Lower Duwamish Waterway Group

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

QUALITY ASSURANCE PROJECT PLAN: SEDIMENT TRANSPORT CHARACTERIZATION

FINAL

For submittal to

The US Environmental Protection Agency
Region 10
Seattle, WA

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

November 19, 2004

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TITLE AND APPROVAL PAGE
SEDIMENT TRANSPORT CHARACTERIZATION
QUALITY ASSURANCE PROJECT PLAN

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Windward Field Coordinator	Name	Date
Windward QA/QC Manager	Name	Date
EPA Project Manager	Name	Date
EPA QA/QC Manager	Name	Date
Ecology Project Manager	Name	Date

Distribution List

This list identifies all individuals to receive a copy of the approved QA Project Plan, either in hard copy or electronic format, as well as any subsequent revisions.

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Tad Deshler, Windward Task Manager

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Craig Jones, Sea Engineering field coordinator

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Chemistry Laboratory Managers:
- Hewitt Jeter, Mass Spec Services
- Sue Dunnihoo, Analytical Resources, Inc.
- Richard Karuhn, Particle Technologies Lab, Ltd.

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Acronyms

Acronym	Definition
ARI	Analytical Resources, Inc.
CAS	Chemical Abstracts Services
COC	chain of custody
CSM	conceptual site model
DQO	data quality objective
DQI	data quality indicator
Ecology	Washington Department of Ecology
EPA	US Environmental Protection Agency
FC	field coordinator
FS	feasibility study
GPS	global positioning system
HSP	health and safety plan
IDW	inverse distance weighted
LDW	Lower Duwamish Waterway
LDWG	Lower Duwamish Waterway Group
MDL	method detection limit
MLLW	mean lower low water
OSHA	Occupational Safety and Health Administration
PCB	polychlorinated biphenyl
PM	project manager
PSEP	Puget Sound Estuary Program
PTL	Particle Technology Labs, Ltd.
QA/QC	quality assurance/quality control
QAPP	quality assurance project plan
QEA	Quantitative Environmental Analysis, LLC
RI	remedial investigation
RM	river mile
SDG	sample delivery group
TM	task manager
TOC	total organic carbon
Windward	Windward Environmental LLC

1.0 Introduction

This quality assurance project plan (QAPP) describes the quality assurance (QA) objectives, methods, and procedures for collecting and analyzing data to characterize sediment transport in the Lower Duwamish Waterway (LDW) Remedial Investigation (RI) study area. As described in the Phase 2 RI work plan (Windward 2004c), the results of these analyses will aid in designing the subsurface sediment sampling program and will refine the preliminary conceptual site model (CSM) for sediment transport presented in the Phase 1 RI report (Windward 2003). In addition, these results will be used in the feasibility study (FS) to evaluate remedial alternatives. This QAPP presents the design for the sediment transport characterization, including details on project organization, field data collection, laboratory and data analyses, and data management.

Sediment transport will be characterized in a phased approach. The first phase consists of field work and data analysis, followed by a decision point at which the need for sediment transport modeling will be discussed among the Lower Duwamish Waterway Group (LDWG), the US Environmental Protection Agency (EPA), and the Washington Department of Ecology (Ecology). If such modeling is required, it would be conducted during the second phase of the sediment transport characterization. The decision on whether to apply a sediment transport model will be based on whether components of the CSM require further evaluation, beyond that provided by the studies being conducted as described in this QAPP. The specific type of modeling would be based on the CSM component requiring further evaluation and the results of field work and data analysis conducted during the first phase.

EPA guidance for QAPPs (2002b)was followed in preparing this project plan. The remainder of this plan is organized into the following sections:

- Section 2 – Project management
- Section 3 – Data generation and acquisition
- Section 4 – Assessment and oversight
- Section 5 – Data validation and usability
- Section 6 – References
- Section 7 – Full-page color figures

Appendix A is a health and safety plan (HSP) designed to protect on-site personnel from physical, chemical, and other hazards posed by the field sampling effort. Field data collection forms are included as Appendix B.

2.0 Project Management

This section describes the overall management of the project. Elements addressed include project organization and key personnel, problem definition and background, project description and scheduling, quality objectives and criteria, special training requirements and certification, and documentation and records.

2.1 Project Organization

The overall project organization and the individuals responsible for the various tasks required for sediment transport data collection and analyses are shown in Figure 2-1. Responsibilities of project team members, as well as laboratory project managers, are described in the following sections.

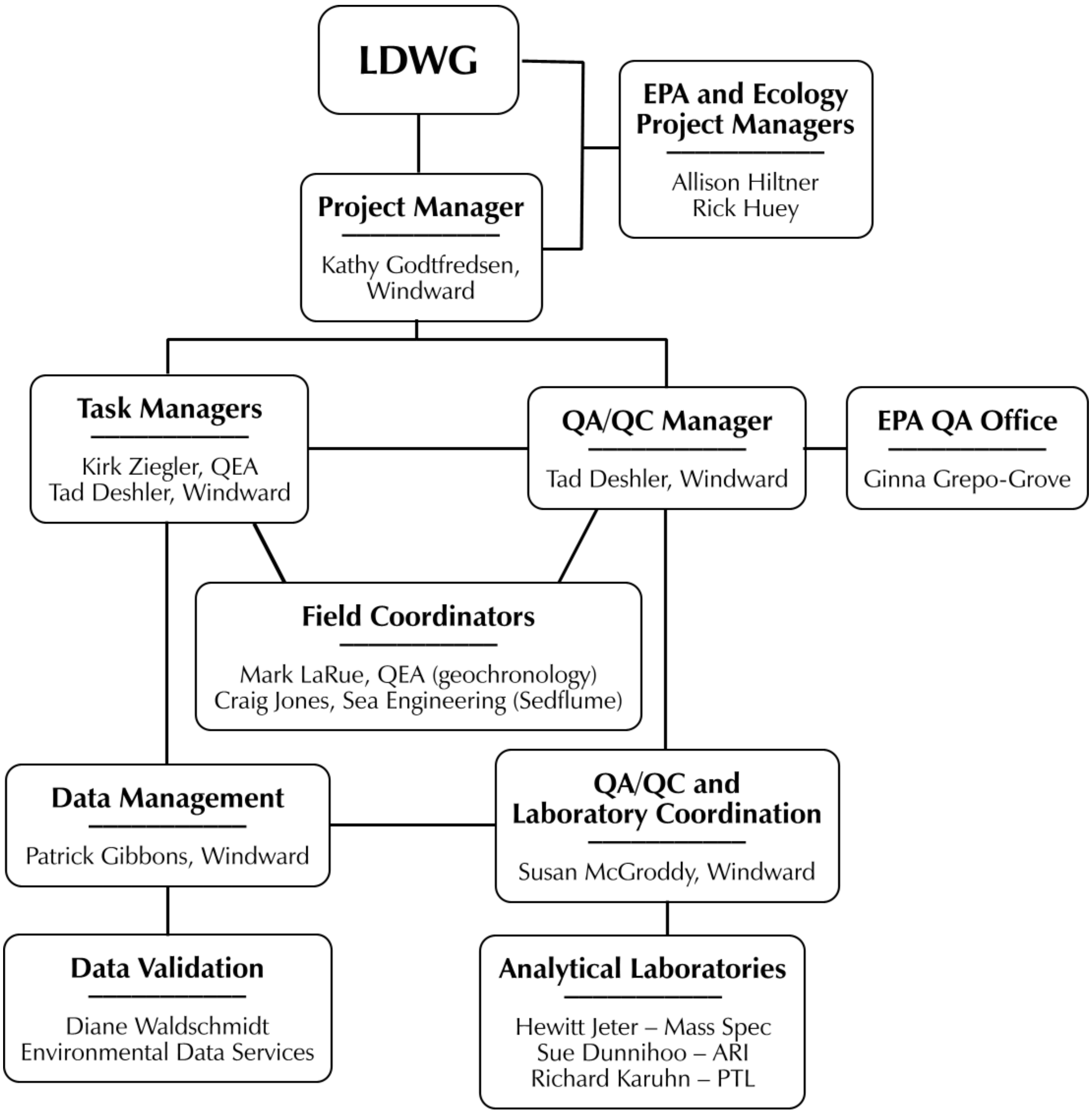

Figure 2-1. Project organization and team responsibilities

2.1.1 Project management

LDWG, EPA, and Ecology will be involved in all aspects of this project, including discussion, review, and approval of the QAPP, and interpretation of the results of the investigation. EPA and Ecology will be represented by their project managers (PMs) for this project, Allison Hiltner and Rick Huey, respectively.

Kathy Godtfredsen will serve as the Windward PM, responsible for overall project coordination and providing oversight on planning and coordination, work plans, all project deliverables, and performance of the administrative tasks needed to ensure timely and successful completion of the project. She will also be responsible for coordinating with LDWG, EPA, and Ecology on schedule, deliverables, and other administrative details. Dr. Godtfredsen can be reached as follows:

Kathy Godtfredsen
Windward Environmental LLC
200 W. Mercer St., Suite 401
Seattle, WA 98119
Telephone: 206.577.1283
Facsimile: 206.217.0089
E-mail: kathyg@windwardenv.com

Tad Deshler will serve as the Windward Task Manager (TM) and Kirk Ziegler will serve as the QEA TM. The TMs are responsible for project planning and coordination, production of work plans, production of project deliverables, and performance of the administrative tasks needed to ensure timely and successful completion of the project. The TMs are responsible for communicating with the Windward PM on progress of project tasks and any deviations from the QAPP. Significant deviations from the QAPP will be further reported to LDWG, EPA, and Ecology. Mr. Deshler and Dr. Ziegler can be reached as follows:

Tad Deshler
Windward Environmental LLC
200 W. Mercer St., Suite 401
Seattle, WA 98119
Telephone: 206.577.1285
Facsimile: 206.217.0089
Email: tad@windwardenv.com

Kirk Ziegler
Quantitative Environmental Analysis, LLC
305 West Grand Ave, Suite 300
Montvale, NJ 07645
Telephone: 201.930.9890 ext. 12
Facsimile: 201.930.9805
Email: kziegler@qeallc.com

2.1.2 Field coordination

Two separate field efforts will be conducted (see Section 3.1 for the study design) and each will have a separate field coordinator (FC). Mark LaRue (QEA) will oversee the collection of the geochronology sediment core samples and Craig Jones (Sea Engineering) will serve as FC for the Sedflume sampling. Each FC is responsible for managing the field sampling activities and general field and quality assurance/quality control (QA/QC) oversight. They will ensure that appropriate protocols for sample collection, preservation, and holding times are observed and will oversee delivery of environmental samples to the designated laboratories for analyses. Deviations from this QAPP will be reported to the Windward and QEA TMs and the Windward PM for consultation. Significant deviations from the QAPP will be further reported to representatives of LDWG, EPA, and Ecology. The FCs can be reached as follows:

Mark D. LaRue
Quantitative Environmental Analysis, LLC
290 Elwood Davis Road, Suite 230
Liverpool, NY 13088
Telephone: 315.453.9009
Facsimile: 315.453.9010
Email: mlarue@qeallc.com

Craig Jones
Sea Engineering, Inc.
200 Washington St., Suite 210
Santa Cruz, CA 95060
Telephone: 831.421.0871
Facsimile: 831.421.0875
Email: cjones@seaengineering.com

2.1.3 Quality assurance/quality control

Tad Deshler of Windward will oversee QA/QC for the project. As the QA/QC manager, he will oversee coordination of the field sampling and laboratory programs, and supervise data validation and project QA coordination, including coordination with the EPA QA officer, Ginna Grepo-Grove.

Ms. Grepo-Grove can be reached as follows:

Ginna Grepo-Grove
US Environmental Protection Agency, Region 10
1200 6th Avenue
Seattle, WA 98101
Telephone: 206.553.1632
Email: grepo-grove.gina@epa.gov

Susan McGroddy will serve as Windward's QA/QC coordinator for chemical and physical analyses. Dr. McGroddy can be reached as follows:

Susan McGroddy
Windward Environmental LLC
200 W. Mercer St., Suite 401
Seattle, WA 98119
Telephone: 206.577.1292
Facsimile: 206.217.0089
Email: susanm@windwardenv.com

Independent third-party chemical data review and validation will be provided by Diane Waldschmidt of Environmental Data Services LLC. Ms. Waldschmidt can be reached as follows:

Diane Waldschmidt
Environmental Data Services, LLC
2690 Oak Hill Dr.
Allison Park, PA 15101
Telephone: 412.486.6989
Email: edatas@aol.com

2.1.4 Laboratory project management

Susan McGroddy of Windward will serve as the laboratory coordinator for the analytical chemistry laboratories. Mass Spec Services will perform the ^{137}Cs and ^{210}Pb analyses of the sediment cores. Analytical Resources, Inc. (ARI) will perform conventional analyses on the geochronology sediment samples. Particle Technology Labs, Ltd. (PTL) will perform the grain size analysis on the Sedflume sediment samples.

The laboratory PM at Mass Spec Services can be reached as follows:

Hewitt Jeter
Mass Spec Services
103 South Greenbush Road
Orangeburg, NY 10962
Telephone: 845.359.1151
Email: hewittjeter@aol.com

The laboratory PM at ARI can be reached as follows:

Sue Dunnihoo
Analytical Resources, Inc.
4611 S. 134th Place, Suite 100
Tukwila, WA 98168-3240
Telephone: 206.695.6207
Email: sue@arilabs.com

The laboratory PM at PTL can be reached as follows:

Richard Karuhn
Particle Technologies Labs, Ltd.
555 Rogers St.
Downers Grove, IL 60515
Telephone: 630.969.2703
Email: experts@particletechlabs.com

The laboratories will accomplish the following:

- 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

Sedflume sediment cores will be processed and analyzed in a shoreside laboratory established specifically for this project. Craig Jones (see contact information in Section 2.1.2) will oversee the development and operation of this laboratory and analyses of the Sedflume sediment cores.

2.1.5 Data management

Patrick Gibbons of Windward will oversee data management, and ensure that analytical data are incorporated into the LDWG database with appropriate qualifiers following acceptance of the data validation. QA/QC of the database entries will ensure accuracy for use in Phase 2.

2.2 Problem Definition and Supporting Information

The transport and fate of particle-bound chemicals, (e.g., polychlorinated biphenyls [PCBs]), in the LDW are affected by sediment transport processes in this estuarine system. Consequently, a credible analysis of particle-reactive chemical transport and fate in the LDW cannot be accomplished without first understanding sediment transport processes (e.g., sedimentation, erosion, and transport). Information and insights about LDW sediment transport gained from the present study will be used in subsequent investigations that are aimed specifically at assessing chemical transport and fate and investigating the efficacy of various remedial alternatives. Specifically, the information obtained during this sediment transport study will be used to:

- identify areas suitable for monitored natural recovery, in-situ capping, or near-water confined disposal facilities (EPA 2002a)
- evaluate capping construct requirements (i.e., armoring)
- evaluate the potential for erosion from propeller wash
- evaluate chemical transport and the potential for recontamination to support source control decisions

Sediment transport in the LDW has been studied for several decades, both across the entire LDW and at specific sites within the LDW (Table 2-1). The Phase 1 RI

(Windward 2003) summarized the information from the historical sediment transport studies, some of which included modeling efforts, and included additional analyses of some of the historical data. Analyses conducted during the Phase 1 RI included temporal comparisons of bathymetry and sediment morphology data to evaluate sediment stability, comparison of measured current velocities within the LDW to estimated critical velocities for scour from other studies outside the LDW (Striplin et al. 1985), estimates of total suspended and bedload solids loading from upstream sources, and review of previous sediment transport studies.

Table 2-1. Sediment transport studies within the LDW

Author and Date	Portion of LDW	Type of Sediment Transport Information
Santos and Stoner (1972)	Salt wedge extent (approximately RM 4.5)	Suspended sediment load, sediment bedload
Stevens Thompson & Runyan (1972)	Navigation channel	Suspended sediment load, sediment bedload, areas of deposition, sediment accumulation rates
Harper-Owes (1981)	Entire LDW	Suspended sediment load, relative suspended sediment inputs
Harper-Owes (1983)	Entire LDW	Suspended sediment load, relative suspended sediment inputs, sediment accumulation rates
Weston (1993)	South of Harbor Island to approximately RM 1.0	Sedimentation rates based on sediment traps and radioisotope dating of sediment cores
McLaren and Ren (1994)	Navigation channel bottom	Sediment transport direction, areas of erosion, deposition, or dynamic equilibrium
King County (1999)	Entire LDW	Sediment erosion potential; deposition rates for grid areas within the LDW calculated from sediment mass balance/hydrodynamics
Pentec et al. (2001)	RM 2.9 to 3.7 (east bank)	Sediment erosion and recontamination potential
King County (2001)	RM 0.3 to 1.0 (east bank)	Sediment natural recovery, erosion and recontamination potential

RM – river mile

The discussion of sediment transport in the Phase 1 RI focused on sedimentation and bed erosion. Previous studies have examined sedimentation rates and patterns in the LDW (Harper-Owes 1983; Windward 2003). Those studies focused on sedimentation in the navigation channel; see Figure 4-7 and Table 4-17 in the Phase 1 RI (Windward 2003). Estimated sedimentation rates in the navigation channel range from 1 to 110 cm/yr. However, few data are available on sediment bed elevation changes in the shallower bench[1] areas of the LDW. Thus, one of the objectives of this QAPP is to collect site-specific data in LDW bench areas.

[1] The sediment bench refers to the shallow subtidal (i.e., sediment elevation < -5 ft to ≧ -20 ft MLLW) or intertidal (i.e., sediment elevation > -5 ft MLLW) sediment bed between the deeper navigation channel in the center of the LDW and the banks on either side of the LDW.

At present, there are no site-specific data to describe sediment bed erosion in the LDW. Estimates of LDW current velocities and bottom shear stresses, which exert hydrodynamic forces on the surface of the sediment bed, were made using current velocity data and modeling during the Phase 1 RI (Windward 2003). The results of those analyses, however, were not sufficient to develop a comprehensive evaluation of hydrodynamic impacts on sediment bed erosion within the LDW. A preliminary analysis of anthropogenic effects (e.g., ship propeller forces) on sediment bed scour has been conducted for the berthing areas of the Duwamish/Diagonal site (King County et al. 2003) and for the area offshore of Boeing Plant 2 (Pentec et al. 2001). Thus, a second objective of this QAPP is to collect site-specific data on sediment erosion potential in the LDW.

Other results from the Phase 1 RI that will be helpful for the sediment transport work described in Section 3.1 are:

- Estimate of total suspended solids loading from upstream sources; see Section 4.4.2.2 of Windward (2003)
- Analysis of bathymetric survey data collected in various portions of the LDW during 1998, 2000, and 2001; see Section 4.4.2.5 of Windward (2003)

The Phase 1 RI summarized useful information on sediment processes and yielded a basic understanding of sediment transport in the system. However, as described in the Phase 2 RI work plan (Windward 2004c), additional data are needed to develop a concise description of LDW sediment transport processes. The work plan described a phased process in which field data on sedimentation and erosion, described in Section 3.1, will be collected and combined with existing sediment transport data and analyses in a weight-of-evidence approach to evaluate whether additional data or modeling are needed to describe sediment stability within the LDW. This phased approach is described in detail in this QAPP.

Thus, the overall study described in this QAPP has three objectives:

- Collect additional sedimentation data in bench areas to supplement existing sedimentation data in the channel. These data will be used to evaluate the depositional nature of the bench areas in the LDW.
- Collect additional data regarding erosion potential as a function of sediment characteristics (i.e., grain size) and sediment elevation to allow for an evaluation of the effects of natural (e.g., hydrodynamics) and anthropogenic (e.g., ship propeller wash) forces on bed scour in the LDW.
- Evaluate the data collected on sedimentation and erosion potential in conjunction with existing data and analyses to determine if additional field data or modeling are needed to refine the CSM describing sediment transport in the LDW. This updated CSM will describe the critical sediment transport processes in the LDW, and provide greater confidence in any subsequent investigation of chemical transport and fate in the system.

