

Lower Duwamish Waterway Group

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

QUALITY ASSURANCE PROJECT PLAN: SURFACE SEDIMENT SAMPLING FOR CHEMICAL ANALYSES IN THE LOWER DUWAMISH WATERWAY ROUND 3 ADDENDUM FINAL

For submittal to

**The US Environmental Protection Agency
Region 10
Seattle, WA**

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

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TITLE AND APPROVAL PAGE
QUALITY ASSURANCE PROJECT PLAN:
SURFACE SEDIMENT SAMPLING FOR CHEMICAL ANALYSES
IN THE LOWER DUWAMISH WATERWAY – ROUND 3 ADDENDUM

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Acronyms

ACRONYM	Definition
ARI	Analytical Resources, Inc.
Axys	Axys Analytical Services, Ltd.
BEHP	bis(2-ethylhexyl) phthalate
COC	chain of custody
CSL	cleanup screening level
CSO	combined sewer overflow
CVAA	cold vapor atomic absorption
DBT	dibutyltin
DGPS	differential global positioning system
DQI	data quality indicator
Ecology	Washington State Department of Ecology
EPA	US Environmental Protection Agency
FC	field coordinator
FS	feasibility study
GC/ECD	gas chromatography/electron capture detection
GC/FPD	gas chromatography/flame photometric detection
GC/MS	gas chromatography/mass spectrometry
GPS	global positioning system
HDPE	high-density polyethylene
HRGC/HRMS	high-resolution gas chromatography/high-resolution mass spectrometry
ICP-MS	inductively coupled plasma – mass spectrometry
ICP-OES	inductively coupled plasma – optical emission spectrometry
ID	identification
LDC	Laboratory Data Consultants, Inc.
LDW	Lower Duwamish Waterway
LDWG	Lower Duwamish Waterway Group
MBT	monobutyltin
MDL	method detection limit
MLLW	mean lower low water
NAD	North American Datum
NOAA	National Oceanic and Atmospheric Administration
PAH	polycyclic aromatic hydrocarbon

ACRONYM	Definition
PCB	polychlorinated biphenyl
PM	project manager
PSEP	Puget Sound Estuary Program
QA/QC	quality assurance/quality control
QAPP	quality assurance project plan
RI	remedial investigation
RL	reporting limit
SDG	sample delivery group
SIM	selected ion monitoring
SMS	Washington State Sediment Management Standards
SQS	Washington State Sediment Quality Standards
SVOC	semivolatile organic compound
TM	task manager
TOC	total organic carbon
TBT	tributyltin
USCG	US Coast Guard
Windward	Windward Environmental LLC
WM HDPE	wide-mouth high-density polyethylene

1.0 Introduction

The purpose of this addendum to the surface sediment sampling of the Lower Duwamish Waterway (LDW) quality assurance project plan (QAPP; Windward 2005) is to provide specifications for collection and chemical analyses of additional surface sediment samples from the LDW. Data from this study will be used in combination with the existing data to determine the nature and extent of chemical contamination for Phase 2 of the LDW remedial investigation (RI), as described in the Phase 2 RI work plan (Windward 2004) and the original surface sediment QAPP (Windward 2005). Data collected during the Round 3 surface sediment sampling will be presented and discussed in an appendix to the Phase 2 RI and used in conjunction with all other datasets to select and refine options for cleanup areas in the feasibility study (FS). Toxicity testing will not be performed on samples collected in this round of sampling because of overall project schedule constraints. Therefore, Washington State Sediment Management Standard (SMS) compliance at these locations will be based solely on the surface sediment chemistry data in lieu of additional toxicity testing data.

This QAPP addendum provides details that are specific to the sediment sampling and chemical analyses in 2006. The original QAPP (Windward 2005) is referenced, as appropriate, for details that remain unchanged from the original sampling design.

This addendum is organized into the following sections:

- ◆ Section 2.0 – project management
- ◆ Section 3.0 – study design
- ◆ Section 4.0 – assessment and oversight
- ◆ Section 5.0 – data validation and usability
- ◆ Section 6.0 – references

Sampling will be conducted in accordance with the health and safety plan presented in the original QAPP (Windward 2005).

2.0 Project Management

This section describes the overall management of the project, including key personnel, project description, problem definition and background, and the project task description and schedule. Details regarding data quality objectives and criteria, special training requirements and certification, and documents and recordkeeping can be found in Sections 2.4 through 2.6 of the original QAPP (Windward 2005).

