnical testing that will be conducted during the Phase II PDI will be included in the Phase II DER.

Table 5-1
Analytical Methods and Sample Handling Requirements for Geotechnical Samples

Parameter	Method	Sample Size	Container Type	Container Size	Preservative	Sample Holding Time
Grain size with hydrometer	ASTM D6913 ASTM D7928	300 g	Jar or double-bagged Ziploc®	16 oz	--	6 months
Atterberg limits	ASTM D4318	300 g	Jar or double-bagged Ziploc®	16 oz	--	6 months
Moisture content	ASTM D2216	50 g	Jar or double-bagged Ziploc®	4 oz	cool to 4 ± 2°C	6 months
Specific gravity	ASTM D854	100 g	Jar or double-bagged Ziploc®	8 oz	--	6 months
Percent fines	ASTM D1140	100 g	Jar or double-bagged Ziploc®	8 oz	--	6 months
1-dimensional consolidation	ASTM D2435	na	Shelby tube	--	--	6 months
Direct shear	ASTM D3080	na	Shelby tube	--	--	6 months
Unconsolidated undrained triaxial shear test	ASTM D2850	na	Shelby tube	--	--	6 months
Consolidated undrained triaxial shear test	ASTM D4767	na	Shelby tube	--	--	6 months
Unit weight	ASTM D7263	na	Shelby tube	--	--	6 months

Notes:

In some cases, multiple tests may be run using a sample in a single container. For example, a sample in a container for grain size testing might also be used for moisture content and/or specific gravity testing. Container requirements will be confirmed with the geotechnical testing laboratory prior to sampling.

ASTM: American Society for Testing and Materials

na: not applicable

5.4 Specialized Surveys

Depending upon the results from the Phase I PDI, to address DQO 14, specialized surveys (e.g., utility, sediment thickness over armor material, and debris surveys) may need to be performed to supplement bathymetric and topographic surveys, and to further define site physical conditions during the engineering design phase of the project. The need for any specialized surveys will be identified in the PDI QAPP addendum for Phase II, including the survey design and methods.

6 Data Validation and Usability

6.1 Data Validation

The data validation process for analytical samples will begin in the laboratory with the review and evaluation of data by supervisory personnel or QA specialists. The laboratory analyst will be responsible for confirming that the analytical data are correct and complete, that appropriate procedures have been followed, and that QC results have been compared to acceptable limits. The project QA/QC coordinator will be responsible for confirming that all analyses performed by the analytical laboratories are correct, properly documented, and complete, and that they satisfy the project DQIs specified in this QAPP. The data validator will confirm that data qualifiers are applied to QC results that are outside of acceptable limits.

Chemistry data will not be considered final until validated. Data validation will be conducted following EPA guidance (EPA 2020a, b, c, 2009). Geotechnical data will not undergo data validation. Instead, the geotechnical laboratory will be responsible for completing the testing in accordance with the appropriate ASTM standards and will report if any anomalies in the data are observed.

Independent third-party data review and validation of the analytical chemistry data will be conducted by LDC or a suitable alternative. All chemistry data will undergo Stage 2B data validation, and a minimum of 10% or one SDG will undergo Stage 4 data validation. Full data validation parameters will include:

- QC analysis frequencies
- Analysis holding times
- Laboratory blank contamination
- Instrument calibration
- Surrogate recoveries
- LCS/CRM recoveries
- MS recoveries
- MS/MSD RPDs
- Compound identifications—verification of raw data with the reported results (10% of analytes)
- Compound quantitations—verification of calculations and RLs (10% of analytes)
- Instrument performance check (tune) ion abundances
- Internal standard areas and retention time shifts
- Ion abundance ratio compared to theoretical ratios for samples analyzed by EPA method 1613b

If no discrepancies are found between reported results and raw data in the dataset that undergoes full data validation, then a summary validation of the rest of the data will proceed using all of the QC forms submitted in the laboratory data package.

QA review of the sediment chemistry data will be performed in accordance with the QA requirements specified in this QAPP, the technical specifications of the analytical methods and laboratory SOPs indicated in Tables 4-7 through 4-12, and EPA guidance for organic and inorganic data review (EPA 2020a, b, c, 2009). The EPA PM may have EPA peer review the third-party validation or perform data assessment/validation on a percentage of the data.

All discrepancies and requests for additional, corrected data will be discussed with the analytical laboratories prior to issuance of the formal data validation report. The project QA/QC coordinator should be informed of all contacts with the analytical laboratories during data validation. Procedures used and findings made during data validation will be documented on worksheets. The data validator will prepare a data validation report that summarizes QC results, qualifiers, and possible data limitations. This data validation report will be appended to the data evaluation report. Only data that have been validated and qualified with appropriate qualifiers will be used for RD.