A preliminary CSM was developed in the Phase 1 RI. In general, a CSM is a narrative or graphical representation of processes that influence the transport and fate of physical media (e.g., water, soil, sediment, air) within a study area of interest. CSMs can also have both spatial and temporal scales. The CSM presented in the Phase 1 RI was considered to be preliminary because sufficient information and data were not available during the Phase 1 RI to confirm it. Based on the data available for the Phase 1 RI, the preliminary CSM concluded:

- The LDW is net depositional on a site-wide scale
- On a local scale, the sediment bed is either aggrading (i.e., sediment bed elevation increasing as a result of sediment deposition) or in dynamic equilibrium (i.e., sediment bed elevation is neither increasing nor decreasing)
- Bed erosion occurs episodically and over small spatial scales

Thus, an important objective of the sediment transport characterization described in this QAPP is to further assess and test this CSM by gathering additional site-specific data to describe the critical sediment transport processes in the LDW. Through an increased understanding of LDW sediment transport processes, the transport and fate of chemicals bound to sediment particles and remedial alternatives that may be applicable to the system can be evaluated with increased confidence.

2.3 PROJECT DESCRIPTION AND SCHEDULE

The phased approach described briefly in this section and in greater detail in Section 3.1 is a combination of field data collection and modeling analyses that will focus on testing and refining the preliminary CSM, as described in Section 2.2. This will be accomplished by using results from various analyses (i.e., lines of evidence) in a weight-of-evidence approach.

Three tasks are described in this QAPP to characterize sediment dynamics in the LDW and to assess whether the preliminary CSM, or a refined modification of it, is understood with sufficient confidence to be used in other components of the Phase 2 RI/FS. These tasks are:

- Task 1: Further evaluate sedimentation in the LDW, particularly in bench areas (see Section 3.1.1)
- Task 2: Further analyze sediment erosion potential as a function of sediment characteristics and elevation (see Section 3.1.2)
- Task 3: Assess existing data and the results of Tasks 1 and 2 to refine the preliminary CSM and determine if any additional data or analyses are needed for the Phase 2 RI (see Section 3.1.3)

Tasks 1 and 2 include field and laboratory components. The data collected under Tasks 1 and 2 will be submitted to EPA and Ecology in a sediment transport data report. The third task (see Section 3.1.3) will use results from Tasks 1 and 2 as lines of evidence for evaluating and refining, if necessary, the preliminary CSM. At the conclusion of Task 3, a decision point in the study will be reached, which will be documented in the sediment transport data analysis report (see Section 3.1.3). If the primary objective of the sediment transport characterization is accomplished (i.e., a refined version of the preliminary CSM for LDW sediment transport is supported by a sufficient body of evidence), then the study will be complete. However, if it is determined that the results from Tasks 1 and 2 and existing data indicate further evaluation of various components of the CSM is required, then two additional tasks will be performed:

- Task 4: Develop and apply a sediment transport model for the LDW (see Section 3.1.4)
- Task 5: Construct a revised CSM, if needed (see Section 3.1.5)

Alternatively, at the conclusion of Task 3, additional data needs may be identified as part of Task 3 that require resolution before a decision can be made about whether Tasks 4 and 5 are necessary. Additional data needs, if any, will be identified in the sediment transport data analysis report. Because such data needs cannot be specified at this time, no specific task has been identified in this QAPP for additional data collection beyond those tasks described briefly above, and in greater detail in Section 3.1.

The detailed schedule for Tasks 1, 2, and 3 is presented in Table 2-2. Start and end dates are specified because the Phase 2 project schedule included with the Phase 2 RI work plan (Windward 2004c) was only preliminary for the sediment transport task; the study design had not been developed at that time. Dates for some of the elements included in Table 2-2 (i.e., draft final and final documents) are estimates only because they are dependent on the timing and complexity of comments received on draft documents. Note that the schedule assumes weather conditions that are favorable to the collection of the geochronology and Sedflume cores; it does not consider any potential delays that could occur in the event that unfavorable weather conditions are experienced in the field during sample collection. Once this QAPP is approved by EPA and Ecology, the dates specified in the final version of Table 2-2 will replace the dates shown in the Phase 2 RI project schedule for the sediment transport task. Tasks 1, 2, and 3 of the project are estimated to require approximately eight months. A schedule for Tasks 4 and 5 has not been developed because of uncertainty in the data needs for a sediment transport model and associated field studies to fill those data needs. If Tasks 4 and 5 are necessary, there may be insufficient time to complete the QAPP for the field work associated with sediment transport modeling and conduct the modeling within the current schedule for delivery of the Phase 2 RI report to EPA (currently scheduled for October 2006). If these tasks are necessary, LDWG will discuss the effect of the timing of this work on the overall project schedule with EPA and Ecology prior to beginning work on these tasks.

Table 2-2. Project schedule

Task	Subtask	Start Date	Finish Date
Task 1: Evaluate depositional environment	Geochronology field work	Dec 6, 2004	Dec 17, 2004
Task 1	Geochronology laboratory analysis	Dec 13, 2004	Jan 14, 2005
Task 2: Analyze erosion potential	Sedflume field work and laboratory analysis	Dec 6, 2004	Dec 23, 2004
Task 1	Bathymetric data analysis	Dec 13, 2004	Jan 14, 2005
Task 2	Sedflume data analysis	Jan 3, 2005	Jan 21, 2005
Task 1	Geochronology data analysis	Jan 17, 2005	Feb 25, 2005
Task 2	Hydrodynamic/bed scour analysis	Jan 3, 2005	Feb 25, 2005
Tasks 1 and 2	Sediment transport data report: draft to EPA [a]	Dec 13, 2004	Mar 11, 2005
Tasks 1 and 2	Sediment transport data report: draft final to EPA [b]	Mar 14, 2005	May 13, 2005
Tasks 1 and 2	Sediment transport data report: final to EPA [b]	May 16, 2005	May 27, 2005
Task 3: CSM confirmation	Sediment transport data analysis report: draft to EPA	Feb 28, 2005	May 6, 2005
Task 3: CSM confirmation	Sediment transport data analysis report: draft final to EPA [b]	May 9, 2005	Jul 1, 2005
Task 3: CSM confirmation	Sediment transport data analysis report: final to EPA [b]	Jul 5, 2005	Jul 22, 2005

[a] Data report includes results from geochronology and Sedflume analyses

[b] Dates for these elements are estimates only and are dependent on the timing and complexity of the comments received on the draft documents.

2.4 Quality Objectives and Criteria for Physical and Chemical Measurement Data

The overall data quality objectives (DQOs) for the collection of data to assess sediment transport are 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, comparability, completeness, and sensitivity. These parameters are discussed, and specific data quality indicators (DQIs) for laboratory analyses are presented in Section 3.4.2.

2.5 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. Federal regulation 29CFR1910.120 requires training to provide employees with the knowledge and skills enabling 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 course and annual 8-hour refresher courses, as necessary, to meet the OSHA regulations (see Appendix A).

2.6 DOCUMENTATION AND RECORDS

This section describes documentation and records needed for field activities and laboratory analyses. In addition, the data reduction process and contents of the data report are described. This section does not describe the contents of the data analysis report because the specific analyses that may be conducted are dependent, in part, on the results obtained during Tasks 1 and 2.

2.6.1 Field observations

All field activities will be recorded in a field logbook maintained by the FC. The field logbook will provide a description of all sampling activities, conferences associated with field sampling activities, sampling personnel, and weather conditions, plus 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. All entries will be made in indelible ink. The field logbook is intended to provide sufficient data and observations to enable participants to reconstruct events that occurred during the sampling period.

The following field data collection forms, included as Appendix B, will also be used to record pertinent information during sample collection:

- sediment collection form
- protocol modification form
- corrective action form
- Sedflume core collection form
- Sedflume core analysis form
- Bulk density data sheet

2.6.2 Laboratory records

Laboratories will be responsible for internal checks on sample handling and analytical data reporting, and will correct errors identified during the QA review. The laboratory data package will be submitted electronically and will include the following:

- **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 quality control, sample shipment, sample storage, and analytical difficulties. Any problems encountered by the laboratory, and their resolutions, will be documented in the project narrative. In addition, operating conditions for instruments used for the analysis of each suite of analytes and definitions of laboratory qualifiers will be provided.
- **Records**: Legible copies of the chain-of-custody (COC) forms will be provided as part of the data package. This documentation will include the time of receipt

and the condition of each sample received by the laboratory. Additional internal tracking of sample custody by the laboratory will also be documented.

- **Sample results**: The data package will summarize the results for each sample analyzed. The summary will include the following information, when applicable:
  - field sample identification code and the corresponding laboratory identification code
  - sample matrix
  - date of sample extraction/digestion
  - date and time of analysis
  - weight and/or volume used for analysis, including final dilution volumes or concentration factor for the sample
  - percent moisture in the samples
  - identification of the instruments used for analysis
  - method detection and reporting limits
  - 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 be documented with the same information required for the sample results (see above). The laboratory will make no recovery or blank corrections. The required summaries are listed below.
  - The calibration data summary will contain the concentrations of the initial calibration and daily calibration standards and the date and time of analysis.
  - The method blank analysis summary will report the method blank analysis associated with each sample and the concentrations of all radioisotopes of interest identified in these blanks.
  - The matrix spike recovery summary will report the matrix spike or matrix spike/matrix spike duplicate recovery data for analyses, as appropriate. The names and concentrations of all compounds added, percent recoveries, and QC limits will be included in the data package. The RPD for all matrix spike and matrix spike duplicate analyses will be reported.
  - The matrix duplicate summary will report the RPD for all matrix duplicate analyses. The QC limits for each compound or analyte will be listed.
  - The laboratory control analysis summary will report the results of the analyses of laboratory control samples. The QC limits for each compound or analyte will be included in the data package.

- **Original data:** Legible copies of the original data generated by the laboratory will be provided, including the following:
  - sample refrigerator temperature logs
  - sample extraction/digestion, preparation, and cleanup logs
  - instrument specifications and analysis logs for all instruments used on days of calibration and analysis
  - original data quantification reports for each sample

The contract laboratories for this project will submit data electronically, in Microsoft Excel® format. Guidelines for electronic data deliverables for chemical data are as follows:

- Each row of data will contain only one analyte for a given sample. Therefore, one complete sample will require multiple rows.
- Each row should contain the following information at a minimum: Windward sample identifier, sample matrix, laboratory sample identifier (if used), date of sampling, date of laboratory analysis, laboratory method, analyte name, measured result, laboratory qualifiers, units, and measurement basis.
- If using a spreadsheet file to produce the electronic deliverable, the value representing the measured concentration or detection limit will be rounded to show the correct number of significant figures and will not contain any trailing digits that are hidden in the formatting.
- If using a database program to produce the electronic deliverable, the value representing the measured concentration or detection limit will be stored in a character field, or a field in addition to the numeric result field will be provided to define the correct number of significant figures.
- If a result for an analyte is below the detection limit, the laboratory qualifier will be U, and the value in the result column will be the sample-specific detection limit.
- Analytical results of laboratory samples for QA/QC will be included and clearly identified in the file with unique laboratory sample identifiers. Additional columns may be used to distinguish the sample type (e.g., matrix spike, matrix spike duplicate).
- If replicate analyses are conducted on a submitted field sample, the laboratory sample identifier must distinguish among the replicates.
- Wherever possible, all analytes and replicates for a given sample will be grouped together.

An example of the acceptable organization of the electronic deliverable for analytical chemistry data is provided in Table 2-3.

Table 2-3. Example of acceptable organization of electronic deliverable for analytical chemistry data

FIELD NAME	REQUIRED OR OPTIONAL
Event name	Required
Chain of custody ID	Required
Laboratory sample ID	Required
Matrix	Required
Sample collection date/time	Required
Requested analysis	Required
Analyte	Required
Chemical Abstracts Services (CAS) registry number	Required
Date/time analyzed	Required
Detection limit	Required
Reporting limit	Required
Reporting limit type	Required
Sample result	Required
Units	Required
Number of significant figures	Required
Laboratory qualifier	optional [a]
Analysis batch	Required
Analyst	Required
Dilution	Required
Extraction batch	Required
Extraction date/time	Required
Extraction method	Required
Laboratory notes	Optional
Laboratory	Required

[a] Required when available. Not all samples are qualified. Blanks and laboratory control standards have no percent moisture. Field samples have no percent recovery.

Laboratory data will also be generated from the Sedflume analysis, but it will be in a different format than the chemistry data described above. An electronic data deliverable will also be provided for the Sedflume analysis, following the structure shown in Table 2-4.

Table 2-4. Example of acceptable organization of electronic deliverable for Sedflume data

FIELD NAME	REQUIRED OR OPTIONAL
Event name	Required
Sample ID	Required
Sample collection date/time	Required
Date/time analyzed	Required
Applied shear stress	Required
Duration of applied shear stress	Required
Starting depth (relative to core surface)	Required
Ending depth (relative to core surface)	Required
Calculated erosion rate	Required
Dry density	Required

FIELD NAME	REQUIRED OR OPTIONAL
Units	Required
Number of significant figures	Required
Notes	Optional

2.6.3 Data reduction

Data reduction is the process by which original data (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 are subjected to further review by the laboratory PM, the Windward PM, the Project QA/QC Coordinator, and independent reviewers. The data will be generated in a form amenable to review and evaluation. Data reduction may be performed manually or electronically. If performed electronically, all software used must be demonstrated to be true and free from unacceptable error.

2.6.4 Data report

A data report will be prepared documenting all activities associated with the collection, handling, and analysis of samples in Tasks 1 and 2. Specifically, the raw data for the geochronology samples and Sedflume analyses will be included in the data report, without interpretation. The interpretation of these results, along with other information evaluated during Tasks 1 and 2, will be presented in the sediment transport data analysis report as part of Task 3. At a minimum, the following will be included in the data report:

- 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
- plan view of the study area showing the actual sampling locations
- summary of the QA/QC review of the physical and chemical data
- copies of field logs (appendix)
- copies of COC forms (appendix)
- data validation report (appendix)
- results from the analyses of field samples, both as summary tables in the main body of the report and appendices with data forms submitted by the laboratories and as cross-tab tables produced from Windward's database

Chemical data will be validated within four weeks of receiving data packages from the respective laboratories. A draft data report will be submitted to EPA and Ecology four weeks after receipt of the validated analytical results. A final data report will be submitted to EPA and Ecology three weeks after receiving comments on the draft report.

3.0 Data Generation and Acquisition

This section describes the study design and methods that will be used to assess sediment transport in the LDW, including methods to collect, process, and chemically and physically analyze sediment samples collected from the LDW. Elements include sampling design, sampling methods, sample handling and custody requirements, analytical chemistry methods, QA/QC, instrument/equipment testing, inspection and maintenance, instrument calibration, supply inspection/acceptance, non-direct measurements, and data management.

3.1 Sampling Design

The primary objective of this sediment transport characterization is to improve and refine the CSM for LDW sediment transport. The study design is based on a weight-of-evidence approach to assess the preliminary CSM for sediment transport in the LDW. The preliminary CSM assumes:

- The LDW is net depositional on a site-wide scale
- On a local scale, the sediment bed is either aggrading or in dynamic equilibrium
- Bed erosion occurs episodically and over small spatial scales

The project is focused on the preliminary CSM, which will be tested and refined as necessary during the study, with the ultimate goal being development of a CSM for sediment transport that supports future remedial design activities. Only after the sediment transport processes in the LDW are understood can an analysis of chemical transport and fate be conducted with reasonable confidence. As such, the results of the present study will be used in subsequent investigations that are aimed specifically at assessing chemical transport and fate and investigating the efficacy of various remedial alternatives.

This sediment transport characterization will consist of up to five tasks to test and refine the CSM:

- **Task 1:** Evaluate sedimentation processes in the LDW
- **Task 2:** Analyze erosion potential
- **Task 3:** Assess the preliminary CSM using existing data and data collected as part of Tasks 1 and 2
- **Task 4:** Model sediment transport (if needed to improve the CSM)
- **Task 5**: Construct a revised CSM (if needed)

These tasks will be conducted in a phased approach. The first three tasks are described in detail in this QAPP because they will be conducted as Phase 1 of the sediment transport characterization. At the conclusion of Task 3, a decision point will be reached. If the CSM for LDW sediment transport is sufficient to facilitate a subsequent evaluation of chemical transport and fate in the LDW, then the characterization is complete. If it is determined, however, that components of the CSM require further evaluation, then either additional data will be collected through an addendum to this QAPP or Tasks 4 and 5 of the study will be conducted. If Tasks 4 and 5 are needed, a separate QAPP addendum for that work will be developed at that time. Consequently, Tasks 4 and 5 are described only briefly in this QAPP.

3.1.1 Task 1: Evaluation of LDW depositional environment

This task will address issues related to the depositional environment within the LDW. The data collection and analysis efforts described in this section are designed to provide lines of evidence to test the following key assumptions of the CSM:

- the LDW is net depositional on a site-wide scale
- on a local scale, the sediment bed is either aggrading or in dynamic equilibrium

As described in Section 2.2, additional data and information are needed about the sediment dynamics within the depositional environment of the bench areas. Thus, the primary objectives of Task 1 are:

- collect and analyze sedimentation data from the bench areas
- develop an improved understanding of the depositional environment within the LDW by combining bench-area data with existing navigation channel data/information and other bathymetric data analyses

Sedimentation data for the bench areas will be obtained from a geochronology study. The methods for the geochronology work are described in Section 3.2.1. As part of this study, high-resolution sediment cores will be collected from the LDW bench areas; cores will not be collected from the navigation channel because some sedimentation rate information already exists for this portion of the LDW, which has been disturbed by dredging and is therefore less amenable to this type of analysis (Windward 2003). The cores are referred to as "high-resolution" because each core is sliced into 1-cm segments and selected segments are submitted for radioisotope analyses (i.e., lead-210 [^{210}Pb] and cesium-137 [^{137}Cs] concentrations). The vertical segmentation scheme for this study is consistent with EPA (2002a) guidance and has been successfully employed in geochronology investigations at other sites (Alcoa 2001). Analysis of the vertical profiles of these isotopes, combined with stratigraphic information, should produce: 1) an estimate of the average net sedimentation rate, and 2) qualitative information concerning the sediment transport regime at a core location (e.g., depositional, episodic erosion).

Theoretical basis

The radioisotopes ^{137}Cs and ^{210}Pb are used to age-date sediments and establish sedimentation rates in estuarine and freshwater systems (Olsen et al. 1978; Orson et al. 1990). ^{137}Cs concentrations in sediments are derived from atmospheric fallout from nuclear weapons testing. The first occurrence of ^{137}Cs in sediments generally marks the year 1954, while peak concentrations correspond to 1963 (Simpson et al. 1976). Based on these dates, long-term average sedimentation rates can be computed by dividing the depth of sediment between the sediment surface and the buried ^{137}Cs peak by the number of years between 1963 and the time of core collection (e.g., 41 years for a core collected in 2004). Sediment core dating using ^{137}Cs has been successfully accomplished in East and West Waterway sediment areas adjoining the LDW (EVS and Hart Crowser 1995).

^{210}Pb, which is a decay product of volatilized atmospheric Radon-222 (^{222}Rn), is present in sediments primarily as a result of recent atmospheric deposition. ^{222}Rn is a volatile, short-lived intermediate daughter of uranium-238 (^{238}U), a naturally-occurring radioisotope found in the earth's crust. Long-term sedimentation rates can be estimated using ^{210}Pb sediment data because: 1) ^{210}Pb is deposited on the earth's surface at an approximately constant rate related to the volatilization rate of ^{222}Rn from the earth's surface, and 2) the activity of ^{210}Pb in sediment decreases exponentially as a function of its decay half-life of 22.3 years. Thus, the long-term sedimentation rate can be estimated by analyzing the vertical profile of ^{210}Pb activity in a sediment core (Olsen et al. 1978; Orson et al. 1990; Robbins 1978). Sediment core dating using ^{210}Pb has been successfully accomplished in Puget Sound (Lavelle et al. 1985).

Sampling locations

Several criteria were considered in the selection of the number and locations of sediment cores for this study:

- samples should be representative of the different hydrological regimes (i.e., intertidal and subtidal bench areas) present within the LDW
- samples should be representative of the range of sediment bed properties (e.g., grain size distribution) observed in the bench areas of the LDW
- sample locations should be situated throughout the LDW so that potential longitudinal variations in the depositional environment of the LDW bench areas can be evaluated
- samples should not be collected from areas that have been subject to disturbances (e.g., repeated dredging in berths)
- sample locations should include areas both within and outside the range of typical influence from the salt wedge, such that potential influences of the salt wedge on the depositional behavior within the LDW can be evaluated

A discussion of how these criteria were used in the study design is provided below.