2.1 PROJECT ORGANIZATION AND TEAM MEMBER RESPONSIBILITIES

The Lower Duwamish Waterway Group (LDWG), the US Environmental Protection Agency (EPA), and the Washington Department of Ecology (Ecology) will be involved

in all aspects of this project, including discussion, review, and approval of the QAPP addendum, and interpretation of the results of the investigation. This sampling effort will be performed by Windward Environmental LLC (Windward). Overall project organization and responsibilities of project team members, as well as those of the laboratory project manager (PM), are described in Section 2.1 of the original QAPP (Windward 2005). Kathy Godtfredsen will serve as the Windward PM, and is 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 PM)
Windward Environmental LLC
200 W. Mercer St., Suite 401
Seattle, WA 98119
Telephone: 206.577.1283
Facsimile: 206.217.0089
Email: kathyg@windwardenv.com

Berit Bergquist will serve as the Windward task manager (TM). The TM is 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 TM is responsible for communicating with the Windward PM on the progress of project tasks and any deviations from the QAPP. Significant deviations from the QAPP will be further reported to LDWG, EPA, and Ecology. Ms. Bergquist can be reached as follows:

Berit Bergquist (Windward TM)
Windward Environmental LLC
200 W. Mercer St., Suite 401
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Telephone: 206.577.1291
Facsimile: 206.217.0089
Email: beritb@windwardenv.com

The field coordinator (FC) and quality assurance/quality control (QA/QC) coordinator for this sampling and analytical effort are different from those specified in the original QAPP. Thai Do will serve as the FC, and Marina Mitchell will serve as QA/QC coordinator. The contact information for these individuals is as follows:

Thai Do (FC)
Windward Environmental LLC
200 W. Mercer St., Suite 401
Seattle, WA 98119

Telephone: 206.812.5407
Facsimile: 206.217.0089
Email: thaid@windwardenv.com

Marina Mitchell (QA/QC coordinator)
Windward Environmental LLC
200 W. Mercer St., Suite 401
Seattle, WA 98119
Telephone: 206.812.5424
Facsimile: 206.217.0089
Email: marinam@windwardenv.com

Analytical Resources, Inc. (ARI), and Axys Analytical Services, Ltd. (Axys), will perform chemical analyses of the sediment samples for consistency with the analyses performed on surface sediment samples collected in 2005. Independent third-party data review and summary validation of the analytical data will be conducted by Laboratory Data Consultants, Inc. (LDC). The laboratory PM at ARI can be reached as follows:

Susan Dunninghoo
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 Axys can be reached as follows:

Georgina Brooks
Axys Analytical Services, Ltd.
PO Box 2219
2045 Mills Road
Sidney, British Columbia V8L 3S8
Telephone: 250.656.0881
Email: gbrooks@axys.com

The data validation PM at LDC can be reached as follows:

Stella Cuenco
Laboratory Data Consultants, Inc.
7750 El Camino Real, Suite 2C
Carlsbad, CA 92009-8519
Telephone: 760.634.0437
Email: scuenco@lab-data.com

See the original QAPP (Windward 2005) for additional details on project organization and team member responsibilities that remain unchanged from the original QAPP.

2.2 PROBLEM DEFINITION/BACKGROUND

The Phase 2 RI work plan (Windward 2004) identified the need for additional surface sediment samples for chemical analyses and toxicity testing beyond the data available for the Phase 1 RI. To address this need, sediment samples were collected from 165 locations in the LDW for chemical analyses in 2005, and 48 of those samples were tested for toxicity, per the original QAPP (Windward 2005). Section 2.2 of the original QAPP presented the objectives, background information, and data needs addressed by the 2005 sampling event.

The objective of this study is to fill remaining data needs for the Phase 2 RI/FS after consideration of existing LDW sediment samples from other studies, as well as completed Phase 2 studies. In general, sampling locations identified for this study were selected by EPA and Ecology. In particular, sampling locations were selected to:

- ◆ Facilitate a better understanding of the areal extent of chemicals of potential concern in the vicinity of locations where previous samples had chemical concentrations that exceeded the sediment quality standards (SQS) or the cleanup screening levels (CSL) of the SMS¹
- ◆ Further characterize the nature and extent of chemical concentrations in sediments near potential current or historical chemical sources and better define the areal extent of potential cleanup areas for the FS
- ◆ Collect surface sediment data where subsurface contamination indicated surface contamination may be present but surface sediment data have not previously been collected
- ◆ Collect data to help evaluate temporal trends in post-cleanup surface chemistry at the Norfolk CSO cap
- ◆ Characterize areas where past King County sampling data indicated a potential for contamination

2.3 PROJECT AND TASK DESCRIPTION AND SCHEDULE

A detailed sampling design is presented in Section 3.1. Sampling of surface sediment will be initiated following EPA's approval of this QAPP addendum. This fieldwork is tentatively scheduled for the week of October 2, 2006, depending on the time required to finalize the QAPP addendum.