Toxicity test data will be reviewed internally by Windward. Data will be compared to DQIs and testing conditions listed in Section 4.11.3. EcoAnalysts will be contacted to correct any discrepancies.

6.2 Reconciliation with Data Quality Indicators

Chemistry data QA will be conducted by the project QA/QC coordinator in accordance with EPA guidelines (EPA 2020a, b, c, 2009). The results of the third-party independent review and validation will be reviewed, and cases wherein the project DQIs were not met will be identified. Any potential data usability issues will be discussed with EPA and described in the DER.

7 Assessment and Oversight

7.1 Compliance Assessments and Response Actions

EPA or its designees may observe field activities during each sampling event, as needed. If situations arise wherein there is a significant inability to follow the QAPP methods precisely, the Windward PM will determine the appropriate actions and consult EPA (or its designee).

7.1.1 Compliance Assessments

Laboratory and field performance assessments will consist of on-site reviews conducted by EPA of QA systems and equipment for sampling, calibration, and measurement. EPA personnel may conduct a laboratory audit prior to sample analysis. Any pertinent laboratory audit reports will be made available to the project QA/QC coordinator upon request. All laboratories are required to have written procedures addressing internal QA/QC. All laboratories and QA/QC coordinators are required to ensure that all personnel engaged in sampling and analysis tasks have appropriate training.

7.1.2 Response Actions for Field Sampling

The FC, or a designee, will be responsible for correcting equipment malfunctions throughout field sampling, and for resolving situations in the field that may result in nonconformance or noncompliance with this QAPP. All corrective measures will be immediately documented in the field logbook, and protocol modification forms will be completed, as necessary.

7.1.3 Corrective Action for Laboratory Analyses

All laboratories will be required to comply with their current written SOPs, laboratory QA plans, and analytical methods. All laboratory personnel will be responsible for reporting problems that may compromise the quality of the data. The analysts will identify and correct any anomalies before continuing with sample analysis. The laboratory PMs will be responsible for ensuring that appropriate corrective actions are initiated as required for conformance with this QAPP.

The project QA/QC coordinator will be notified immediately if any QC sample exceeds the DQIs outlined in this QAPP (Tables 4-7, 4-11, and 4-14), and the exceedance cannot be resolved through standard corrective action procedures (Table 7-1). A description of the anomaly, the steps taken to identify and correct the anomaly, and the treatment of the relevant sample batch (i.e., recalculation, reanalysis, and re-extraction) will be submitted with the data package using the case narrative or corrective action form.

Table 7-1
Acceptance Limits and Corrective Actions for Laboratory Analyses

Parameter	QC Sample	Acceptance Limits	Corrective Action
TOC	Method blank	Less than ½ the LOQ or greater than 1/10th the amount measured in any sample or 1/10th the regulatory limit, whichever is greater	Reprocess affected samples in batch. If insufficient sample volume remains for reprocessing or if holding times have been exceeded, the results shall be reported with B-flags.
	CRM	+/- 25%	Rerun CRM to confirm outlying condition. Verify operating conditions on a Corrective Action Form. As the CRM is received dry, no batch sample control is based on recovery values.
	Laboratory replicate	+/- 20%	Review data for errors. Matrix QC control limits are advisory as they are an indication of sample characteristics. Flag outliers.
	MS/MSD	+/- 25% recovery, +/-20% RPD	Review data for errors. Matrix QC control limits are advisory as they are an indication of sample characteristics. Flag outliers.
Percent Solids	Laboratory replicate	+/- 20%	Review data for errors and notes for indications of sample appearance (rocks, wood chips, etc.). Flag outliers.
Grain size	Laboratory triplicate	+/-20%	For matrix evaluation only. Note outliers.