Bench areas within the LDW were separated into nine distinct categories, each representing a different combination of hydrologic conditions (e.g., intertidal and subtidal) and sediment characteristics (e.g., grain size distribution) observed within the LDW (Table 3-1). These categories are the same as those used to develop the benthic sampling program conducted during summer 2004 (Windward 2004b). One sediment core will be collected from each of these categories so that the depositional nature of the various regimes can be assessed. Four additional cores were added to the sampling design to assess potential differences in the depositional environment of the LDW based on presence of the salt wedge; these four cores were placed in the categories that comprise a larger proportion of the surface area of the LDW. Finally, the thirteen cores were located so that an adequate spatial representation of the entire LDW is achieved. Care was taken not to place any sampling locations within the navigation channel or areas subject to disturbances (e.g., repeated dredging in berths). Core sampling locations for the study are presented in Figures 3-1a through 3-1d (full-page color figures are located in a separate section at the end of the main text of this document).

Although the sampling locations were identified to satisfy the matrix presented in Table 3-1, sediment chemical concentrations were also considered in determining core sampling locations. The study design presented in this QAPP is not intended to directly address chemical transport and fate, but sediment transport data from areas with elevated chemical concentrations will be important for evaluating remedial alternatives at such areas. PCBs have been the primary focus for the ongoing early action areas and are also likely to be one of the main risk drivers for the Phase 2 risk assessments. Consequently, the proposed geochronology sampling locations were evaluated relative to the existing surface sediment PCB concentrations, as represented by inverse distance weighted (IDW) interpolation (Figures 3-2a and 3-2b). These figures indicate that the proposed sampling locations cover a broad range of total PCB concentrations. Approximately one-half the locations are in areas expected to have PCB concentrations in surface sediment close to or in excess of the Washington State Sediment Quality Standard of 12 mg/kg organic carbon. Subsurface sediment has been characterized to a much lesser degree compared to surface sediment, but the existing subsurface data corroborates the surface data. Subsurface samples previously collected close to the proposed locations Sf8 and Sf9 had total PCB concentrations similar to the surface sediments shown in Figures 3-2a and 3-2b.

Table 3-1. Number of geochronology cores planned as a function of LDW sediment elevation and grain size

Elevation (ft MLLW)	Grain Size (% fines)	Surface Area (acres)	Surface Area (% of total)	Location IDs [c]	Estimated Total PCB Concentration (mg/kg OC) in Surface Sediment [d]
Intertidal					
≥ - 5[a]	<40%	12	17	Sf9	200
≥ - 5[a]	40-80%	43	62	Sf2, Sf11	0.5, 125
≥ - 5[a]	>80%	14	21	Sf5	36
Subtidal					
< -5 to > -15[b]	<40%	8	9	Sf10	286
< -5 to > -15[b]	40-80%	34	35	Sf4, Sf13	171, 4.5
< -5 to > -15[b]	>80%	23	24	Sf8, Sf12	147, 2.8
≤ -15 to > -20[b]	<40%	3	3	Sf6	10
≤ -15 to > -20[b]	40-80%	14	14	Sf7	3.7
≤ -15 to > -20[b]	>80%	15	15	Sf1, Sf3	7.1, 6.5

Note: Area estimates based on available bathymetry data. Bathymetry data are not available in some areas (mostly intertidal) because of obstruction by piers, barges etc., which would have underestimated total intertidal area

MLLW - mean lower low water

a Areas reported as percent of total intertidal area, which is approximately 22% of the total LDW area

b Areas reported as percent of total subtidal area above -20 ft MLLW, which is approximately 29% of the total LDW area

c For areas where two cores will be collected, one will be obtained from a bench area that is typically influenced by the salt wedge and the second from an area that is rarely influenced by the salt wedge.

d Estimated concentrations are from inverse distance weighted interpolations shown in Figures 3-2a and 3-2b. Where two concentrations are given, they correspond to the two proposed sampling locations, in the order they are listed

Data analysis

For this study, average sedimentation rates will be calculated for interpretable cores.[2] Where possible, long-term average sedimentation rates will be calculated by analyzing vertical profiles of ^{210}Pb and ^{137}Cs concentrations in a core; consistency between rates estimated from the two methods will reduce uncertainty in the results. This approach produces the best estimate of long-term average sedimentation rates.

Through examination of vertical profiles of radioisotope concentrations in conjunction with stratigraphic and sediment bed property information, a description of the depositional environment at each core location will be developed. Stratigraphic and

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[2] Experience from geochronology studies at other sites shows that useful data and information are not typically extracted from every core. For example, an erratic depositional history at a particular location might produce complex ^{210}Pb or ^{137}Cs profiles that cannot be used to determine the average long-term sedimentation rate with reasonable accuracy. In these cases, other data collected from these cores (e.g., TOC and bulk density) may still provide useful information for the weight-of-evidence approach described in Section 3.1.3.

sediment bed property data include general sediment type (via visual observation), approximate grain size (via visual observation), total organic carbon (TOC) content, bulk density, and percent moisture.

In addition to analysis of the geochronology cores, an analysis of LDW bathymetric data will be conducted for the bench areas within the LDW where sufficient spatial overlap in bathymetry measurements exists. Multi-beam bathymetry data were collected throughout most of the LDW during August 2003 (Windward 2004a). Bathymetric data collected from various areas within the LDW during 1998, 2000, and 2001 were compared to each other as part of the Phase 1 RI (Windward 2003). These data sets will be used in conjunction with the 2003 multi-beam bathymetric data to evaluate, where possible, sediment bed elevation changes within the LDW during the period between 1998 and 2003.

The results of the geochronology and bathymetric analyses will be combined, along with other relevant information, to develop a weight-of-evidence characterization of the depositional environment in the LDW. While estimates of sedimentation rates (over various time periods) are a primary result of these analyses, other insights about the LDW depositional environment may result from this work. These insights may include, but not be limited to, potential temporal variations in deposition rates that may have resulted from land use changes within the drainage basin of the Green and Duwamish rivers and the extent to which episodic events (as evidenced by disturbances in the vertical profiles of ^{210}Pb and ^{137}Cs) may have affected erosion and deposition in the LDW. In addition, the geochronologic and bathymetric data analysis may be useful for calibration and validation of a sediment transport model (if developed during Task 4).

3.1.2 Task 2: Analyze erosion potential

Sediment bed scour resulting from both natural and anthropogenic causes will be investigated to assess whether sediment bed erosion occurs episodically and, if so, at what scale. Evaluating the potential for sediment bed scour within the LDW requires information on: 1) erosion properties of the sediment bed, and 2) both natural and anthropogenic hydrodynamic forces exerted on the sediment bed.

As described in Section 2.2, additional data and analyses relating to sediment bed scour are needed. Thus, the objectives of Task 2 are to:

- collect and analyze data on the potential for sediment bed erosion
- quantify the effects of hydrodynamics on the spatial distribution of bottom shear stress in the LDW for various flow conditions
- determine areas of potential sediment bed scour during rare high-flow events
- quantify the impacts of anthropogenic forces (e.g., ship propeller scour) on sediment bed erosion

Theoretical basis

Erosion of a sediment bed depends on a number of factors, including, but not limited to: applied shear stress, grain size distribution, dry (bulk) density, TOC content, and gas content (Jepsen et al. 1997; Roberts et al. 1998). A simple illustration of the erosion process is presented in Figure 3-3. The rate at which sediment is removed from the consolidated sediment bed and transported to a thin near-bed layer that exists between the consolidated sediment bed and the water column is termed the gross erosion rate (E_{gross}). Some of the eroded sediment in the near-bed layer is re-deposited to the consolidated bed; the rate at which this occurs is referred to as the gross deposition rate (D_{gross}). The remainder of the eroded material in the near-bed layer is transported to the water column. The rate at which this occurs is referred to as the net erosion rate (E_{net}).

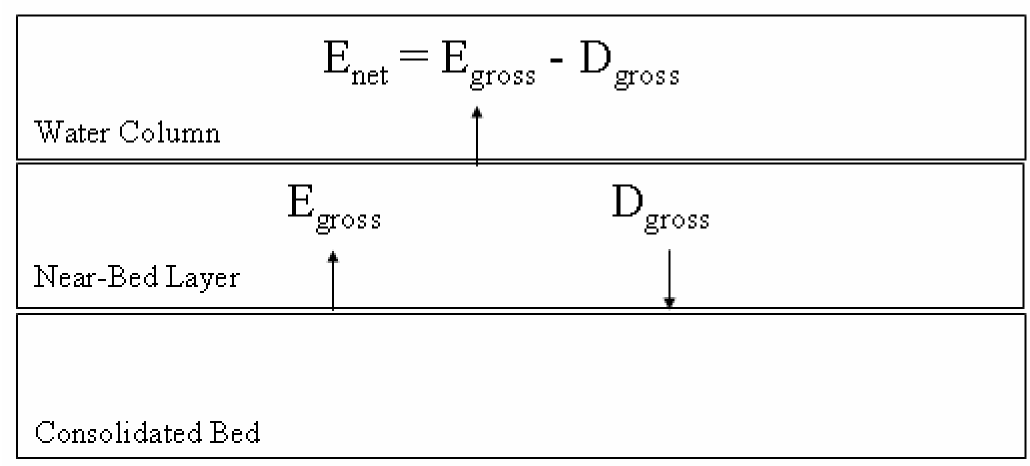

Figure 3-3. Relationship between net (E_{net}) and gross (E_{gross}) erosion rates and gross deposition rate (D_{gross})

Jones (2000) presents the following equation, which is used to quantify the gross erosion rate:

$$E_{gross} = A\,\tau^n \text{ when } \tau > \tau_{cr}$$ **Equation 3-1**

$$E_{gross} = 0 \text{ when } \tau \le \tau_{cr}$$

where:

E_{gross}	=	gross erosion rate (e.g., cm/s)
A	=	site-specific parameter that may be dependent on the sediment dry density (ρ), as well as on other sediment bed properties
τ	=	bottom shear stress
n	=	site-specific exponent
τ_{cr}	=	critical shear stress

Generally, the site-specific parameters A, *n* and τ_{cr} vary horizontally and vertically throughout the sediment bed. Typically, consolidation of the sediment bed results in critical shear stresses (τ_{cr}) that increase with increasing depth in the sediment bed.

Site-specific data on the potential for sediment erosion are needed to determine values for the three parameters (A, *n* and τ_{cr}). A device that has proven useful for measuring the erosion properties of sediments is called Sedflume (McNeil et al. 1996). The main purpose of Sedflume is to measure gross erosion rate (E_{gross}) over a range of applied shear stresses (τ) at various depths in a sediment core. Erosion rates from a typical Sedflume core are presented as a function of depth and applied shear stress in Figure 3-4. In addition to measuring erosion rate, dry density and particle size distribution data are usually obtained as a function of depth in the core. These sediment bed property data can be useful for interpreting erosion rate data.

Sedflume measures the gross erosion rate, which is a quantity that may be significantly larger than the net erosion rate. Calculation of net erosion rate using Sedflume data requires incorporation of the gross erosion data into a sophisticated sediment transport model. Thus, gross erosion rate data obtained from Sedflume cannot be used in a simplified analysis to calculate sediment bed scour depths, as doing so will result in the over-prediction of scour depths.

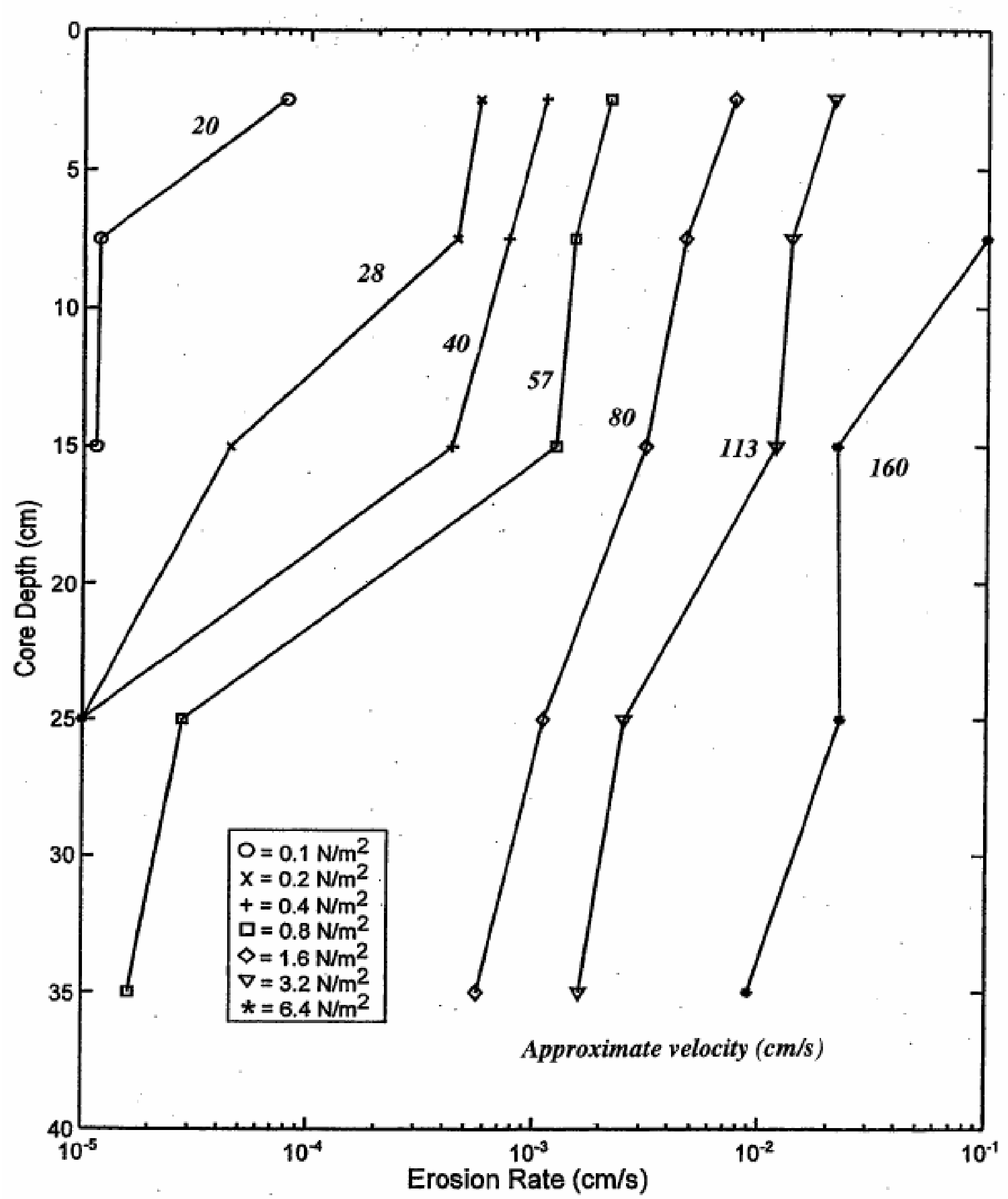

Figure 3-4. Measured erosion rates as a function of depth and applied shear stress from a typical Sedflume core

Sampling locations

A field study will be conducted to collect sediment cores in the LDW and use Sedflume to measure gross erosion rates and critical shear stresses. Section 3.2.2 describes the methods for the field study. Sedflume will be used to collect two types of data: 1) gross erosion rate as a function of depth (i.e., over the top 30 cm of the core), and 2) critical shear stress of the surficial sediments. Critical shear stress as a function of depth (i.e., below the surficial layer) can also be determined from Sedflume data.

Because there are no historical erosion property data for the navigation channel, this program will include the collection of sediment cores from both the bench areas and the navigation channel of the LDW.

Sediment cores will be collected from 17 locations for the erosion property field study —13 cores from the bench and channel side-slope areas and 4 cores from the navigation channel. Two replicate cores will be collected; one replicate core will be obtained at location Sf6 (bench area) and another replicate core at location Sf16 (navigation channel). The replicate cores will provide information on the spatial variability of bed erosion properties over small spatial scales within the LDW. The proposed locations for the bench area cores (i.e., Sf1 through Sf13) are the same as those proposed for the geochronology study (see Table 3-1), and thus satisfy the same five criteria presented in Section 3.1.1 (i.e., they represent the various combinations of hydrological conditions [intertidal and subtidal] and sediment bed characteristics [grain size] observed within the LDW). The four cores (plus one replicate) from the navigation channel (i.e., Sf14 through Sf17) will be collected at approximately RMs 3.0, 3.5, 3.9 and 4.4. All 17 core locations were selected so that the erosion properties of representative sediments located inside and outside of the typical influence of the salt wedge can be assessed. The sampling locations for all Sedflume cores are shown in Table 3-2 and Figures 3-1a through 3-1d (full-page color figures are located in a separate section at the end of the main text of this document).

Table 3-2. Coordinates for geochronology and Sedflume sampling locations

Location ID	River Mile	Northing (y)	Easting (x)	Sample Type
Sf1	0.5	209047.7	1266460.9	Geochronology and Sedflume
Sf2	0.7	207668.6	1266071.7	Geochronology and Sedflume
Sf3	1.2	205700.6	1268138.4	Geochronology and Sedflume
Sf4	1.5	204438.6	1268519.7	Geochronology and Sedflume
Sf5	2.0	201586.1	1269233.2	Geochronology and Sedflume
Sf6	2.3	200348.7	1270523.6	Geochronology and Sedflume
Sf7	2.7	198724.0	1272122.3	Geochronology and Sedflume
Sf8	3.5	196095.3	1275347.0	Geochronology and Sedflume
Sf9	3.6	195568.8	1275494.5	Geochronology and Sedflume
Sf10	3.7	195535.3	1275838.5	Geochronology and Sedflume
Sf11	3.9	193944.1	1276330.8	Geochronology and Sedflume
Sf12	4.3	192170.4	1276480.9	Geochronology and Sedflume
Sf13	4.4	191595.9	1276809.1	Geochronology and Sedflume
Sf14	3.0	197783.3	1273260.9	Sedflume
Sf15	3.5	195983.9	1275266.2	Sedflume
Sf16	3.9	193964.8	1276133.0	Sedflume
Sf17	4.4	191576.3	1276714.3	Sedflume

Note: Coordinates in Washington State Plane North, NAD 83, US survey feet

Data analysis

Gross erosion rate and critical shear stress

Gross erosion rate data will be obtained from the Sedflume cores. These data, in conjunction with dry density and particle size data from the cores, will be analyzed graphically and statistically to evaluate: 1) vertical variations in dry density, erosion rate, and critical shear stress, 2) spatial variability of erosion properties in the LDW, 3) effects of dry density and particle size distribution on erosion rate, and 4) estimates of A and *n* (see Equation 3-1). Qualitative evaluations of these data will also be used to gain insights about sediment bed scour and sediment stability in the LDW.

In addition to the gross erosion rate, the Sedflume cores provide information for determining values for critical shear stress. These data, from a total of 17 locations, will be analyzed graphically and statistically to develop an understanding of the variability of surficial τ_{cr} within the LDW. An investigation will be conducted to determine if surficial τ_{cr} correlates with dry density and/or particle size distribution.

The critical shear stress (τ_{cr}), defined as the shear stress at which a small but measurable rate of erosion occurs, can also be estimated from Sedflume erosion rate data. For Sedflume studies performed at other sites, the critical erosion rate was set at 10^{-4} cm/s (Jepsen et al. 2001; Jones 2000; McNeil et al. 1996) and this value will be used in this study. Because Sedflume tests are conducted using a range of discrete shear stress values (e.g., 0.1 to 6.4 Pascals [Pa]), τ_{cr} values are estimated by linearly interpolating between measured erosion rates, at two successive shear stresses, that are less than (at the lower applied shear stress) and greater than (at the higher applied shear stress) the critical erosion rate (10^{-4} cm/s).

Hydrodynamic Model

A three-dimensional hydrodynamic model of the LDW and Elliott Bay was developed during a water quality study of Elliott Bay, the East and West Waterways, and the LDW (King County 1999). This model was created using the Environmental Fluid Dynamics Code. Calibration and validation results indicate that the model simulates hydrodynamic processes in the LDW and Elliott Bay with reasonable accuracy. Relatively low grid resolution, however, was used in the LDW, with three grid cells typically being used to represent lateral variations in bathymetry. Thus, the King County version of the model may not simulate hydrodynamics in the LDW with sufficient spatial resolution for analyzing sediment bed scour during rare high-flow events.