The sediment samples will be chemically analyzed at ARI for the analytes specified in Sections 3.4 and Appendix A, with a turn-around time of three weeks. Dioxins and

¹ WAC 173-204. The SQS represent numeric chemical concentrations below which sediments are designated as having no adverse effects on biological resources. At chemical concentrations above the SQS but below the CSL, sediments are designated as having minor adverse effects on biological resources. At chemical concentrations above the CSL, there is a high probability of adverse biological affects.

furans will be analyzed in a subset of samples by Axys, with a turn-around time of 6 weeks. Samples will not undergo toxicity testing. Analytical data will be validated by LDC within 3 weeks of receiving data packages from the respective laboratories. A data report documenting all activities associated with the collection, handling, and analysis of sediment samples will be prepared. At a minimum, the following information will be included in the data report:

- ◆ Summary of all field activities, including descriptions of any QAPP deviations
- ◆ Sediment sampling location coordinates
- ◆ Plan view showing the actual sampling locations
- ◆ Maps showing results from the Round 3 sampling event combined with results from the baseline surface sediment dataset
- ◆ Summary of the validation of the analytical data
- ◆ Data validation reports (appendices)
- ◆ Results from the analysis of field samples, presented as summary tables in the main body of the report and appendices
- ◆ Data forms submitted by the laboratories (appendices)

The draft data report is scheduled for submittal to EPA and Ecology on February 9, 2007, contingent on timely receipt of data from the laboratories and data validation. The final data report will be submitted to EPA and Ecology following revision of the data report in response to agency comments. Once the data report has been approved by EPA and Ecology, database exports will be created from Windward's database. The data will be exported in SEDQUAL format (Release 5), as well as Microsoft® Access™ tables, which will include information pertaining to the sampling event, locations, samples, and results.

3.0 Study Design

This section describes the collection and handling of sediment samples for chemical analyses. Elements include sampling design, sampling methods, sample handling, and analytical methods. Details regarding custody requirements, QA/QC, instrument/equipment testing and frequency, inspection and maintenance, instrument calibration, supply inspection/acceptance, and data management can be found in the original QAPP, Sections 3.3 and 3.5 through 3.10 (Windward 2005).

3.1 SAMPLING DESIGN

This section describes the specific sampling design developed to meet the data needs presented in Section 2.2. In general, this sampling design was developed by EPA and Ecology. There may be contingencies during field activities that require modification of the general procedures outlined below. Modification of procedures will be at the

discretion of the FC after consultation with the Windward PM and the boat operator, if applicable. EPA and Ecology will be consulted immediately in the event that significant deviations from the sampling design are required (e.g., significant relocation of a sample). All modifications will be recorded in the field logbook.

3.1.1 Surface sediment sampling locations

This section presents the sampling locations selected for this round of surface sediment sampling. Surface sediment samples will be collected from 44 locations that were identified by EPA and Ecology as being of interest. In some instances, permission may be required from landowners to access specific locations, and, if access is denied, new sampling locations may need to be identified. Table 3-1 lists each area, the rationale for its selection, and the numbers of individual sampling locations selected within each area. Specific sampling locations are shown in Figures 3-1a through 3-1d (located at the end of this document), and their coordinates are given in Table 3-2.