Table 7-1
Acceptance Limits and Corrective Actions for Laboratory Analyses

Parameter	QC Sample	Acceptance Limits	Corrective Action
Metals	Method blank	Less than ½ the LOQ or greater than 1/10th the amount measured in any sample or 1/10th the regulatory limit, whichever is greater	Reprocess affected samples in batch. If insufficient sample volume remains for reprocessing or if holding times have been exceeded, the results shall be reported with the appropriate data qualifiers.
	LCS	+/- 20%	Correct problem; then, if necessary, re-prep and reanalyze the LCS and all samples for failed analytes if sufficient sample material is available. If reanalysis cannot be performed, explain in the Case Narrative.
	Laboratory replicate	+/- 20%	Review data for errors. Matrix QC control limits are advisory as they are an indication of sample characteristics. Flag outliers.
	MS	+/- 25%	Review data for errors. For matrix evaluation only; no corrective action required.
	Internal standards	30-120% if IS in the ICAL Blank	If recoveries area is acceptable for QC samples but not field samples, the field samples may be considered to suffer from matrix effect.
Mercury	Method Blank	Less than ½ the LOQ or greater than 1/10th the amount measured in any sample or 1/10th the regulatory limit, whichever is greater	Reprocess affected samples in batch. If insufficient sample volume remains for reprocessing or if holding times have been exceeded, the results shall be reported with the appropriate data qualifiers.
	LCS	+/- 20%	Correct problem; then, if necessary, re-prep and reanalyze the LCS and all samples for failed analytes if sufficient sample material is available. If reanalysis cannot be performed, explain in the Case Narrative.
	Laboratory replicate	+/- 20%	Review data for errors. Matrix QC control limits are advisory as they are an indication of sample characteristics. Flag outliers.
	MS	+/- 25%	Review data for errors. For matrix evaluation only; no corrective action required.

Table 7-1
Acceptance Limits and Corrective Actions for Laboratory Analyses

Parameter	QC Sample	Acceptance Limits	Corrective Action
PAHs	Method blank	Less than ½ the LOQ or greater than 1/10th the amount measured in any sample or 1/10th the regulatory limit, whichever is greater	Reprocess affected samples in batch. If insufficient sample volume remains for reprocessing or if holding times have been exceeded, the results shall be reported with the appropriate data qualifiers.
	LCS	Laboratory acceptance criteria (see Table 4-6 for limits) or 50–150% until sufficient data have been generated for in-house limits	Correct problem; then, if necessary, re-prep and reanalyze the method blank, LCS, and all samples in the batch (including matrix QC) for failed analytes if sufficient sample material is available. If reanalysis cannot be performed, data must be explained in the Case Narrative.
	CRM	See reference material certification for windows	Review data for errors. Flag outliers on summary sheet. If all laboratory QC and field samples have surrogates within limits, narrate the outliers in the Case Narrative.
	MS/MSD	Use LCS limits as advisory limits	Review data for errors. For matrix evaluation only; no corrective action required.
	Internal standards	50–200% of ICAL Midpoint standard	Inspect instrument for malfunctions, correct problem, and reanalyze extracts. Review data for possible matrix effect and rerun samples at dilution to bring internal standards into control. If corrective action fails, explain in Case Narrative.
	Surrogates	Laboratory acceptance criteria 21–134% or 50–150% until sufficient data have been generated for in-house limits	Correct problem; then, if necessary, re-prep and reanalyze failed samples for surrogates in the batch if sufficient material is available. If obvious chromatographic interference is present, reanalysis may not be necessary, but the client must be notified prior to reporting data, and failures must be discussed in the Case Narrative.

Table 7-1
Acceptance Limits and Corrective Actions for Laboratory Analyses

Parameter	QC Sample	Acceptance Limits	Corrective Action
PCB Aroclors	Method blank	Less than ½ the LOQ or less than 1/10th the amount measured in any sample or 1/10th the regulatory limit, whichever is greater	Reprocess affected samples in batch. If insufficient sample volume remains for reprocessing or if holding times have been exceeded, the results shall be reported with the appropriate data qualifiers.
	RM (Puget Sound Reference Material)	See Table 4-6 for limits	Review data for errors. Flag outliers on summary sheet. If all laboratory QC and field samples have surrogates within limits, narrate the outliers in the Case Narrative.
	LCS	Laboratory acceptance criteria (see Table 4-6 for limits) or 50–150% until sufficient data have been generated for in-house limits	Correct problem; then, if necessary, re-prep and reanalyze the method blank, LCS, and all samples in the batch (including matrix QC) for failed analytes if sufficient sample material is available. If reanalysis cannot be performed, data must be explained in the Case Narrative.
	MS/MSD	Use LCS limits as advisory limits	Review data for errors. For matrix evaluation only; no corrective action required.
	Internal standards	50–200% of ICAL Midpoint standard	Inspect instrument for malfunctions, correct problem, and reanalyze extracts. Review data for possible matrix effect and rerun samples at dilution to bring internal standards into control. If corrective action fails, explain in Case Narrative.
	Surrogates	Laboratory acceptance criteria 44–126% or 50–150% until sufficient data have been generated for in-house limits	Correct problem; then, if necessary, re-prep and reanalyze failed samples for surrogates in the batch if sufficient material is available. If obvious chromatographic interference is present, reanalysis may not be necessary, but the client must be notified prior to reporting data, and failures must be discussed in the Case Narrative.