Dr. Earl Hayter (EPA) has been modifying the King County version of the hydrodynamic model such that improved grid resolution in the LDW is achieved. Discussions with Dr. Hayter indicate that grid resolution has been increased in both the lateral and longitudinal directions, with seven lateral grid cells at most locations in the LDW. This level of LDW grid resolution should be adequate for a sediment bed scour evaluation. Dr. Hayter began an effort to recalibrate the refined model during summer 2004; model calibration and validation is ongoing. Dr. Hayter will provide the completed model and the details of calibration and validation once they are complete. Therefore, the refined model should be a good tool for conducting an analysis of sediment bed scour during rare high-flow events.

Two sequential current meter deployments, during the period of December 2003 through February 2004, were made at RM 1.1 of the LDW. Each deployment lasted approximately one month and consisted of two SonTek 1500 kHz Acoustic Doppler Profiling current meters. In both deployments, one meter was placed in the deep channel while the other was placed on the shallower side slopes. During the second deployment the daily average flow reached 7,440 cfs (USGS gauge at Auburn) on January 30, 2004. A flow this large occurs in approximately 70% of the years since completion of the Howard A. Hanson Dam in 1962.

Following completion of the dam, peak flows have not exceeded 12,400 cfs. A peak flow hydrograph has been created based on the recorded hydrograph in February 1996, adjusted to create a peak flow of 12,500 cfs. This hydrograph will be used in the hydrodynamic modeling to represent a rare high-flow event (< 1/40 year occurrence).

A rare high-flow event analysis will be conducted using the refined hydrodynamic model in conjunction with critical shear stress data obtained from the Sedflume field study. The refined model will be used to simulate hydrodynamics in the LDW over a range of flow conditions, with the primary focus on the impacts of rare high-flow events. Several high-flow event scenarios, including the elevated flow measured in the LDW during winter 2004, will be investigated, using freshwater inflows in the Duwamish River corresponding to flows with a range of return frequencies. Because tidal conditions may impact the effects of a high-flow event on sediment bed scour, the range of tidal conditions for two scenarios will be evaluated: neap tide and spring tide. Tidal data collected in the LDW will be analyzed to determine representative neap and spring tide conditions. By using these extremes in typical tidal conditions, the potential effects of tides during a high-flow event will be captured in the analysis.

For each high-flow event/tide simulation, the hydrodynamic model will be used to determine the spatial distribution of bottom shear stress in the LDW. The predicted shear stresses (τ) will be compared to critical shear stresses (τ_{cr}) for surficial sediments determined from the Sedflume data. In areas where τ is greater than τ_{cr}, sediment bed scour may occur during the specific high-flow event/tide scenario. The depth of scour, however, cannot be estimated from this analysis because the Sedflume testing yields only gross erosion rate information. Therefore, only the areas within the LDW where potential sediment bed scour could occur for each high-flow event/tide scenario can be determined. Potential scour areas (i.e., areas where $\tau > \tau_{cr}$) will be analyzed for each high-flow event/tide scenario.

Uncertainty will exist in the estimated value of critical shear stress of surficial sediments as a result of spatial variability. This uncertainty translates into uncertainty in the scour analysis results. An analysis will be conducted to quantify the level of uncertainty in the rare high-flow event evaluation. The exact approach used in the uncertainty analysis will depend on the site-specific data; the uncertainty analysis cannot be specified *a priori*. The approach will be developed after the critical shear stress data for the LDW are collected.

Propeller Wash

An important anthropogenic influence on sediment erosion is boat propellers. A propeller wash model will be used to estimate current velocities and bottom shear stresses so the erosion potential from this source can be evaluated. The effects of ship wakes (i.e., waves created from the displacement of water by the boat hull) will also be assessed. A specific model or model framework has not been selected at this time, but it is envisioned that propeller wash models developed by the US Army Corps of Engineers (Blaauw and van de Kaa 1978; Hamill et al. 1996; Maynord 2000; Verhey 1983) will be evaluated to select the model or models most appropriate for typical navigational activities in the Lower Duwamish.

Data requirements for a propeller wash model include, but are not limited to: ship type and geometry (e.g., length, draft), propeller properties (e.g., number of blades, diameter), ship speed, applied shaft horsepower; channel geometry, and sediment characteristics. In addition, the frequency of specific types of ships traversing the LDW will need to be determined for this analysis. The necessary input data will be obtained from the Port of Seattle, any other entities who have conducted similar modeling in the LDW, and potentially shipping and tugboat companies.

The rare high-flow event and propeller-wash scour analyses will be used as lines of evidence in the evaluation of the effects of natural and anthropogenic events on sediment bed scour. Other relevant data and data analyses (e.g., qualitative analysis of Sedflume data) on factors influencing sediment erosion in the LDW will be combined with the rare high-flow event and propeller-wash scour results using a weight-of-evidence approach to understand the importance of episodic events on sediment scour within the LDW.

3.1.3 Task 3: CSM testing and revision

The objective of this task is to test and refine the preliminary CSM, as needed, using data collected as part of the Phase 1 RI and the results from Tasks 1 and 2. Results from the depositional and sediment bed scour investigations conducted during Tasks 1 and 2 (in addition to relevant Phase 1 RI information) will be used in a weight-of-evidence approach in Task 3 to test the validity of the components of the preliminary CSM. Results of the weight-of-evidence test will be described in a data analysis report. If the CSM adequately describes the sediment transport processes within the LDW, then the sediment transport study will be complete. If the preliminary CSM (or a modified version of it) requires further evaluation, then additional work will be required. Tasks 4 and 5 will be conducted after an addendum to this QAPP for those tasks is developed and approved. Alternatively, additional data may be needed before a determination can be made of whether Tasks 4 and 5 are necessary. The methods for collecting those additional data, if needed, would also be described in an addendum to this QAPP.

3.1.4 Task 4: Sediment transport modeling

A sediment transport model can be used as a predictive tool to investigate erosion, deposition, and transport of sediment within the LDW. The need to develop a sediment transport model for the LDW will be determined at the conclusion of Task 3. If required, the advantages and disadvantages of the model, its limitations, and any identified data gaps, will be considered when the specific objectives of this task are developed and described in an addendum to this QAPP. However, details of work to be completed during this task cannot be specified at this time. The major steps that would be taken are presented below:

- Review available data and determine data gaps for developing and calibrating a sediment transport model
- Design and implement field studies for obtaining the data needed to develop and calibrate the model
- Develop, calibrate, validate and apply the model. A preliminary strategy (subject to revision) for model calibration/validation is to use TSS concentration data collected during a high-flow event for model calibration. If possible, TSS composition will also be used during model calibration. Bed elevation changes and sedimentation rate data will be evaluated during model validation.
- Determine the extent and location of sediment erosion under various flow and tide conditions

3.1.5 Task 5: CSM finalization

This task, if it is necessary, would be similar to Task 3, except that modeling results from Task 4 will be used as additional lines of evidence to improve the CSM. The results of all analyses (i.e., Tasks 1, 2, and 4, as well as the Phase 1 RI) will be used in a weight-of-evidence approach to refine, as necessary, the preliminary CSM in Task 5, with the goal of finalizing the CSM for LDW sediment transport. A technical report describing the results of Tasks 4 and 5 will likely be created if these tasks are implemented, but the scope and content of this report cannot be determined at this time.

3.2 SAMPLING METHODS

This section describes the methods for the two field studies to be conducted as part of Tasks 1 (geochronology field study) and 2 (Sedflume field study). Sections 3.2.1 (location and sample identification) and 3.2.2 (location positioning) refer to both field studies. Sections 3.2.3 and 3.2.4 refer specifically to the Task 1 and Task 2 field studies, respectively.

3.2.1 Identification scheme for all locations and samples

Each sampling location will be assigned a unique alphanumeric location identification (ID) number. The first three characters of the location ID are "LDW" to identify the Lower Duwamish Waterway project area. The next characters indicate the type of samples to be collected (i.e., Sg for sediment cores for geochronology analysis and Sf for sediment cores for Sedflume analysis), followed by a consecutive number identifying the specific location within the LDW area. The 13 geochronology locations and 17 Sedflume locations will be numbered independently. Table 3-2 and Figures 3-1a through 3-1d show only the Sf locations because all geochronology locations will also be sampled for Sedflume.

Sample ID numbers are similar to location ID numbers, but also indicate the depth interval included in the sample. For example, the 0 to 1 cm section of the sediment core collected at location LDW-Sg would be called LDW-Sg-0-1. Sedflume cores will be analyzed as a continuous unit (i.e., no discrete sampling intervals), so the sample ID number will be the same as the location ID number for these cores.

3.2.2 Location positioning

Sampling locations will be located by global positioning system (GPS). The GPS unit will be mounted on the winch arm used to collect the sediment cores. The GPS unit will receive GPS signals from satellites to produce positioning accuracy to within 3 m. Washington State Plane coordinates North (NAD 83) will be used for the horizontal datum.

3.2.3 Geochronology field study

Sediment cores will be collected using a gravity corer with a 3-inch (outer diameter) steel core tube and a butyl acetate core-tube liner. Because inertia will be utilized as the primary driving force to achieve the desired penetration depth, the degree of penetration will be altered by either adjusting the number of weights at the top of the tube or by changing the vertical distance from which the core tube is allowed to free-fall. The corer will be advanced into the sediment to refusal using enough weight to achieve the minimum target penetration depth of 80 cm. At each sample location, total water depth and total sediment recovered will be measured and recorded in the field log book. Time and date of core collection will also be recorded. Cores will be photographed through the clear liner, and the strata, visible organic material, etc. of each core will be documented.

Following core collection, each high-resolution core will be either sliced into segments that are 1 cm thick using a vibratory saw, or extruded in 1-cm increments using a hydraulic extruder jack, depending on sediment cohesion at a given sample location. Regardless of the optimal core processing method, the outer layer (0.25 to 0.5 cm) of each 1 cm core section will be scraped away using a stainless steel straight edge to exclude any sediment that has come into contact with the wall of the core tube. Prior to sample extrusion, the sediment core will be secured vertically into the hydraulic sediment extrusion device. Using a foot pedal, a piston will advance upward into the core until 1 cm of sediment extends above the top of the core tube. The portion of the piston which contacts the sediment core will be covered with a clean piece of aluminum foil. The top 1 cm of sediment will be separated from the core using a stainless steel straight edge such that contamination with adjacent sediments will be avoided. If necessary, a vibratory saw will be employed to cut through the core tube at 1 cm increments, using a clean stainless steel saw blade. Each 1 cm sediment section will then be removed using the stainless steel straight edge and placed in a stainless steel bowl. This process, which has been successfully employed during high-resolution core collection/processing at other sites (Alcoa 2003, 2004; QEA and Environmental Standards 2002), will be repeated for each sediment sample interval, including those that will be archived. The physical characteristics of each sample interval will be determined by visual inspection and recorded. These characteristics include general sediment type using the Unified Soil Classification System and approximate grain size (i.e., fine, medium, coarse). The sample will be thoroughly homogenized. The homogenized sample will be split and placed into two separate sample containers, labeled, and chilled at 4 degrees Celsius (°C).

Every fifth segment of the sediment core (e.g., 0-1 cm, 5-6 cm, 10-11 cm) will be submitted for laboratory analysis for ^{210}Pb, ^{137}Cs, and conventional parameters (see Section 3.3.1 for a list of all parameters). Samples (1-cm thick) that are not submitted for laboratory analysis will be archived in jars prepared identically to the samples that are submitted to the laboratory. The number of segments submitted for laboratory analysis per core will vary because of differences in total sediment core lengths collected. A maximum of 17 segments per core will be selected for laboratory analysis, which represents a maximum segment depth of 80-81 cm. The maximum sampling depth (i.e., 80-81 cm) is based on the expectation that sedimentation rates in the bench areas will be less than 2 cm/yr. Sedimentation rates higher than 2 cm/yr have been estimated for the LDW navigation channel, particularly in the upstream regions of the study area, but sedimentation rates as low as 1 cm/yr have been estimated for both the East and West Waterways and the downstream regions of the LDW (Windward 2003). Based on observed sedimentation rates of 1-2 cm/yr (Windward 2003) and higher in the navigation channel (where enhanced deposition occurs) and the fact that many of the LDW bench areas have never required dredging, assuming a maximum sedimentation rate of 2 cm/yr in the bench areas appears reasonable. Based on this assumption, and consistent with observations in the East and West Waterways, peak ^{137}Cs concentration will likely be observed between the sediment bed surface and a depth of about 80 cm (i.e., 2 cm/yr x 41 years, the time interval between present and the assumed 1963 peak). Limiting the core segment analysis to the top 80-cm of a core does not prevent estimation of sedimentation rate in cores where the sedimentation rate is greater than 2 cm/yr. In that case, the peak ^{137}Cs concentration is deeper than 80 cm but the ^{210}Pb data can be used to estimate the sedimentation rate. In the event that the ^{137}Cs peak is not observed in a particular core or a sedimentation rate cannot be obtained from the ^{210}Pb profile for that core, then a subset of the archived sediment samples obtained from sediments deeper than the 81-cm interval can be analyzed for ^{137}Cs. Sample handling and analysis methods are described in Sections 3.3 and 3.4, respectively.

3.2.4 Erosion property field study

Sedflume sediment cores with a minimum length of 30 cm will be obtained using the following procedure. A 10 cm x 15 cm rectangular core will be used during this study. Cores are inserted into a thin stainless steel sleeve. The neck of the sleeve is an outer rectangular tube (10 cm x 15 cm in size), while the main body is a box with dimensions such that the outer rectangular core tube fits tightly inside.

The assembled coring sleeve is lowered to the sediment bed using either a pole or gravity corer, depending on water depth. Pressure is applied to the top of the sleeve, causing the sleeve to penetrate into the sediment bed. The coring sleeve is then pushed as far as possible into the sediment bed; the distance of penetration will vary as a result of the characteristics of the sediment (i.e., deeper penetration will occur in softer sediment than in compact sediment). The objective of this process is to obtain a relatively undisturbed core. After retrieving the coring unit and bringing it onboard the sampling boat, the barrel is lifted off of the core tube. A plug is inserted into the core tube from the bottom (to act as a piston for later use in Sedflume) and the core is then capped. Sediment cores are transported and stored in an upright position. After sealing, each core is stored in an ambient temperature water bath to prevent the sediment from drying.

After capping, cores will be visually inspected for length and quality. Sediment cores that show signs of disturbance during the coring process will be discarded and another core will be taken from the sampling location. Approved cores will be capped and stored on deck until returned to the onshore processing site. At the processing site, samples taken from the core for bulk property analysis will be placed in appropriate containers, labeled, sealed, and preserved for delivery to the laboratory for analysis. The sampling procedure for the bulk property samples is described below.

All sediment cores will be tested using a Sedflume at the onshore processing site. Detailed descriptions of Sedflume and its use are given by McNeil et al. (1996). A schematic of Sedflume is shown in Figure 3-5; basically, this device is a straight flume that has a test section with an open bottom through which a rectangular or circular coring tube containing sediment can be inserted. The main components of the flume are: coring tube; test section; inlet section to create uniform, fully-developed, turbulent flow; flow outlet section; water storage tank; and pump to force water through the system. The coring tube, test section, inlet section, and exit section are made of clear acrylic so that sediment-water interactions can be observed.

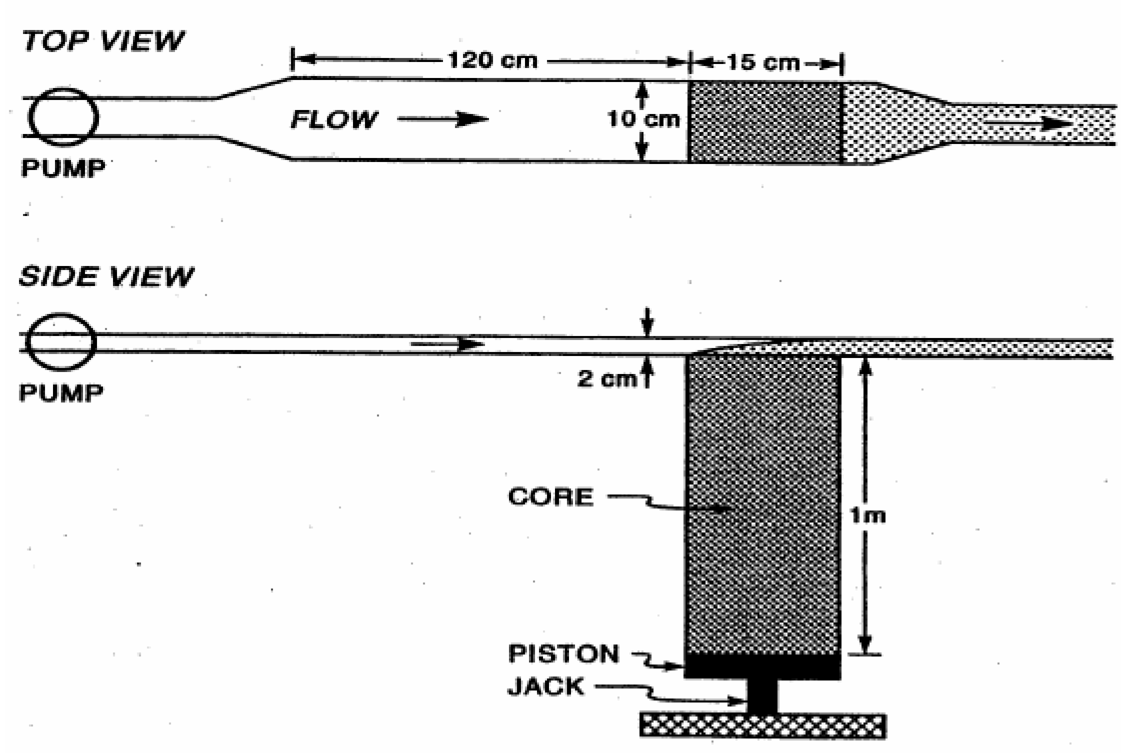

Figure 3-5. Schematic diagram of Sedflume apparatus

Prior to testing a core in Sedflume, a visual description of sediment in the core will be recorded. Bulk property subsamples for each core will be obtained from within the core; subsamples will be collected at the surface (prior to starting the first shear stress cycle) and after each shear stress cycle. Two 5-g subsamples of sediment will be collected from the surface of the sediment core near the downstream edge of the test section. This sampling affects a small portion (i.e., less than 5% of the surface area) of the erosion surface of the core and, thus, has minimal impact on the test results. These subsamples will be obtained while the core is in the Sedflume by stopping flow within the device, opening up the Sedflume, and manually collecting the samples. The samples will be analyzed for particle size distribution, using a laser particle size analyzer, and bulk density.

At the start of each test, the core is inserted into the bottom of the test section. An operator moves the sediment upward using a piston that is inside the core; the piston is connected to a hydraulic jack. By these means, the sediment in the core is raised and the sediment surface is positioned so that it is level with the bottom of the test section in Sedflume. The jack movement can be controlled in increments as small as 0.5 mm.

Water is forced through the duct and the test section over the surface of the sediments. The shear stress produced by this flow may cause sediment to erode. A relationship between flow rate and shear stress in the test section has been developed (McNeil et al. 1996). As the sediment in the core erodes, the sediment core is moved upwards so that the sediment-water interface remains level with the bottom of the test section. The erosion rate is determined by measuring the amount of erosion (i.e., distance sediment is moved upward) in a specific amount of time.

In order to measure erosion rates at several different shear stresses using only one core, the following procedure is used. Starting at a low shear stress, the flume is run sequentially at higher shear stresses with each succeeding shear stress being twice the previous one. Generally, about four shear stresses are run sequentially during a particular shear stress cycle. Each shear stress is applied until at least 1 to 3 mm, but no more than 2 cm, of sediment are eroded, with each shear stress being applied for a minimum of 20 seconds and a maximum of 10 minutes. The amount of erosion (i.e., distance sediment is moved upward) and time are recorded for each shear stress. This procedure defines the minimum and maximum erosion rates to be 1.67×10^{-4} and 0.1 cm/s, respectively. The time interval is recorded for each cycle with a stopwatch. The flow is then increased to the next higher shear stress until the highest shear stress in the cycle is applied. This cycle is repeated until the top 30 cm of sediment in the core is eroded or, if the core is shorter than 30 cm, the entire core is eroded. If after three shear stress cycles, an erosion rate of less than approximately 1.7×10^{-4} cm/s occurs for a particular shear stress, that shear stress value is dropped from the cycle; if after multiple cycles the erosion rates decrease significantly, a higher shear stress is included in the cycle.