Table 3-1. Locations selected for additional surface sediment sampling

SAMPLE LOCATION NUMBER	RATIONALE
301	Coverage near storm drain and marina; delineate potential impacts to sediments from outfalls versus marinas by collecting samples within marina footprints; fluoranthene exceeded SQS in a Phase 2 surface sediment sample; PCBs, phthalates, and mercury exceeded CSL in the top interval of the Phase 2 subsurface sediment core sample.
302	
303	Coverage near outfalls and cement plant; PCBs, lead, and BEHP exceeded CSL in a Phase 2 surface sediment sample; PCBs, BEHP, and metals exceeded CSL in the top interval of the Phase 2 subsurface sediment core sample.
304	
305	
306	PCBs exceeded SQS in the top interval of the Phase 2 subsurface sediment core; historical subsurface sediment core with CSL exceedances for PCBs, BEHP, and mercury in the top interval; coverage near three storm drains in channel to north of area.
307	PCBs exceeded SQS in a historical surface sediment sample; metals exceeded the SQS in the top interval of the Phase 2 subsurface sediment core; further delineate area near shore to the south of cement plant.
308	PCBs exceeded SQS in a Phase 2 surface sediment samples; mercury exceeded CSL in one mid-channel Phase 2 surface sediment sample; phenol exceeded SQS in a historical surface sediment sample; further characterize area.
309	
310	PCBs and PAHs exceeded SQS in historical surface sediment samples; PCBs exceeded CSL in top interval of historical subsurface core; elevated TBT concentrations in historical surface sediment sample in vicinity of sampling location; further delineate surface sediment.
311	Further investigate PAH, mercury, and PCB CSL exceedances in surface sediment samples in the King County water quality assessment investigation (1997); mercury, benzyl alcohol, and PAHs exceeded CSL and zinc exceeded SQS in a Phase 2 surface sediment sample; PCBs exceeded SQS in a historical surface sediment sample; PCBs, PAHs, and metals exceeded CSL in the top interval of the Phase 2 subsurface sediment cores; further delineate area.
312	
313	Coverage west of Kellogg Island to further investigate hexachlorobenzene and benzoic acid CSL exceedances found in King County water quality assessment investigation (1997), but not shown of the map because of missing coordinate information.
314	

SAMPLE LOCATION NUMBER	RATIONALE
315	
316	PCBs and mercury exceeded CSL in the top interval of the Phase 2 subsurface sediment core; phthalates exceeded SQS in the top interval of the Phase 2 subsurface sediment core; PCBs exceeded SQS in Phase 2 surface sediment sample; elevated dioxin/furan concentration in Phase 2 surface sediment sample just south of these sampling locations; further delineate surface sediment.
317	
318	
319	
320	PCBs and metals exceeded SQS in historical surface sediment samples and PCBs and fluoranthene exceeded SQS in top interval of Phase 2 subsurface sediment core; further delineate area.
321	
322	Elevated dioxin/furan concentration in Phase 2 surface sediment sample; PCBs and mercury exceeded the CSL in Phase 2 surface sediment sample; PCBs and mercury exceeded the CSL in the top interval of the Phase 2 subsurface sediment core; further define extent of contamination in area.
323	
324	
325	
326	PCBs and benzyl alcohol exceeded SQS in historical surface sediment sample; further characterize area.
327	PCBs exceeded SQS in the top interval of Phase 2 subsurface sediment core; re-occupy location of subsurface sediment core station SC-32 to further characterize surface sediment.
328	Two historical subsurface sampling locations (PSDDA99 S11 and S12) with PCB SQS exceedances in the top core interval; re-occupy PSDDA99 station S12 location to further characterize surface sediment.
329	Further characterize area south of sample location 328.
330	Metals exceeded CSL in Phase 2 surface sediment sample and top interval of adjacent Phase 2 subsurface sediment core; characterize spatial extent of contamination in area near metal debris underlying pier structure.
331	Additional coverage in restoration area with pipes of unknown use.
332	
333	PCBs exceeded SQS and mercury exceeded CSL in adjacent Phase 2 surface sediment sample; further delineate the extent of contamination in area.
334	
335	PAHs exceeded CSL in Phase 2 surface sediment sample; PAHs exceeded SQS in top interval of Phase 2 subsurface sediment core; further characterize area with recently removed derelict barges.
336	
337	Further characterize area in the navigation channel where there was inadequate spatial coverage.
338	
339	PCBs exceeded SQS in Phase 2 surface sediment sample and top interval of Phase 2 subsurface sediment core; phenol exceeded SQS in historical surface sediment sample; further characterize surface sediment in important habitat area.
340	

SAMPLE LOCATION NUMBER	RATIONALE
341	Extend monitoring period at four Norfolk monitoring locations (NFK501, NFK502, NFK503, and NFK504).
342	
343	
344	