Table 7-1
Acceptance Limits and Corrective Actions for Laboratory Analyses

Parameter	QC Sample	Acceptance Limits	Corrective Action
SVOCs	Method blank	Less than ½ the LOQ or greater than 1/10th the amount measured in any sample or 1/10th the regulatory limit, whichever is greater. Common contaminants must not be detected > LOQ	Correct problem. Reprocess affected samples in batch. If insufficient sample volume remains for reprocessing or if holding times have been exceeded, the results shall be reported with the appropriate data qualifiers.
	LCS	Laboratory acceptance criteria (see Table 4-6 for limits) or 50–150% until sufficient data have been generated for in-house limits	Correct problem; then, if necessary, re-prep and reanalyze the method blank, LCS, and all samples in the batch (including matrix QC) for failed analytes if sufficient sample material is available. If reanalysis cannot be performed, data must be explained in the Case Narrative.
	MS/MSD	Use LCS limits as advisory limits	Review data for errors. For matrix evaluation only; no corrective action required.
	Internal standards	50–200% of ICAL Midpoint standard	Inspect instrument for malfunctions, correct problem, and reanalyze extracts. Review data for possible matrix effect and rerun samples at dilution to bring internal standards into control. If corrective action fails, explain in Case Narrative.
	Surrogates	Laboratory acceptance criteria 24–134% or 50–150% until sufficient data have been generated for in-house limits	Correct problem, then re-prep and reanalyze failed samples for surrogates in the batch if sufficient material is available. If obvious chromatographic interference is present, reanalysis may not be necessary, but the client must be notified prior to reporting data, and failures must be discussed in the Case Narrative.

Table 7-1
Acceptance Limits and Corrective Actions for Laboratory Analyses

Parameter	QC Sample	Acceptance Limits	Corrective Action
Dioxin/Furans	Method blank	Less than ½ the LOQ, except OCDF and OCDD, which should be less than three times the LOQ, or less than 1/10th the amount measured in any sample or 1/10th the regulatory limit, whichever is greater	Confirm results by reanalyzing method blank. Re-extract and reprocess all associated samples if attributed to processing. Qualify data with B-flags as appropriate.
	Internal standards	25–150% of the continuing calibration verification	Correct problem, then reanalyze the sample(s) with failed internal standards. If corrective action fails in field samples with passing internal standards in laboratory QC, data must be explained in the Case Narrative.
	RM (Puget Sound Reference Material)	See Table 4-6	Review data for errors. If labels are in control for all samples and targets are in control for LCS, describe the issue in the case narrative.
	Extraction (cleanup) standard	35–197%	Review data for matrix effect. Rerun at dilution to prove matrix effect. Re-extract affected sample if attributed to processing error. If insufficient sample volume remains for reprocessing, the results shall be reported with the appropriate data qualifiers and narrated.
	Labeled compounds	See Table 4-6	If matrix affects are noted from perfluorkerosene dropouts, rerun samples at dilution to bring labels into control. If not attributed to matrix effect, re-extract and reanalyze affected sample.
	Laboratory replicate	+/- 25%	For matrix evaluation only. Review data for errors. Flag outliers on summary sheet.

Table 7-1
Acceptance Limits and Corrective Actions for Laboratory Analyses

Parameter	QC Sample	Acceptance Limits	Corrective Action
Ammonia	Method blank	Less than ½ the LOQ or greater than 1/10th the amount measured in any sample or 1/10th the regulatory limit, whichever is greater	Reprocess affected samples in batch. If insufficient sample volume remains for reprocessing or if holding times have been exceeded, the results shall be reported with the appropriate B-flag qualifiers.
	LCS	+/-10%	Correct problem, then, if necessary, re-prep and reanalyze the LCS and all samples in the associated batch if sufficient sample material available. If reanalysis cannot be performed, data must be explained in the Case Narrative.
	Laboratory replicate	+/- 20%	Review data for errors. Matrix QC control limits are advisory, as they are an indication of sample characteristics. Flag outliers.
	MS	+/-25%	For matrix evaluation only. If MS results are outside the limits, the data shall be evaluated to the source of the difference (i.e., matrix effect or analytical error). Explain in the Case Narrative.
Total sulfides	Method blank	Less than ½ the LOQ or greater than 1/10th the amount measured in any sample or 1/10th the regulatory limit, whichever is greater	Reprocess affected samples in batch. If insufficient sample volume remains for reprocessing or if holding times have been exceeded, the results shall be reported with the appropriate B-flag qualifiers.
	LCS	+/-25%	Correct problem; then, if necessary, re-prep and reanalyze the LCS and all samples in the associated batch if sufficient sample material available. If reanalysis cannot be performed, data must be explained in the Case Narrative.
	Laboratory replicate	+/- 20%	Review data for errors. Matrix QC control limits are advisory as they are an indication of sample characteristics. Flag outliers.
	MS	+/-25%	For matrix evaluation only. If MS results are outside the limits, the data shall be evaluated to the source of the difference (i.e. matrix effect or analytical error). Explain in the Case Narrative.