3.3 Sample Handling and Custody Requirements

This section describes how individual samples will be processed, labeled, tracked, stored, and transported to the laboratory for analysis. In addition, this section describes decontamination procedures, disposal of field generated waste, sample custody procedures, 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.

3.3.1 Sample handling procedures

Sediment samples from the geochronology cores will be placed in appropriately sized, certified-clean, wide-mouth glass jars and capped with Teflon®-lined lids (Table 3-3). Jars will be filled leaving a minimum of 1 cm of headspace to prevent breakage during shipping and storage. A minimum of 50 g (wet) and 10 g (wet) of sediment are required for the radiological and conventional analyses, respectively. Prior to shipment, each glass container for conventional analyses will be wrapped in bubble wrap and placed in a cooler with wet ice. There are no temperature requirements for sediment samples to be analyzed for radioisotopes, so each glass container for radiological analysis will be wrapped in bubble wrap and placed in a cooler without ice. Each jar will be sealed, labeled, and stored under appropriate conditions, as outlined in Section 3.4.1.

For each Sedflume core, two 5-g aliquots will be removed for grain size and percent moisture analyses and placed on aluminum weighing pans. After weighing, each aliquot for grain size analysis will be transferred to a 10-mL Whirlpak. Aliquots for percent moisture analysis will be analyzed in the same processing facility used for the Sedflume analysis, so no special sample handling or shipping will be necessary for these samples.

Table 3-3. Sample containers and laboratory conducting chemical analyses of sediment samples

Parameter	Container	Laboratory	Cores to Analyze
^{137}Cs and ^{210}Pb	4-oz glass jar	Mass Spec Services	Geochronology
TOC and percent moisture	4-oz glass jar	ARI	Geochronology
Grain size	10-mL Whirlpak	PTL	Sedflume

Sample labels will be waterproof and self-adhering. Each sample label will contain the project number, sample identification, analyses, date and time of collection, and initials of the person(s) preparing the sample. A completed sample label will be affixed to each sample container. The labels will be covered with clear tape immediately after they have been completed to protect them from being stained or spoiled from water and sediment.

At each laboratory, a unique sample identifier will be assigned to each sample (using either project ID or laboratory ID). 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 responsible individuals performing the analyses, dates of sample extraction/preparation and analysis, and the type of analysis being performed.

3.3.2 Decontamination procedures

Sources of extraneous contamination include contamination from 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. Sampling equipment that has obviously been contaminated by oils, grease, diesel fuel, or gasoline will not be used, unless it can be thoroughly decontaminated using detergent and distilled water. Between sampling areas, the field collection team will clean each sampling device, including coring tubes, with Alconox® detergent, rinse it with ambient water, and wrap it in aluminum foil to prevent contamination.

3.3.3 Field-generated waste disposal

Excess sediment, generated equipment rinsates, and decontamination water will be returned to each sampling location after sampling is completed for that location. 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.

3.3.4 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 will be used for all samples throughout the collection, transport, and analytical process, and for all data and data documentation whether in hard copy or electronic format. Custody procedures will be initiated during sample collection. A COC form will accompany samples to the analytical laboratory. Each person who has custody of the samples will sign the COC form and ensure that the samples are not left unattended unless properly secured. Minimum documentation of sample handling and custody will include:

- sample location, project name, and unique sample number
- sample collection date and time
- any special notations on sample characteristics or problems
- initials of the person collecting the sample
- date sample was sent to the laboratory
- shipping company name and waybill number

The FC will be responsible for all sample tracking and custody procedures for samples in the field. The FC will be responsible for final sample inventory and will maintain sample custody documentation. The FC will also complete COC forms prior to removing samples from the sampling area. At the end of each day, and prior to transfer, COC entries will be made for all samples. Information on the labels will be checked against sample log entries, and sample tracking forms and samples will be recounted. COC forms will accompany all samples. The COC forms will be signed at each point of transfer. Copies of all COC forms will be retained and included as appendices to QA/QC reports and data reports. Sediment samples will be shipped in sealed coolers to Mass Spec Services, ARI, and PTL.

The laboratories will ensure that COC forms are properly signed upon receipt of the samples and will note questions or observations concerning sample integrity on the COC forms. The laboratories will contact the FC and Project QA/QC Coordinator immediately if discrepancies are discovered between the COC forms and the sample shipment upon receipt.

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 analyses, and the types of analyses being performed.

3.3.5 Shipping requirements

Samples will be shipped in coolers from Windward to Mass Spec Services and PTL and hand-delivered in coolers to ARI. Prior to shipping or hand delivery, sample containers will be wrapped in bubble wrap and securely packed inside a cooler with wet ice (for coolers going to ARI). There are no temperature requirements for shipments going to Mass Spec Services and PTL, so these coolers will not be packed with ice. The original signed COC forms will be placed in a sealable plastic bag, sealed, 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 sediment samples will be checked by ARI upon receipt of the samples. ARI will specifically note any coolers that do not contain ice packs or that are not sufficiently cold (4° ± 2°C) upon receipt. All samples will be handled so as to prevent contamination or loss of any sample. Samples will be assigned a specific storage area within the laboratories. The analytical laboratories will not dispose of the environmental samples for this project until notified in writing by the QA/QC coordinator.

3.4 Laboratory Methods

This section discusses standard analytical methods and DQIs for laboratory analyses.

3.4.1 Analytical methods

Analytical methods, holding times, and detection limits are presented in Table 3-4. One sample container from each geochronology sediment core segment will be submitted to Mass Spec Services (Orangeburg, NY) for ^{210}Pb and ^{137}Cs analyses. The other sample container from each geochronology sediment core segment will be submitted to ARI (Tukwila, WA) for TOC content and percent moisture analyses. Geochronology sediment core segments not selected for laboratory analyses will be archived at room temperature for future analyses, if needed.

Five-g samples from each Sedflume core will be analyzed for percent moisture and sediment grain size, according to the methods in Table 3-4. Grain size distribution analysis will be conducted by PTL using a Malvern Mastersize 2000. Five-g aliquots are collected from the Sedflume cores, placed in a 10-mL Whirlpak, and shipped to PTL for analysis by Standard Operating Procedure (SOP) PTL-IO-200. Particle sizes and particle size distributions will be determined by PTL using laser dispersion techniques. A sufficient volume of wet sediment is added to water in the sampling chamber of the Mastersizer 2000 to achieve the optical density requirement. Hand shaking or low sonication will be used to create a well-dispersed, homogeneous suspension of particles that is passed through a laser beam at the appropriate concentration. Each sample is analyzed in four 1-minute loops, particle size data are collected electronically, and the results of the four analyzes averaged for each sample. The analysis of particle size by laser diffraction is certified under International Organization for Standardization (ISO) 13320. This method is sensitive for particle sizes between 0.2 and 2,000 μm.

Dry density will be estimated for Sedflume samples, according to Equation 3-2, in the processing facility used to analyze the Sedflume core samples. The same equation will be used estimate dry density for the geochronology sediment samples using the percent moisture data generated by ARI.

$$\rho_b = \frac{\rho_w \rho_s}{\rho_w + (\rho_s - \rho_w)W} \qquad \textbf{Equation 3-2}$$

where

ρ_b = dry density (g/cm^3)

ρ_w = density of water (g/cm^3)

ρ_s = density of sediment particles (assumed 2.65 g/cm^3)

W = water content (i.e., percent moisture expressed as a unitless fraction)

Table 3-4. Laboratory analytical methods and maximum holding times

Parameter	Method	Maximum Holding Time	Preservative
^{210}Pb	Radiochemical isolation/beta assay of Bi-210 daughter product	1 year	none
^{137}Cs	Direct gamma spectral analysis	1 year	none
TOC	Plumb (1981)	28 days	cool/4°C
Dry density	see Equation 3-2	calculated – no field sample	calculated – no field sample
Percent moisture	ASTM D-2216	7 days	cool/4°C
Sediment grain size	Laser diffraction (Malvern Mastersizer 2000)	28 days	none

3.4.2 Data quality indicators

The parameters used to assess data quality are precision, accuracy, representativeness, comparability, completeness, and sensitivity. Table 3-5 lists specific DQIs for sediment analyses.

Table 3-5. Data quality indicators for sediment analyses

Parameter	Precision	Accuracy	Completeness	Sensitivity (Method Detection Limit)
^{210}Pb	±30%	70-130%	95%	0.2 piC/g dw
^{137}Cs	±30%	70-130%	95%	0.2 piC/g dw
TOC	±30%	75-125%	95%	0.01% dw
Dry density	±20%	na	95%	0.01 g/cm^3
Percent moisture	±20%	na	95%	0.1% ww
Sediment grain size	±30%	na	95%	0.1% dw

dw – dry weight

ww – wet weight

na – not applicable

3.4.2.1 Precision

Precision is the measure of the 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 and 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 (duplicate samples, MS duplicates, LCS duplicates) for all parameters. Precision measurements can be affected by the nearness of a chemical concentration to the method detection limit (MDL), where the percent error (expressed as either % RSD or RPD) increases. The DQI for precision varies depending on the analyte (Table 3-5). The equations used to express precision are as follows:

$$\text{RPD} = \frac{(\text{measured conc} - \text{measured duplicate conc})}{(\text{measured conc} + \text{measured duplicate conc}) \div 2} \times 100$$

$$\%\text{RSD} = (\text{SD}/\text{D}_{\text{ave}}) \times 100$$

where:

$$\text{SD} = \sqrt{\left(\frac{\sum (\text{D}_n - \text{D}_{\text{ave}})^2}{(n-1)}\right)}$$

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

3.4.2.2 Accuracy

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 matrix spike and laboratory control sample analyses. The DQI for accuracy varies, depending on the analyte (Table 3-5). The equation used to express accuracy for spiked samples is as follows:

$$\text{Percent recovery} = \frac{\text{spike sample result} - \text{unspiked sample result}}{\text{amount of spike added}} \times 100$$

3.4.2.3 Representativeness

Representativeness expresses the degree to which data accurately and precisely represent an environmental condition. The sampling approach was designed to address the specific objectives described in Sections 3.1.1 and 3.1.2. Assuming those objectives are met, the samples collected should be considered adequately representative of the environmental conditions they are intended to characterize.

3.4.2.4 Comparability

Comparability expresses the confidence with which one data set can be evaluated in relation to another data set. Therefore, the sample collection and chemical and physical testing will adhere to the most recent Puget Sound Estuary Program (PSEP) QA/QC procedures (PSEP 1997) and EPA and PSEP analysis protocols.

3.4.3.5 Completeness

Completeness is a measure of the amount of data that is determined to be valid in proportion to the amount of data collected. Completeness will be calculated as follows:

$$\text{Completeness} = \frac{\text{number of valid measurements}}{\text{total number of data points planned}} \times 100$$

The DQI for completeness for all components of this project is 95%. 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.

3.4.3.6 Sensitivity

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 will be used as the measure of sensitivity of each measurement process. Results will be reported at or below the target detection limits presented in Table 3-5.

3.5 QUALITY ASSURANCE/QUALITY CONTROL

This section discusses the types of samples analyzed and procedures conducted for QA/QC in the field and laboratory.

3.5.1 Field duplicates

Field duplicates are generally used to evaluate the variability attributable to sample handling. Field duplicate samples will be collected according to the frequency described in Table 3-6 by splitting the homogenized sediment from a single sample into two identical samples

Table 3-6. Quality control samples and frequency of analysis for sediment samples

Parameter	Field Duplicate	Method Blank	Matrix Replicates	Laboratory Control Standard	Matrix Spike	Matrix Spike Duplicate
^{210}Pb	1/20	1/20	1/20	1/20	1/20	1/20
^{137}Cs	1/20	1/20	1/20	1/20	1/20	1/20
TOC	1/20	1/20	1/20	1/batch	na	na
Bulk density	1/20	na	1/20	na	na	na
Percent moisture	1/20	na	1/20	na	na	na
Sediment grain size	1/20	na	1/20	na	na	na

na - not applicable

3.5.2 Laboratory quality control

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

3.5.2.1 Determination of MDLs

The MDL is defined as the lowest concentration of an analyte or compound that a method can detect in either a sample or a blank with 99% confidence. The laboratories determine MDLs using standard procedures outlined in 40 CFR§136, where seven replicate samples are fortified at 1 to 5 times (but not to exceed 10 times) the expected MDL concentration. The MDL is then determined by calculating the standard deviation of the replicates and multiplying by a factor of 3.14.

3.5.2.2 Sample delivery group

Project and/or method-specific quality control measures such as matrix spikes and matrix spike duplicates will be analyzed per sample delivery group (SDG) or sample batch. An SDG is defined as no more than 20 samples or a group of samples received at the laboratory within a two-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.

3.5.2.3 Laboratory quality control samples

The analyst will review 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 are exceeded in the sample group, the Project QA/QC Coordinator will be contacted immediately, and corrective action, such as method modifications followed by reprocessing of the affected samples, will be initiated before processing a subsequent group of samples.

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 comparison with an independent standard. Laboratory QC standards are verified a multitude of ways. Second source calibration verifications are run (i.e., same standard, two different vendors) for calibrations. New working standard mixes (calibrations, spikes, etc.) are verified against the results of the original solution and must be within 10%. 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 3-6 summarizes the QC procedures to be performed by the laboratory. The associated control limits for precision and accuracy are summarized in Table 3-5.

Method Blanks

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

Matrix Replicates

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

Laboratory Control Standard

A laboratory control standard, also referred to as a blank spike, provides information on the extraction efficiency of the method without regard to the sample matrix. A minimum of one laboratory control standard will be analyzed for each sample group or for every 20 samples, whichever is more frequent.

Matrix Spikes and Matrix Spike Duplicates

The analysis of matrix spike samples provides information on the extraction efficiency of the method on the sample matrix. By performing duplicate matrix spike analyses, information on the precision of the method is also provided for organic analyses. A minimum of one matrix spike will be analyzed for each sample group or for every 20 samples, whichever is more frequent, when possible.

3.6 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 will be tested for use before leaving for the field event.

The FC will be responsible for overseeing the testing, inspection, and maintenance of all field equipment. The laboratory PM will be responsible for ensuring laboratory equipment testing, inspection, and maintenance requirements are met. The methods used in calibrating the analytical instrumentation are described in the following section.

3.7 Instrument/Equipment Calibration and Frequency

Multipoint initial calibration will be performed on each instrument at the start of the project, after each major interruption to the analytical 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 for every 10 samples for the inorganic analyses, and with every sample batch for conventional parameters to ensure proper instrument performance.

Calibration of analytical equipment used for chemical analysis includes 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 one blank for every 10 samples analyzed for inorganic analyses and one blank for 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.

3.8 Inspection/Acceptance of Supplies and Consumables

The field team leaders for each sampling event will have a checklist of supplies required for each day in the field. The FC will gather and check these supplies daily for satisfactory conditions before each field event. Batteries used in the GPS unit will be checked daily and recharged as necessary. Supplies and consumables for the field sampling effort will be inspected upon delivery and accepted if the condition of the supplies is satisfactory.

3.9 Non-direct Measurements

Tide stage data will be obtained from the NOAA tide gage in Elliott Bay at the foot of Columbia Street (http://www.co-ops.nos.noaa.gov/data_res.html).

3.10 DATA MANAGEMENT

All field data will be recorded on field forms, which will be checked for missing information by the FC at the end of each field day and amended. After sampling is completed, all data from field forms will be entered into a Microsoft Excel® spreadsheet. A QC check will be conducted to ensure that all data were properly transferred from the field forms to the spreadsheet. This spreadsheet will be kept on the Windward network drive, which is backed up daily. Field forms will be archived in the Windward library.

The analytical laboratories are expected to submit data in an electronic format as described in Section 2.6.2 and Table 2-2. 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 ensures that all data are consistently converted into 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. Data management files will be stored on a secure computer.

4.0 Assessment and Oversight

4.1 COMPLIANCE ASSESSMENTS AND RESPONSE ACTIONS

EPA, Ecology, or other their designees may observe field activities during each sampling event as needed. If situations arise where there is an inability to follow QAPP methods precisely, the Windward PM will determine the appropriate actions or consult EPA and Ecology if the issue is significant.

4.1.1 Compliance assessments

Laboratory and field performance assessments 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. Analytical laboratories are required to have written procedures addressing internal QA/QC; these procedures will be submitted for review by the Project QA/QC Coordinator to ensure compliance with the QAPP. All laboratories and QA/QC Coordinators are required to ensure that all personnel engaged in sampling and analysis tasks have appropriate training.

4.1.2 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 the QAPP. All corrective measures will be immediately documented in the field logbook, and protocol modification forms will be completed.

4.1.3 Corrective action for laboratory analyses

Analytical laboratories are required to comply with the standard operating procedures previously submitted to the project QA/QC Coordinator. The laboratory PMs will be responsible for ensuring that appropriate corrective actions are initiated as required for conformance with this QAPP. All laboratory personnel will be responsible for reporting problems that may compromise the quality of the data.

The Project QA/QC Coordinator will be notified immediately if any QC sample exceeds the project-specified control limits (Table 3-5). The analyst will identify and correct the anomaly before continuing with the sample analysis. The laboratory PM will document the corrective action taken in a memorandum submitted to the Project QA/QC Coordinator within 5 days of the initial notification. A narrative describing the anomaly, the steps taken to identify and correct the anomaly, and the treatment of the relevant sample batch (i.e., recalculation, reanalysis, re-extraction) will be submitted with the data package using a corrective action form (Appendix B).

4.2 Reports to Management

Progress reports will be prepared by the FC for submittal to LDWG following each sampling event. The project QA/QC coordinator will also prepare progress reports for submittal to LDWG after the sampling is completed and samples have been submitted for analysis, when information is received from the laboratory, and when analyses are complete. The status of the samples and analyses will be indicated, with emphasis on any deviations from the QAPP. A data report will be written after validated data are available, as described in Section 2.6.4.

5.0 Data Validation and Usability

5.1 Data Validation

Data are not considered final until validated. Data validation will be conducted following guidance prepared by the US Department of Energy (TPR-80 – SOP-12.1.2, Radiological Data Validation). EPA has no data validation guidance for radiological data.

The data validation process begins within the laboratory with the review and evaluation of data by supervisory personnel or QA specialists. The laboratory analyst is responsible for ensuring that the analytical data are correct and complete, that appropriate procedures have been followed, and that QC results are within the acceptable limits. The project QA/QC coordinator is responsible for ensuring that all analyses performed by the laboratories are correct, properly documented, and complete, and that they satisfy the project DQOs specified in this QAPP.

Independent third-party data review and summary validation of the analytical chemistry data will be conducted by Diane Waldschmidt (Environmental Data Services). A minimum of 10% or a single SDG will undergo full data validation. Full data validation parameters include:

- quality control analysis frequencies
- analysis holding times
- laboratory blank contamination
- instrument calibration
- LCS recoveries
- matrix spike recoveries
- matrix spike/matrix spike duplicate RPDs

If no discrepancies are found between reported results and raw data in the set that undergoes full data validation, then validation can proceed as a summary validation on the rest of the data using all of the QC forms submitted in the laboratory data package. Quality assurance review of the sediment chemistry data will be performed in accordance with the QA requirements of the project, the technical specifications of the analytical methods indicated in Table 3-4, and Department of Energy guidance for radiochemical data review. 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 laboratories prior to issuing the formal data validation report. All contacts with the laboratories will be documented in a communication report. Review procedures used and findings made during data validation will be documented on worksheets. Ms. Waldschmidt will prepare a data validation report that will summarize QC results, qualifiers, and possible data limitations. This data validation report will be appended to the sediment transport data report. Only validated data with appropriate qualifiers will be released for general use.

5.2 RECONCILIATION WITH DATA QUALITY OBJECTIVES

Data quality assessment will be conducted by the project QA/QC Coordinator in accordance with EPA guidelines. The results of the third-party independent review and validation will be reviewed and cases where the projects DQOs were not met will be identified. The usability of the data will be determined in terms of the magnitude of the DQO exceedance.