BEHP – bis(2-ethylhexyl) phthalate

CSL – cleanup screening level

CSO – combined sewer overflow

PAH – polycyclic aromatic hydrocarbon

PCB – polychlorinated biphenyl

SQS – sediment quality standard

Table 3-2. Surface sediment sampling location coordinates

LOCATION ID	X COORDINATE ^a	Y COORDINATE ^a	LATITUDE ^b	LONGITUDE ^b	ESTIMATED DEPTH ABOVE (+) OR BELOW (-) MLLW (ft) ^c
LDW-SS301	1266210	211325	47 34 09.240	122 20 57.438	-17.9
LDW-SS302	1266437	211221	47 34 08.261	122 20 54.092	na
LDW-SS303	1266910	211349	47 34 09.613	122 20 47.232	na
LDW-SS304	1267051	211325	47 34 09.399	122 20 45.179	-7.8
LDW-SS305	1267097	211038	47 34 06.577	122 20 44.415	-20.6
LDW-SS306	1265950	210561	47 34 01.650	122 21 01.002	na
LDW-SS307	1267019	210683	47 34 03.064	122 20 45.457	na
LDW-SS308	1266431	209987	47 33 56.082	122 20 53.836	-40.2
LDW-SS309	1266471	209768	47 33 53.925	122 20 53.180	-38.3
LDW-SS310	1266483	209455	47 33 50.844	122 20 52.920	-38.7
LDW-SS311	1265971	208308	47 33 39.420	122 21 00.060	0
LDW-SS312	1265952	208004	47 33 33.420	122 21 00.240	4
LDW-SS313	1266326	207619	47 33 32.691	122 20 54.683	na
LDW-SS314	1266203	207452	47 33 31.026	122 20 56.425	na
LDW-SS315	1267334	207247	47 33 29.216	122 20 39.887	-35.2
LDW-SS316	1267300	207014	47 33 26.914	122 20 40.307	-25.1
LDW-SS317	1267481	207060	47 33 27.405	122 20 37.690	-34.7
LDW-SS318	1267471	206835	47 33 25.179	122 20 37.764	-39.0
LDW-SS319	1267822	206718	47 33 24.093	122 20 32.616	-26.3
LDW-SS320	1267960	206670	47 33 23.646	122 20 30.590	-25.1
LDW-SS321	1267693	206344	47 33 20.377	122 20 34.386	-33.7
LDW-SS322	1267593	206143	47 33 18.377	122 20 35.783	-30.6
LDW-SS323	1267825	206206	47 33 19.044	122 20 32.419	-29.1
LDW-SS324	1267783	205991	47 33 16.913	122 20 32.983	-34.4

LOCATION ID	X COORDINATE ^a	Y COORDINATE ^a	LATITUDE ^b	LONGITUDE ^b	ESTIMATED DEPTH ABOVE (+) OR BELOW (-) MLLW (ft) ^c
LDW-SS325	1268445	204741	47 33 04.709	122 20 22.970	-10.5
LDW-SS326	1268416	204485	47 33 02.174	122 20 23.319	-25.6
LDW-SS327	1269345	202959	47 32 47.295	122 20 09.345	-16.9
LDW-SS328	1269510	201597	47 32 33.888	122 20 06.553	-25.8
LDW-SS329	1269671	201555	47 32 33.501	122 20 04.201	na
LDW-SS330	1270484	201439	47 32 32.517	122 19 52.316	-15.9
LDW-SS331	1269568	200916	47 32 27.180	122 20 05.520	na
LDW-SS332 ^d	1269603	200875	47 32 26.781	122 20 04.997	na
LDW-SS333	1271773	199401	47 32 12.654	122 19 32.949	-8.3
LDW-SS334	1271829	199194	47 32 10.625	122 19 32.078	-17.8
LDW-SS335	1271975	198625	47 32 05.033	122 19 29.790	na
LDW-SS336	1272224	198560	47 32 04.437	122 19 26.145	-11.2
LDW-SS337	1275788	195240	47 31 32.361	122 18 33.282	-15.4
LDW-SS338	1275934	194824	47 31 28.283	122 18 31.037	-14.5
LDW-SS339	1277656	190148	47 30 42.465	122 18 04.665	na
LDW-SS340	1277524	189892	47 30 39.914	122 18 06.511	na
LDW-SS341	1278543	190194	47 30 43.086	122 17 51.753	na
LDW-SS342	1278515	190156	47 30 42.706	122 17 52.150	na
LDW-SS343	1278589	190169	47 30 42.848	122 17 51.076	na
LDW-SS344	1278627	190079	47 30 41.967	122 17 50.497	na

^a Coordinates are in Washington State Plane N, NAD83, US ft.