Notes:

Acceptance limits and corrective actions were provided by ARL based on its standard analytical protocols.

ARL: Analytical Resources LLC
CRM: certified reference material
ICAL: initial calibration
LCS: laboratory control sample
LOQ: limit of quantitation
MS: matrix spike
MSD: matrix spike duplicate
OCDD: octachlorodibenzo-*p*-dioxin
OCDF: octachlorodibenzofuran
PAH: polycyclic aromatic hydrocarbon
PCB: polychlorinated biphenyl
QC: quality control
RM: reference material
RPD: relative percent difference
SVOC: semivolatile organic compound
TOC: total organic carbon

7.2 Reports to Management

The FC or designee will prepare a summary email for submittal to LDWG and EPA following each sampling and survey day. The project QA/QC coordinator will also email LDWG and EPA after sampling has been completed and samples have been submitted for analysis. In these progress reports, the statuses of the samples and analyses will be indicated, with emphasis on any deviations from this QAPP. A DER will be written after validated data are available, as described in Section 7.3.

7.3 Data Evaluation Reports

A DER will be prepared documenting all activities associated with the collection, handling, and analysis of samples for each phase of sampling, as specified in AOC5 (EPA 2018). The reports will document the sampling events and present and interpret the analytical results. EPA comments on the Phase I DER will be reflected in subsequent deliverables, rather than in revised versions of that report.

The following base information will be included in the Phase I and II DERs or posted on http://ldwg.org as part of data packages. If Phase III sampling is required, the results and will be included in the 90% design package.

- Summary of all field activities, including descriptions of any deviations from the approved QAPP
- Sampling locations reported in latitude and longitude to the nearest one-tenth of a second and in northing and easting to the nearest foot
- Summary of the chemical data QA/QC review
- Summary of field QC result evaluation
- Summary of the geotechnical data (*in situ* and *ex situ* data results)
- Results of structure inspections, including field inspection forms and structure conditions ratings
- Results of the visual bank inspection, including maps, photographs, video (if used), and detailed observations collected on field inspection forms
- Results from the analyses of field samples; included as summary tables in the main body of the report, data forms submitted by the analytical laboratories, and cross-tab tables produced from the project SQL Server database
- Copies of field logs and photographs
- Copies of chain of custody forms
- Laboratory and data validation reports
- Results of focused topographic surveys and additional shoreline/bank survey data collected during Phase II efforts

Once the data in the DERs have been approved by EPA, the bioassay results and the chemistry database exports will be created from the project SQL Server database. The chemistry data will be exported in two formats: one that is compatible with Ecology's Environmental Information Management (EIM) system, and one that is compatible with EPA's Scribe database. The bioassay data will be exported in a format that is compatible with EIM. The exported data files will be uploaded to EIM and EPA Scribe databases, and a copy of the EPA Scribe EDDs will be provided to EPA per AOC5 deliverable requirements. The EIM Study ID will be included in the Phase II DER. Based on preliminary reconnaissance, geotechnical data are not planned to be collected during Phase I but will be collected during Phase II. They will be presented in the Phase II DER as an appendix to the document or posted on http://ldwg.org in the data package.

As described in Section 6.1.4 of the RDWP (Anchor QEA and Windward 2022b), the DERs will also contain an interpolation of the data in order to define RAL exceedance area boundaries, depths, technologies, and remaining data needs for the next phase.

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FINAL

Appendix A
Health and Safety Plan

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Appendix B
Archaeological Monitoring and Inadvertent Discovery Plan

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Appendix C
Field Forms

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Appendix D
Sampling Location Details

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Appendix E
SOPs

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Appendix F
Site-specific Dive Safety and Work Plan

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Appendix G
Analytical Methods and Reporting Limits

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