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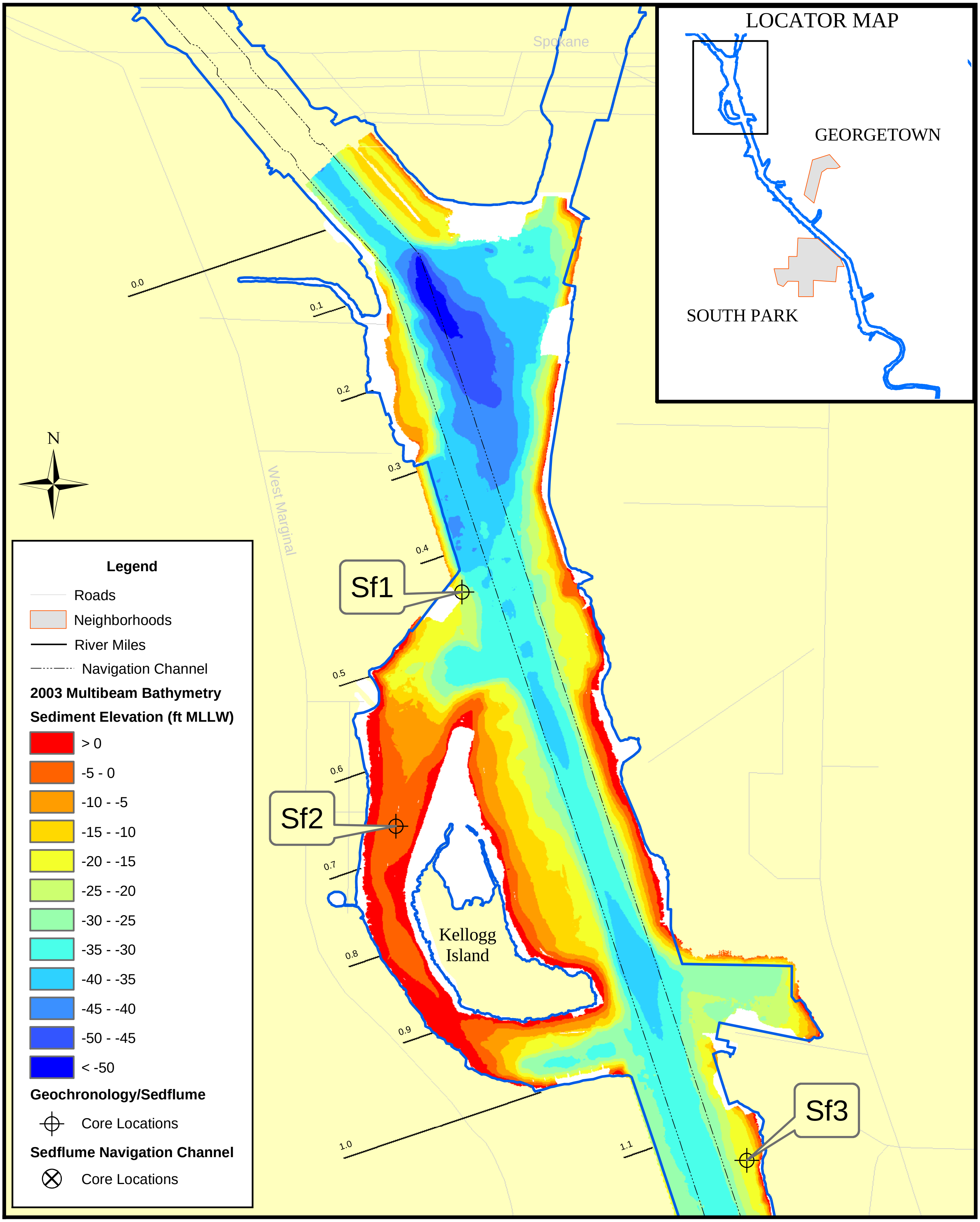
7.0 Color Figures



LOWER DUWAMISH WATERWAY STUDY AREA
SEATTLE, WA

Figure 3-1a. Geochronology and Sedflume sample locations (RM 0.0 - 1.1)

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November 2004

0 250 500 Feet

0 100 200 Meters

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Quantitative Environmental Analysis, LLC

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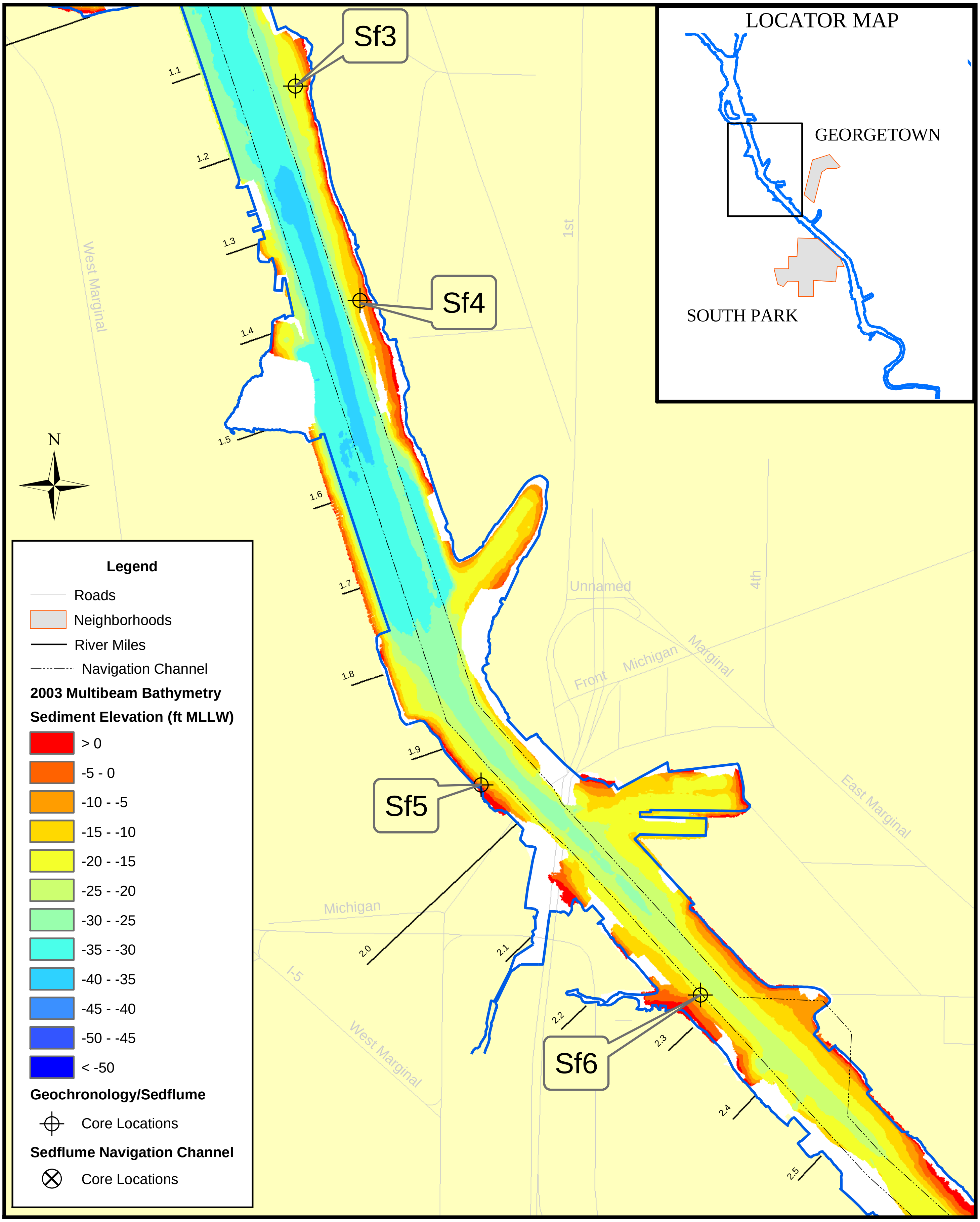

LOWER DUWAMISH WATERWAY STUDY AREA
SEATTLE, WA

Figure 3-1b. Geochronology and Sedflume sample locations (RM 1.1 - 2.5)

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QEA Quantitative Environmental Analysis, LLC

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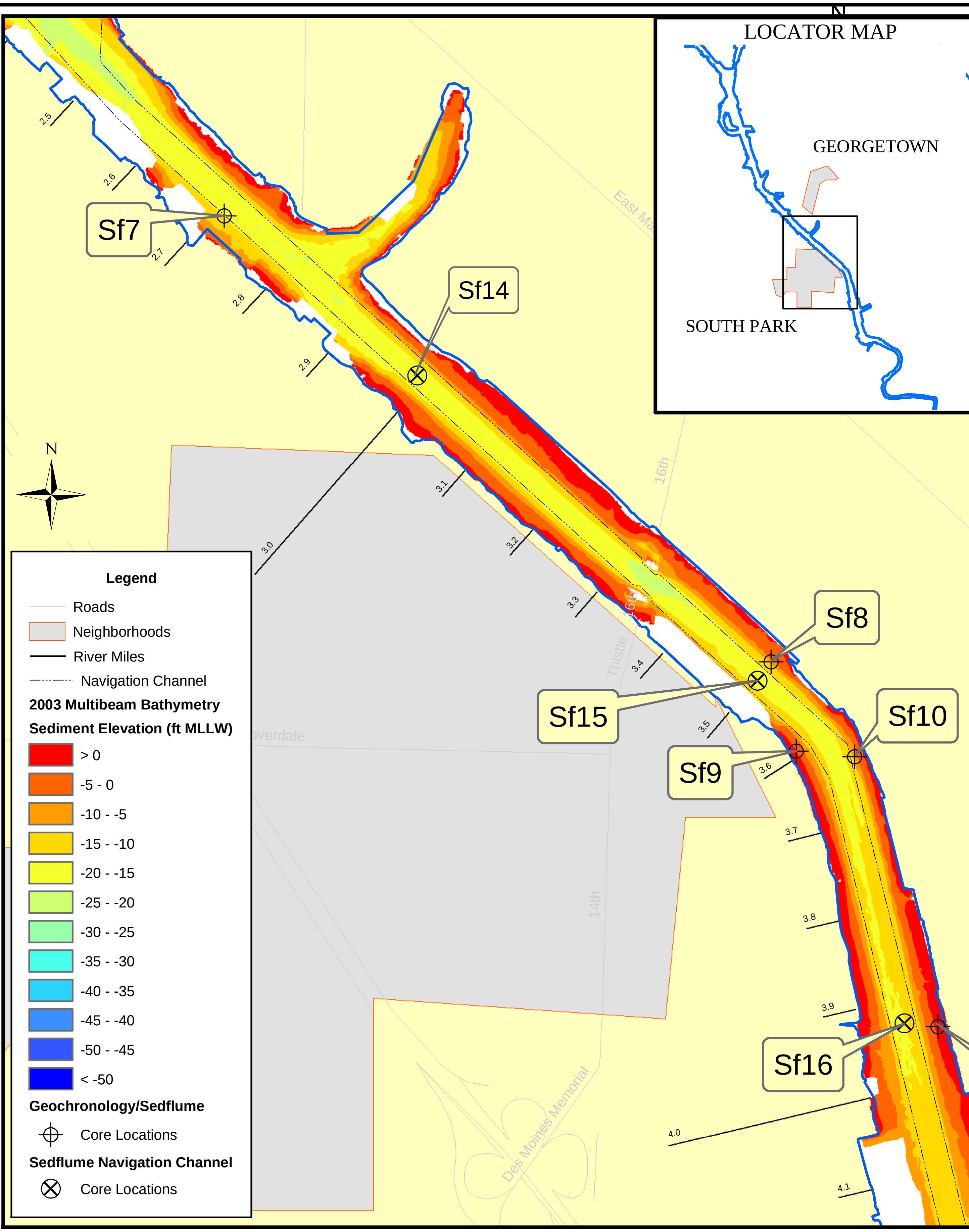

LOWER DUWAMISH WATERWAY STUDY AREA
SEATTLE, WA

Figure 3-1c. Geochronology and Sedflume sample locations (RM 2.5 - 3.9)

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0 100 200 Meters

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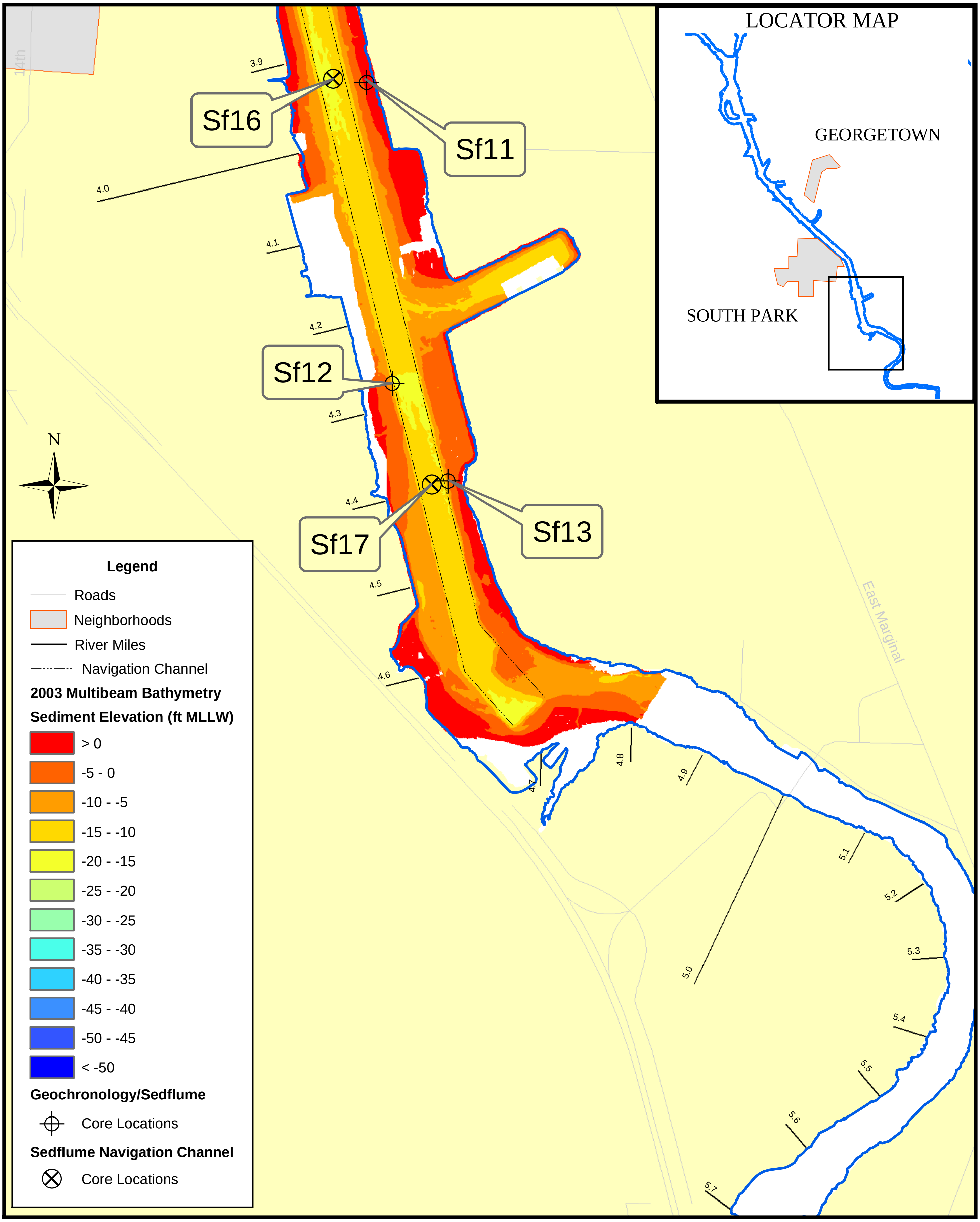

LOWER DUWAMISH WATERWAY STUDY AREA
SEATTLE, WA

Figure 3-1d. Geochronology and Sedflume sample locations (RM 3.9 - 4.8)

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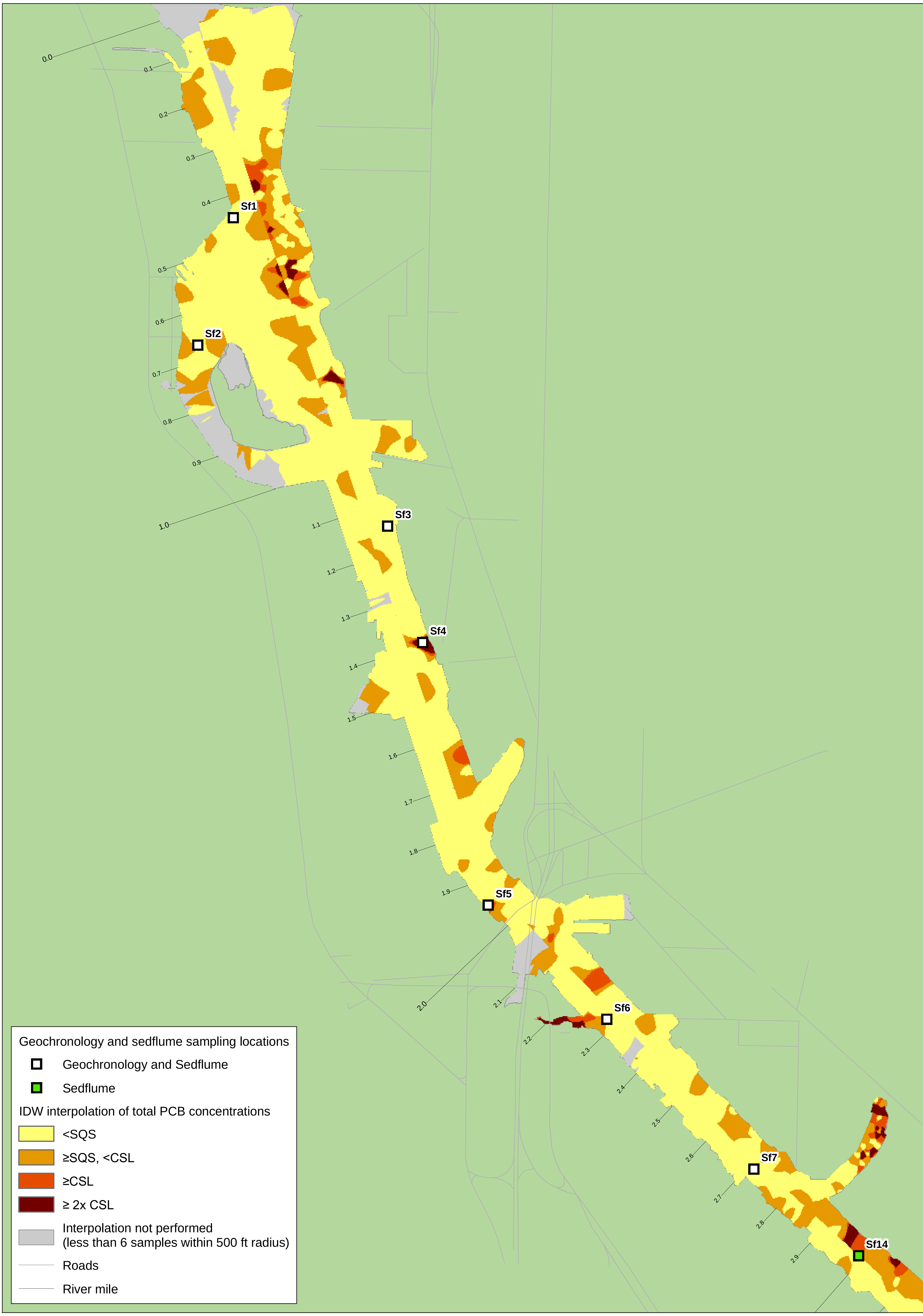

Figure 3-2a. Proposed geochronology and Sedflume sampling locations relative to existing surface sediment PCB concentrations, as represented by IDW interpolation, RM 0.0-3.0

For the purposes of data aggregation and IDW interpolation, a value of half the detection limit was assigned for samples in which PCBs were undetected. IDW interpolation methods used for this map are subject to revision for future Phase 2 RI/FS deliverables.

0 500 1,000 2,000 Feet

0 130 260 520 Meters

N

Windward environmental LLC

Prepared by STS 11/12/04 Map 1539

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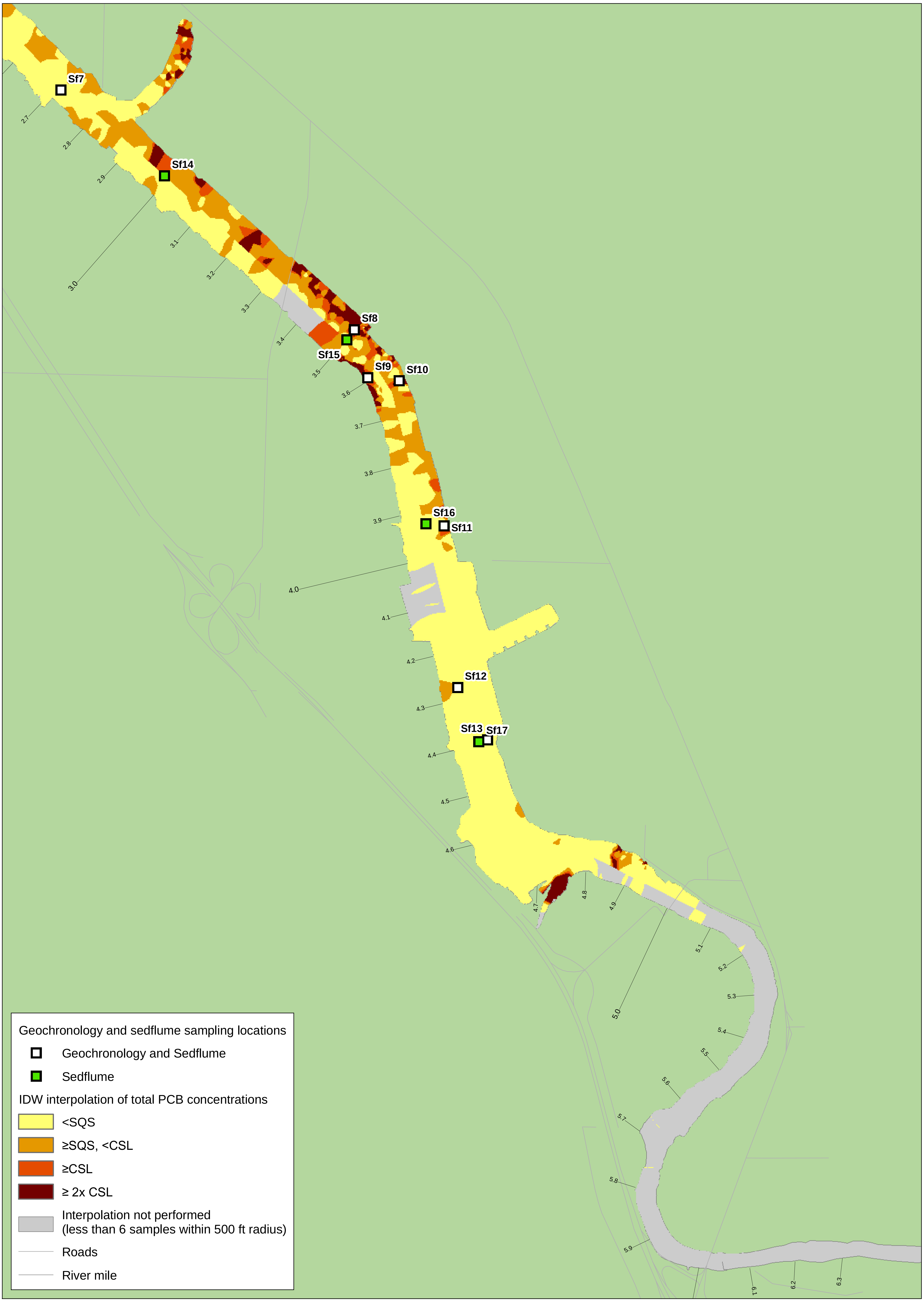

Figure 3-2b. Proposed geochronology and Sedflume sampling locations relative to existing surface sediment PCB concentrations, as represented by IDW interpolation, RM 3.0-6.0

For the purposes of data aggregation and IDW interpolation, a value of half the detection limit was assigned for samples in which PCBs were undetected. IDW interpolation methods used for this map are subject to revision for future Phase 2 RI/FS deliverables.

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APPENDIX A. HEALTH AND SAFETY PLAN

Title and Approval Page
LDW Sediment Transport Characterization
Health and Safety Plan

By their signature, the undersigned certify that this Health and Safety Plan (HSP) is approved and that it will be used to govern health and safety aspects of fieldwork described in the Quality Assurance Project Plan to which it is attached.

Name Project Manager	Date
Name Corporate Health and Safety Manager	Date
Name Field Coordinator/Health and Safety Officer	Date

Acronyms

ACRONYM	Definition
CPR	cardiopulmonary resuscitation
EPA	US Environmental Protection Agency
FC	field coordinator
HSM	Project Health and Safety Manager
HSO	Field Health and Safety Officer
HSP	health and safety plan
OSHA	Occupational Safety and Health Administration
PCBs	polychlorinated biphenyls
PFD	personal flotation device
PPE	personal protective equipment
TBT	tributyltin

A.1.0 Introduction

This site-specific health and safety plan (HSP) describes safe working practices for conducting field activities at potentially hazardous sites and for handling potentially hazardous materials/waste products. This HSP covers elements as specified in 29CFR1910§120. The procedures and guidelines contained in this plan are based on generally recognized health and safety practices. Any changes or revisions to this plan will be made by a written amendment, which will become a permanent part of this plan. The goal of the HSP is to establish procedures for safe working practices for all field personnel.

This HSP addresses all activities associated with collection and handling of sediment samples in the Lower Duwamish Waterway (LDW) for the sediment transport characterization study. During site work, this HSP will be implemented by the Field Coordinator (FC), who is also the designated site Health and Safety Officer (HSO), in cooperation with the Corporate Health and Safety Manager (HSM) and the Project Manager.

All personnel involved in fieldwork on this project are required to comply with this HSP. The contents of this HSP reflect anticipation of the types of activities to be performed, knowledge of the physical characteristics of the site, and consideration of chemical data from previous investigations at the site. The HSP may be revised based on new information and/or changed conditions during site activities. Revisions will be documented in the project records.

Observers for the sampling event who are not field personnel will be given a safety briefing by the HSO on physical and chemical hazards. Agency observers, or their designees, will be advised of chemicals that may be present at the site and where those chemicals may be located. In addition, appropriate attire and any precautions necessary while walking along the shoreline will be discussed.

A.2.0 Site Description and Project Scope

A.2.1 Site Description

The sampling area is in the LDW (see Figures 3-1 to 3-4 in the QAPP). The area is affected by tidal fluctuations. The QAPP to which this HSP is attached provides complete details of the sampling program. The following section summarizes the types of work that will be performed during field activities.

A.2.2 Scope of Work

Specific tasks to be performed are as follows:

- collection of sediment core samples from a boat

- processing of sediment cores in the laboratory using the Sedflume device (see Section 3.2.4)

Additional details on the sampling design and sampling methods are provided in Sections 3.1 and 3.2, respectively.

A.3.0 Health and Safety Personnel

Key health and safety personnel and their responsibilities are described below. These individuals are responsible for implementation of this HSP.

Windward Project Manager: The Windward project manager (PM) has overall responsibility for the successful outcome of the project. The PM will ensure that adequate resources and budget are provided for the health and safety staff to carry out their responsibilities during fieldwork. The PM, in consultation with the HSM, makes final decisions concerning implementation of the HSP.

Field Coordinator/Health and Safety Officer: Because of the limited scope and duration of fieldwork, the Field Coordinator (FC) and Health and Safety Officer (HSO) will be the same person. The FC/HSO will direct field sampling activities, coordinate the technical components of the field program with health and safety components, and ensure that work is performed according to the QAPP.

The FC/HSO will implement this HSP at the work location and will be responsible for all health and safety activities and the delegation of duties to a health and safety technician in the field, if appropriate. The FC/HSO also has stop-work authority, to be used if there is an imminent safety hazard or potentially dangerous situation. The FC/HSO or his designee shall be present during sampling and operations.

Corporate Health and Safety Manager: The HSM has overall responsibility for preparation, approval, and revisions of this HSP. The HSM will not necessarily be present during fieldwork, but will be readily available, if required, for consultation regarding health and safety issues during fieldwork.

Field Crew: All field crew members must be familiar with and comply with the information in this HSP. They also have the responsibility to report any potentially unsafe or hazardous conditions to the FC/HSO immediately.

A.4.0 Hazard Evaluation and Control Measures

This section covers potential physical and chemical hazards that may be associated with the proposed project activities, and presents control measures for addressing these hazards. The activity hazard analysis, Section A.4.3, lists the potential hazards associated with each site activity and the recommended site control to be used to minimize each potential hazard.

Confined space entry will not be necessary for this project. Therefore, hazards associated with this activity are not discussed in this HSP.

A.4.1 PHYSICAL HAZARDS

For this project, it is anticipated that physical hazards will present a greater risk of injury than chemical hazards. Physical hazards are identified and discussed below.

A.4.1.1 Slips, trips, and falls

As with all field work, caution should be exercised to prevent slips on slick surfaces. In particular, sampling from a boat or other floating platform requires careful attention to minimize the risk of falling down or of falling overboard. The same care should be used in rainy conditions or on the shoreline where slick rocks are found. Slips can be minimized by wearing boots with good tread, made of material that does not become overly slippery when wet.

Trips are always a hazard on the uneven deck of a boat, in a cluttered work area, or in the intertidal zone where uneven substrate is common. Personnel will keep work areas as free as possible from items that interfere with walking.

Falls may be avoided by working as far from exposed edges as possible, by erecting railings, and by using fall protection when working on elevated platforms. For this project, no work is anticipated that would present a fall hazard.

A.4.1.2 Sampling equipment deployment

A core sampler will be used to collect sediment samples. The sampler will be deployed from the stern of the boat by manual techniques. Care will be taken to ensure that the sampler is safely guided from the stern over the railing and into the water. Before sampling activities begin, there will be a training session for all field personnel for the equipment that will be onboard the sampling vessel.

A.4.1.3 Falling overboard

The sampling activities will be done from a boat. As with any work from a floating platform, there is a chance of falling overboard. Personal flotation devices (PFDs) will be worn while working on the boat.

A.4.1.4 Manual lifting

Equipment and samples must be lifted and carried. Back strain can result if lifting is done improperly. During any manual handling tasks, personnel should lift with the load supported by their legs and not their backs. For heavy loads, an adequate number of people will be used, or if possible, a mechanical lifting/handling device will be used.

A.4.1.5 Heat stress, hypothermia, or frostbite

Sampling operations and conditions that might result in the occurrence of heat stress are not anticipated. The sampling will occur during the time of year when cold weather conditions may occur, making hypothermia or frostbite a concern. The FC/HSO will monitor all crew members for early symptoms of hypothermia (e.g., shivering, muscle uncoordination, mild confusion). If such symptoms are observed, the FC/HSO will take immediate steps to reduce heat loss by providing extra layers of clothing or by temporarily moving the affected crew member to a warmer environment.

A.4.1.6 Weather

In general, field team members will be equipped for the normal range of weather conditions. The FC/HSO will be aware of current weather conditions, and of the potential for those conditions to pose a hazard to the field crew. Some conditions that might force work stoppage are electrical storms, high winds, or high waves resulting from winds. In the event of heavy rain, field team members will not sample near a flowing combined sewer overflow because of potentially high levels of fecal coliform bacteria.

A.4.1.7 Sharp objects

Sampling operations might result in exposure of field personnel to sharp objects on top of or buried within the sediment. If encountered, field personnel should not touch these objects. Also, field personnel should not dig in the sediment by hand.

A.4.2 Vessel Hazards

Because of the high volumes of vessel and barge traffic on the LDW, precautions and safe boating practices will be implemented to ensure that the field boat does not interrupt vessel traffic. Additional potential vessel emergency hazards and responses are listed in Table A-1.

Table A-1 Potential vessel emergency hazards and responses

Potential Emergency Hazard	Response
Fire or explosion	If manageable, attempt to put out a small fire with a fire extinguisher. Otherwise, call the Coast Guard or 911 and evacuate the area (by rescue boat or swimming) and meet at a designated area. The FC/HSO will take roll call to make sure everyone evacuated safely. Emergency meeting places will be determined in the field during the daily safety briefing.
Medical emergency/ personal injury	At least one person with current first aid and cardiopulmonary resuscitation (CPR) training will be aboard the vessel at all times. This person will attempt to assess the nature and severity of the injury, call 911 immediately, and apply CPR if necessary. Stop work and wait for medical personnel to arrive. Fill out a site accident report.
Person overboard	All persons aboard the sampling vessel will wear a PFD at all times. Have one person keep an eye on the person and shout the distance (boat lengths) and direction (o'clock) of the person from the vessel. Stop work and use the vessel to retrieve the person in the water.

Potential Emergency Hazard	Response
Sinking vessel	Call the Coast Guard immediately. If possible, wait for a rescue boat to arrive to evacuate vessel personnel. See fire/explosion section for emergency evacuation procedures. The FC/HSO will take a roll call to make sure everyone is present.
Lack of visibility	If the navigation visibility or personal safety is compromised because of smoke, fog, or other unanticipated hazards, stop work immediately. The vessel operator and FC/HSO will assess the hazard and, if necessary, send out periodic horn blasts to mark vessel location to other vessels potentially in the area, move to a secure location (i.e., berth), and wait for the visibility to clear.
Loss of power	Stop work and call Coast Guard for assistance. Use oars to move vessel towards the shoreline. Vessel personnel should watch for potential collision hazards and notify vessel operator if hazards exist. Secure vessel to a berth, dock, or mooring as soon as possible.
Collision	Stop work and call Coast Guard for assistance. The FC/HSO and vessel operator will assess damage and potential hazards. If necessary, vessel will be evacuated and secured until repairs can be made.

A.4.3 Chemical Hazards

Previous investigations have shown that some chemicals are present at higher-than-background concentrations in the sampling area. For the purposes of discussing potential exposure to chemicals in sediments, the chemicals of concern are metals, tributyltin (TBT), petroleum hydrocarbons, polycyclic aromatic hydrocarbons (PAHs), and polychlorinated biphenyls (PCBs).

A.4.3.1 Exposure routes

Potential routes of chemical exposure include inhalation, dermal contact, and ingestion. Exposure will be minimized by using safe work practices and by wearing the appropriate personal protective equipment (PPE). Further discussion of PPE requirements is presented in Section A.7.

Inhalation —Inhalation is not expected to be an important route of exposure.

Dermal exposure — Dermal exposure to hazardous substances associated with sediments, surface water, or equipment decontamination will be controlled by the use of PPE and by adherence to detailed sampling and decontamination procedures.

Ingestion — Ingestion is not considered a major route of exposure for this project. Accidental ingestion of surface water is possible. However, careful handling of equipment and containers aboard the boat should prevent the occurrence of water splashing or spilling during sample collection and handling activities.

A.4.3.2 Description of chemical hazards

Metals and tributyltin — Exposure to metals may occur via ingestion or skin contact. As mentioned above, neither is likely as an exposure route. Metal fumes or metal-contaminated dust will not be encountered during field and sample handling activities. Large amounts of sediment would need to be ingested for any detrimental effects to occur. Momentary skin contact allows little, if any, opportunity for passage of any of the metals into the body. Field procedures require immediate washing of sediments from exposed skin.

Petroleum hydrocarbons and PAHs — Exposure to petroleum hydrocarbons and PAHs may occur via ingestion or skin contact. The most important human health exposure pathway for this group of chemicals, inhalation, is not expected to occur at this site. Animal studies have also shown that PAHs can cause harmful effects on the skin, body fluids, and ability to fight disease after both short- and long-term exposure, but these effects have not been seen in people. Some PAHs may reasonably be expected to be carcinogens. Large amounts of sediment would need to be ingested for any detrimental effects to occur. Momentary skin contact allows little, if any, opportunity for passage of any of these compounds into the body. Field procedures require immediate washing of sediments from exposed skin.

PCBs — Prolonged skin contact with PCBs may cause acne-like symptoms known as chloracne. Irritation to eyes, nose, and throat may also occur. Acute and chronic exposure can damage the liver, and cause symptoms of edema, jaundice, anorexia, nausea, abdominal pains, and fatigue. PCBs are a suspected human carcinogen. Skin absorption may substantially contribute to the uptake of PCBs. Large amounts of sediment would need to be ingested for any detrimental effects to occur. Momentary skin contact allows little, if any, opportunity for passage of any of the compounds into the body. Field procedures require immediate washing of sediments from exposed skin.

A.4.4 Activity Hazard Analysis

The activity hazard analysis summarizes the field activities to be performed during the project, outlines the hazards associated with each activity, and presents controls that can reduce or eliminate the risk of the hazard occurring.

Table A-2 presents the activity hazard analysis for sediment sampling from a boat.

Table A-2. Activity hazard analysis

Activity	Hazard	Control
Sediment sampling from a boat	Falling overboard	Use care in boarding/departing from vessel. Deploy and recover the sampler from the back deck of the boat. Wear PFD.
	Skin contact with contaminated sediments or liquids	Wear modified Level D PPE.
	Back strain	Use appropriate lifting technique when deploying and retrieving heavy equipment, or seek help.

A.5.0 Work Zones and Shipboard Access Control

During sampling and sample handling activities, work zones will be established to identify where sample collection and processing are actively occurring. The intent of the zone is to limit the migration of sample material out of the zone and to restrict access to active work areas by defining work zone boundaries.

A.5.1 Work Zone

The work zone on the beach will encompass the area where sample collection and handling activities are performed. Only persons with appropriate training, PPE, and authorization from the FC/HSO will be allowed to enter the work zone while work is in progress.

A.5.2 Decontamination Station

A decontamination station will be set up, and personnel will clean soiled boots or PPE prior to leaving the work zone. The station will have the buckets, brushes, soapy water, rinse water, or wipes necessary to clean boots, PPE, or other equipment leaving the work zone. Plastic bags will be provided for expendable and disposable materials. If the location does not allow the establishment of a decontamination station, the FC/HSO will provide alternatives to prevent the spread of contamination.

Decontamination of the boat will also be completed at the end of each work day. Cockpit and crew areas will be rinsed down with LDW water to minimize accumulation of sediment.

A.5.3 Access Control

Security and control of access to the boat will be the responsibility of the FC/HSO and boat captain. Boat access will be granted only to necessary project personnel and authorized visitors. Any security or access control problems will be reported to the client or appropriate authorities.

A.6.0 Safe Work Practices

Following common sense rules will minimize the risk of exposure or accidents at a work site. These general safety rules will be followed on site:

- Do not climb over or under obstacles of questionable stability.
- Do not eat, drink, smoke, or perform other hand-to-mouth transfers in the work zone.
- Work only in well-lighted spaces.
- Never enter a confined space without the proper training, permits, and equipment.
- Make eye contact with equipment operators when moving within the range of their equipment.
- Be aware of the movements of shipboard equipment when not in the operator's range of vision.

- Get immediate first aid for all cuts, scratches, abrasions, or other minor injuries.
- Use the established sampling and decontamination procedures.
- Always use the buddy system.
- Be alert to your own and other workers' physical condition.
- Report all accidents, no matter how minor, to the FC/HSO.
- Do not do anything dangerous or unwise even if ordered by a supervisor.

A.7.0 Personal Protective Equipment and Safety Equipment

Appropriate PPE will be worn as protection against potential hazards. In addition, a PFD will be required when working aboard the boat. Prior to donning PPE, the field crew will inspect their PPE for any defects that might render the equipment ineffective.

Fieldwork will be conducted in Level D or modified Level D PPE, as discussed below in Sections A.7.1 and A.7.2. Situations requiring PPE beyond modified Level D are not anticipated. Should the FC/HSO determine that PPE beyond modified Level D is necessary, the HSM will be notified and an alternative selected.

A.7.1 Level D Personal Protective Equipment

Workers performing general activities in which skin contact with contaminated materials is unlikely will wear Level D PPE. Level D PPE includes the following:

- cotton overalls or lab coats
- chemical-resistant steel-toed boots
- chemical-resistant gloves
- safety glasses

A.7.2 Modified Level D Personal Protective Equipment

Workers performing activities where skin contact with contaminated materials is possible and in which inhalation risks are not expected will be required to wear an impermeable outer suit. The type of outerwear will be chosen according to the types of chemical contaminants that might be encountered. Modified Level D PPE includes the following:

- impermeable outer garb such as rain gear
- chemical-resistant steel-toed boots
- chemical-resistant outer gloves

A.7.3 Safety Equipment

In addition to PPE that will be worn by shipboard personnel, basic emergency and first aid equipment will also be provided. Equipment for the field team will include:

- a copy of this HSP
- first aid kit adequate for the number of personnel
- emergency eyewash

The FC/HSO will ensure that the safety equipment is aboard. Equipment will be checked daily to ensure its readiness for use.

A.8.0 Monitoring Procedures for Site Activities

A monitoring program that addresses the potential site hazards will be maintained. For this project, air, dust, and noise monitoring will not be necessary. No volatile organic compounds have been identified among the expected contaminants, the sampled media will be wet and will not pose a dust hazard, and none of the equipment emits high-amplitude (>85 dBA) sound. For this project, the monitoring program will consist of all workers monitoring themselves and their co-workers for signs that might indicate physical stress or illness.

All personnel will be instructed to look for and inform each other of any deleterious changes in their physical or mental condition during the performance of all field activities. Examples of such changes are as follows:

- headaches
- dizziness
- nausea
- symptoms of heat stress
- blurred vision
- cramps
- irritation of eyes, skin, or respiratory system
- changes in complexion or skin color
- changes in apparent motor coordination
- increased frequency of minor mistakes
- excessive salivation or changes in papillary response
- changes in speech ability or speech pattern
- shivering
- blue lips or fingernails

If any of these conditions develop, work shall be halted immediately and the affected person(s) evaluated. If further assistance is needed, personnel at the local hospital will be notified, and an ambulance will be summoned if the condition is thought to be serious. If the condition is the direct result of sample collection or handling activities, procedures will be modified to address the problem.

A.9.0 Decontamination

Decontamination is necessary to prevent the migration of contaminants from the work zone(s) into the surrounding environment and to minimize the risk of exposure of personnel to contaminated materials that might adhere to PPE. The following sections discuss personnel and equipment decontamination. The following supplies will be available to perform decontamination activities:

- wash buckets
- rinse buckets
- Long-handled scrub brushes
- clean water sprayers
- paper towels
- plastic garbage bags
- Alconox® or similar decontamination solution

A.9.1 MINIMIZATION OF CONTAMINATION

The first step in addressing contamination is to prevent or minimize exposure to existing contaminated materials and the spread of those materials. During field activities, the FC/HSO will enforce the following measures:

Personnel:

- Do not walk through areas of obvious or known contamination.
- Do not handle, touch, or smell contaminated materials directly.
- Make sure PPE has no cuts or tears prior to use.
- Fasten all closures on outer clothing, covering with tape if necessary.
- Protect and cover any skin injuries.
- Stay upwind of airborne dusts and vapors.
- Do not eat, drink, chew tobacco, or smoke in the work zones.

Sampling equipment and boat:

- Place clean equipment on a plastic sheet or aluminum foil to avoid direct contact with contaminated media.
- Keep contaminated equipment and tools separate from clean equipment and tools.
- Clean boots before entering the boat.

A.9.2 PERSONNEL DECONTAMINATION

The FC/HSO will ensure that all site personnel are familiar with personnel decontamination procedures. Personnel will perform decontamination procedures, as appropriate, before eating lunch, taking a break, or before leaving the work location. Following is a description of these procedures.

Decontamination procedure:

1. If outer suit is heavily soiled, rinse it off.
2. Wash and rinse outer gloves and boots with in water.
3. Remove outer gloves; inspect and discard if damaged.
4. Wash hands if taking a break.
5. Don necessary PPE before returning to work.

Dispose of soiled, expendable PPE before leaving for the day.

A.9.3 SAMPLING EQUIPMENT DECONTAMINATION

Before use at each sampling location, the sampler will be rinsed in river water to dislodge and remove any sediment, washed with detergent, rinsed again with LDW water, and rinsed with deionized water.

A.9.4 VESSEL DECONTAMINATION

All sampling will be conducted from a boat. Care will be taken not to spill any sediment collected in the core tubes in the vessel, so vessel decontamination should not be necessary. In the event that any sediment is spilled, the vessel will be rinsed with LDW water at the end of the sampling day to remove sediment from cockpit and crew areas.

A.10.0 Disposal of Contaminated Materials

Contaminated materials that may be generated during field activities include PPE, decontamination fluids, and excess sample material. These contaminated materials will be disposed of as an integral part of the project.

A.10.1 PERSONAL PROTECTIVE EQUIPMENT

Gross surface contamination will be removed from PPE. All disposable sampling materials and PPE, such as disposable coveralls, gloves, and paper towels used in sample processing, will be placed in heavyweight garbage bags. Filled garbage bags will be placed in a normal refuse container for disposal as solid waste.

A.10.2 EXCESS SAMPLE MATERIALS

At each sampling location, excess sediment collected will be returned to the water.

A.11.0 Training Requirements

Individuals performing work at locations where potentially hazardous materials and conditions may be encountered must meet specific training requirements. It is not anticipated that hazardous concentrations of contaminants will be encountered in sampled material, so training will consist of site-specific instruction for all personnel and oversight of inexperienced personnel by an experienced person for one working day. The following sections describe the training requirements for this fieldwork.

A.11.1 PROJECT-SPECIFIC TRAINING

In addition to HAZWOPER training, as described in Section 2.5 of the QAPP, field personnel will undergo training specifically for this project. All personnel must read this HSP and be familiar with its contents before beginning work. They shall acknowledge reading the HSP by signing the field team HSP review form contained in Attachment 1. The form will be kept in the project files.

The boat captain and FC/HSO or a designee will provide project-specific training prior to the first day of fieldwork and whenever new workers arrive. Field personnel will not be allowed to begin work until project-specific training is completed and documented by the FC/HSO. Training will address the HSP and all health and safety issues and procedures pertinent to field operations. Training will include, but not be limited to, the following topics:

- activities with the potential for chemical exposure
- activities that pose physical hazards, and actions to control the hazard
- ship access control and procedure
- use and limitations of PPE
- decontamination procedures
- emergency procedures
- use and hazards of sampling equipment
- location of emergency equipment on the vessel

- vessel safety practices
- vessel evacuation and emergency procedures

A.11.2 Daily Safety Briefings

The FC/HSO or a designee and the boat captain will present safety briefings before the start of each day's activities. These safety briefings will outline the activities expected for the day, update work practices and hazards, address any specific concerns associated with the work location, and review emergency procedures and routes. The FC/HSO or designee will document safety briefings in the logbook.

A.11.3 First Aid and CPR

At least one member of the field team must have first-aid and CPR training. Documentation of which individuals possess first-aid and CPR training will be kept in the project health and safety files.

A.12.0 Medical Surveillance

A medical surveillance program conforming to the provisions of 29 CFR 1910§120(f) is not necessary for field team members because they do not meet any of the four criteria outlined in the regulations for implementation of a medical surveillance program:

- Employees who are or may be exposed to hazardous substances or health hazards at or above permissible exposure levels for 30 days or more per year (1910.120(f)(2)(I).
- Employees who must wear a respirator for 30 days or more per year (1910.120(f)(2)(ii)).
- Employees who are injured or become ill due to possible overexposures involving hazardous substances or health hazards from an emergency response or hazardous waste operation (1910.120(f)(2)(iii)).
- Employees who are members of HAZMAT teams (1910.120(f)(2)(iv)).

As described in Section A.8, employees will monitor themselves and each other for any deleterious changes in their physical or mental condition during the performance of all field activities.

A.13.0 Reporting and Record Keeping

Each member of the field crew will sign the HSP review form (see Attachment 1). If necessary, accident/incident report forms and OSHA Form 200s will be completed by the FC/HSO.

The FC/HSO or a designee will maintain a health and safety field logbook that records health- and safety-related details of the project. Alternatively, entries may be made in the field logbook, in which case a separate health and safety logbook will not be required. The logbook must be bound and the pages must be numbered consecutively. Entries will be made with indelible blue ink. At a minimum, each day's entries must include the following information:

- project name or location
- names of all personnel onboard
- weather conditions
- type of fieldwork being performed

The person maintaining the entries will initial and date the bottom of each completed page. Blank space at the bottom of an incompletely filled page will be lined out. Each day's entries will begin on the first blank page after the previous workday's entries.

A.14.0 Emergency Response Plan

As a result of the hazards onboard and the conditions under which operations will be conducted, the potential exists for an emergency situation to occur. Emergencies may include personal injury, exposure to hazardous substances, fire, explosion, or release of toxic or non-toxic substances (spills). OSHA regulations require that an emergency response plan be available for use onboard to guide actions in emergency situations.

Onshore organizations will be relied upon to provide response in emergency situations. The local fire department and ambulance service can provide timely response. Field personnel will be responsible for identifying an emergency situation, providing first aid if applicable, notifying the appropriate personnel or agency, and evacuating any hazardous area. Shipboard personnel will attempt to control only very minor hazards that could present an emergency situation, such as a small fire, and will otherwise rely on outside emergency response resources.

The following sections identify the onboard individual(s) who should be notified in case of emergency, provide a list of emergency telephone numbers, offer guidance for particular types of emergencies, and provide directions for getting from any sampling location to a hospital.

A.14.1 Pre-Emergency Preparation

Before the start of field activities, the FC/HSO will ensure that preparation has been made in anticipation of emergencies. Preparatory actions include the following:

- Meeting with the FC/HSO and equipment handlers concerning the emergency procedures in the event that a person is injured.
- A training session given by the FC/HSO informing all field personnel of emergency procedures, locations of emergency equipment and their use, and proper evacuation procedures.

- A training session given by senior staff operating field equipment, to apprise field personnel of operating procedures and specific risks associated with that equipment.
- Ensuring that field personnel are aware of the existence of the emergency response plan in the HSP and ensuring that a copy of the HSP accompanies the field team.

A.14.2 PROJECT EMERGENCY COORDINATOR

The FC/HSO will serve as the Project Emergency Coordinator in the event of an emergency. He will designate his replacement for times when he is not onboard or is not serving as the Project Emergency Coordinator. The designation will be noted in the logbook. The Project Emergency Coordinator will be notified immediately when an emergency is recognized. The Project Emergency Coordinator will be responsible for evaluating the emergency situation, notifying the appropriate emergency response units, coordinating access with those units, and directing interim actions onboard before the arrival of emergency response units. The Project Emergency Coordinator will notify the HSM and the Project Manager as soon as possible after initiating an emergency response action. The Project Manager will have responsibility for notifying the client.

A.14.3 EMERGENCY RESPONSE CONTACTS

All onboard personnel must know whom to notify in the event of an emergency situation, even though the FC/HSO has primary responsibility for notification. Table A-3 lists the names and phone numbers for emergency response services and individuals.

Table A-3. Emergency response contacts

CONTACT	TELEPHONE NUMBER
Emergency Numbers	
Ambulance	911
Police	911
Fire	911
Harborview Medical Center	(206) 323-3074
Emergency Responders	
U.S. Coast Guard Emergency General information	 (206) 286-5400 (206) 442-5295 UHF Channel 16
National Response Center	(800) 424-8802
EPA	(908) 321-6660
Washington State Department of Ecology – Northwest Region Spill Response (24-hour emergency line)	(206) 649-7000

CONTACT	TELEPHONE NUMBER
Emergency Contacts	
Project Manager	
Kathy Godtfredsen	(206) 577-1283
Corporate Health and Safety Manager	
Tad Deshler	(206) 577-1285
Field Coordinator/ Field Health and Safety Officer	Site cellular telephone:
Mark LaRue	(315) 730-5341
Craig Jones	(831) 212-1566

A.14.4 RECOGNITION OF EMERGENCY SITUATIONS

Emergency situations will generally be recognizable by observation. An injury or illness will be considered an emergency if it requires treatment by a medical professional and cannot be treated with simple first-aid techniques.

A.14.5 DECONTAMINATION

In the case of evacuation, decontamination procedures will be performed only if doing so does not further jeopardize the welfare of site workers. If an injured individual is also heavily contaminated and must be transported by emergency vehicle, the emergency response team will be told of the type of contamination. To the extent possible, contaminated PPE will be removed, but only if doing so does not exacerbate the injury. Plastic sheeting will be used to reduce the potential for spreading contamination to the inside of the emergency vehicle.

A.14.6 FIRE

Field personnel will attempt to control only small fires, should they occur. If an explosion appears likely, personnel will follow evacuation procedures specified during the training session. If a fire cannot be controlled with a fire extinguisher on board that is part of the required safety equipment, personnel will either withdraw from the vicinity of the fire or evacuate the boat as specified in the training session.

A.14.7 PERSONAL INJURY

In the event of serious personal injury, including unconsciousness, possibility of broken bones, severe bleeding or blood loss, burns, shock, or trauma, the first responder will immediately do the following:

- Administer first aid, if qualified.
- If not qualified, seek out an individual who is qualified to administer first aid, if time and conditions permit.
- Notify the Project Emergency Coordinator of the incident, the name of the individual, the location, and the nature of the injury.

The Project Emergency Coordinator will immediately do the following:

- Notify the boat captain and the appropriate emergency response organization.
- Assist the injured individual.
- Follow the emergency procedures for retrieving or disposing equipment reviewed in the training session and leave the site en route to the predetermined land-based emergency pick-up.
- Designate someone to accompany the injured individual to the hospital.
- If a life-threatening emergency occurs, i.e., injury where death is imminent without immediate treatment, the FC/HSO or boat captain will call 911 and arrange to meet the Medic One unit at the nearest accessible dock. Otherwise, for emergency injuries that are not life-threatening (i.e., broken bones, minor lacerations, etc.) the Project Emergency Coordinator will follow the procedures outlined above and proceed to the Harbor Island Marina or to an alternative location of his choice if that would be more expedient.
- Notify the HSM and the Project Manager.

If the Project Emergency Coordinator determines that emergency response is not necessary, he or she may direct someone to decontaminate and transport the individual by vehicle to the nearest hospital. Directions showing the route to the hospital are in Section A.14.10.

If a worker leaves the boat to seek medical attention, another worker should accompany them to the hospital. When in doubt about the severity of an injury or exposure, always seek medical attention as a conservative approach, and notify the Project Emergency Coordinator.

The Project Emergency Coordinator will have responsibility for completing all accident/incident field reports, OSHA Form 200s, and other required follow-up forms.

A.14.8 Overt Personal Exposure or Injury

If an overt exposure to toxic materials occurs, the first responder to the victim will initiate actions to address the situation. The following actions should be taken, depending on the type of exposure.

A.14.8.1 Skin contact

- Wash/rinse the affected area thoroughly with copious amounts of soap and water.
- If eye contact has occurred, eyes should be rinsed for at least 15 minutes using the eyewash that is part of the emergency equipment onboard.
- After initial response actions have been taken, seek appropriate medical attention.

A.14.8.2 Inhalation

- Move victim to fresh air.
- Seek appropriate medical attention.

A.14.8.3 Ingestion

- Seek appropriate medical attention.

A.14.8.4 Puncture wound or laceration

- Seek appropriate medical attention.

A.14.9 SPILLS AND SPILL CONTAINMENT

No bulk chemicals or other materials subject to spillage are expected to be used during this project. Accordingly, no spill containment procedure is required for this project.

A.14.10 EMERGENCY ROUTE TO THE HOSPITAL

The name, address, and telephone number of the hospital that will be used to provide medical care is as follows:

Harborview Medical Center
325 - 9th Ave
Seattle, WA
(206) 323-3074

Directions from the vicinity of LDW to Harborview Medical Center are as follows:

- Dock the vessel at the 1st Ave S boat launch.
- Drive east on S River Street.
- Turn left on Occidental Ave S.
- Turn left on E Marginal Way S.
- Turn right on S Michigan Street.
- Look for entrance ramps to I-5 Northbound.
- Head north on I-5.
- Take the James Street exit.
- Head east on James Street to 9th Avenue.
- Turn right on 9th Avenue.
- Emergency entrance will be two blocks south on the right.

Attachment A1. Field Team Health and Safety Plan Review

I have read a copy of the Health and Safety Plan, which covers field activities that will be conducted to investigate potentially contaminated areas in the LDW. I understand the health and safety requirements of the project, which are detailed in this Health and Safety Plan.

Signature	Date
Signature	Date
Signature	Date
Signature	Date
Signature	Date
Signature	Date
Signature	Date
Signature	Date
Signature	Date
Signature	Date

APPENDIX B. FIELD COLLECTION FORMS

SEDIMENT COLLECTION FORM

Project Name:		Project no.	
Date:		Station:	
Start/Stop time:			X:
Sampling Method:			Y:
Weather:		Sample ID:	
Crew:			

Subsample #:	Sample depth:	Penetration depth		Time:
Sampling gear:			Acceptable sample (circle)	yes no
type:	color:	odor:		Comments:
cobble	drab olive	none	H_2S	
gravel	gray	slight	petroleum	
sand C M F	black	moderate	other:	
silt clay	brown	strong		
organic matter	brown surface	overwhelming		

Subsample #:	Sample depth:	Penetration depth		Time:
Sampling gear:			Acceptable sample (circle)	yes no
type:	color:	odor:		Comments:
cobble	drab olive	none	H_2S	
gravel	gray	slight	petroleum	
sand C M F	black	moderate	other:	
silt clay	brown	strong		
organic matter	brown surface	overwhelming		

Subsample #:	Sample depth:	Penetration depth		Time:
Sampling gear:			Acceptable sample (circle)	yes no
type:	color:	odor:		Comments:
cobble	drab olive	none	H_2S	
gravel	gray	slight	petroleum	
sand C M F	black	moderate	other:	
silt clay	brown	strong		
organic matter	brown surface	overwhelming		

SAMPLE ALTERATION FORM

Project Name and Number: ______________________________

Material to be Sampled: ______________________________

Measurement Parameter: ______________________________

____

____

Standard Procedure for Field Collection & Laboratory Analysis (cite reference):

____

____

Reason for Change in Field Procedure or Analysis Variation: ______________

____

____

Variation from Field or Analytical Procedure: ______________

____

____

Special Equipment, Materials or Personnel Required: ______________

____

____

____

Initiator's Name: ______________________ Date: __________

Project Officer: ______________________ Date: __________

QA Officer: ______________________ Date: __________

CORRECTIVE ACTION FORM

Project Name and Number: ______________________________

Sample Dates Involved: ______________________________

Measurement Parameter: ______________________________

____

____

Acceptable Data Range:

____

____

____

Problem Areas Requiring Corrective Action: ______________________________

____

____

Measures Required to Correct Problem: ______________________________

____

____

Means of Detecting Problems and Verifying Correction: ______________________________

____

____

Initiators Name:	______________________________	Date:	______________
Project Officer:	______________________________	Date:	______________
QA Officer:	______________________________	Date:	______________

SEDFLUME SAMPLING DATA SHEET

Sea Engineering, Inc.
Project Number: **Project Title**:

DATE (mm/dd/yy) ____________ INITIAL ________ AREA-STATION ID ______________

ON STATION ____________ WATER _________ Ft M

STATION POSITION Latitude or ____________________ Longitude or Easting ____________________

SAMPLER USED (circle one) Vibracorer Gravity Corer Push Corer (size _______) Van Veen Grab Other:

Sampling Area	Sample Type	Minimum Acceptable Recovery
	Sedflume*	30 cm (1 ft)
* Core must have undisturbed surface and no visible fractures in core.		

Attempt Number					
Attempt Start/End Time	/	/	/	/	/
Apparent Penetration Depth (ft or cm)					
Recovery (ft or cm)					
Accepted (yes/no)					
Rejection Code					

Rejection Codes

OP	Overpenetrated	DB	Debris interference	NS	No sediment in sampler
NR	Insufficient Recovery	DS	Disturbed surface	FR	Core has visible fracture in sediments

For Acceptable Sample: Visible color change near surface? No Yes at _______cm Photographed ? No Yes	Attach Unique Sample ID here

Comments ____

Reviewed by ______________________ Date ___________

SEDFLUME LABORATORY DATASHEET

Sample Designation:

Date/Time:

Core Height: cm

Reference Height for the top of the core: cm

Reference Contact:

Location:

Project:

Item Number	Shear Stress (dynes/cm^2)	Starting Height (mm)	Ending Height (mm)	Time (sec)	NOTES

Bulk Density Datasheet

Sample Designation:

Date/Time:

Core Height: cm

Location:

Reference Contact:

Project:

Depth	Wet Wt. (g)	Dry Wt. (g)