^b Coordinates are in degrees, minutes and decimal seconds, NAD83.

^c Depth estimated from recent bathymetry data (Windward and DEA 2004).

^d Coordinates presented in the table match the sampling location selected during the 9/18/2006 field visit with EPA oversight personnel.

ID – identification

LDW – Lower Duwamish Waterway

MLLW – mean lower low water

na – not available; bathymetry data were not available because the area was too shallow to be surveyed or because barges were present during the bathymetry survey

3.1.2 Surface sediment sample analyses

SMS chemicals and conventional parameters will be analyzed in all of the surface sediment samples specified in this QAPP addendum. The conventional parameters to be analyzed are sediment grain size, total organic carbon (TOC), and total solids.

In addition, a subset of the samples will also be analyzed for dioxins/furans and butyltins, as summarized in Table 3-3. The sample locations selected for additional dioxin/furan analyses are based on existing data that show elevated concentrations of these chemicals in nearby locations. The location for butyltins was selected to further

characterize the area around the marina. Chemical analysis methods are described in Section 3.4.

Table 3-3. Chemical analyses specified for each surface sediment sample

SAMPLE LOCATION NUMBER	SMS CHEMICALS ^a	DIOXINS/FURANS	BUTYLTINS	RATIONALE
301	X		X	Historical surface sediment samples showed higher concentrations of TBT in area where samples are located. Characterize potential source from marina or outfall and assess whether lower concentrations of TBT based on Phase 2 data have been maintained.
302	X		X	
303	X			
304	X			
305	X			
306	X			
307	X			
308	X			
309	X			
310	X		X	Historical surface sediment samples showed elevated concentrations of TBT near sample location and no TBT analyses were performed in this area during Phase 2 surface sediment sampling. Characterize current TBT concentrations in area.
311	X			
312	X			
313	X			
314	X			
315	X			
316	X			
317	X			
318	X	X		Determine northern extent of elevated Phase 2 dioxin/furan concentration.
319	X			
320	X			
321	X	X		Elevated Phase 2 dioxin/furan concentrations in area.
322	X	X		
323	X	X		
324	X	X		
325	X			
326	X			
327	X			
328	X			
329	X			
330	X			
331	X			
332	X			
333	X			
334	X			
335	X			
336	X			
337	X			
338	X			
339	X			
340	X			

SAMPLE LOCATION NUMBER	SMS CHEMICALS ^a	DIOXINS/FURANS	BUTYLINS	RATIONALE
341	X			
342	X			
343	X			
344	X			

^a All samples will be analyzed for all SMS chemicals and conventional parameters at a minimum. A subset of samples will be analyzed for additional chemical groups as indicated in this table. Analytes associated with the various methods cited in Section 3.4 are presented in Appendix A.

dw – dry weight

SMS – Sediment Management Standards

TBT – tributyltin

3.2 SAMPLING METHODS

The sampling methods for surface sediment sampling are described in this section. There may be contingencies during field activities that require modification of the general procedures outlined below. Modification of procedures will be at the discretion of the FC after consultation with the Windward PM and the boat operator, if applicable. EPA and Ecology will be consulted immediately in the event that significant deviations from the sampling design are required (e.g., significant re-location of a sample). All modifications will be recorded in the field logbook. The field forms presented in Appendix B of the original QAPP (Windward 2005) will be used during sampling.

3.2.1 Identification scheme for all locations and samples

Each surface sediment sampling location will be assigned a unique alphanumeric location identification (ID) number. The first three characters of the location ID will be “LDW” to identify the LDW project area. The next characters will be “SS” to indicate the type of samples to be collected (surface sediment), followed by a consecutive number beginning with 301 to identify the specific location within the LDW.

The sample ID will be similar to the location ID but will include a suffix of “010” to indicate that sediment from the 0- to 10-cm depth range is included in the sample. For example, the sediment sample collected at location LDW-SS301 will be identified as LDW-SS301-010. Field duplicates will be identified using location numbers starting with 401. For example, the field duplicate at LDW-SS301 would be identified as LDW-SS401-010.

Rinsate blanks, as described in Section 3.5, will be assigned the same characters as the station identifier, followed by the identifier “RB.” For example, the rinsate blank collected at LDW-SS301 would be LDW-SS301-RB.

3.2.2 Location positioning

Target sample locations will be positioned using a Trimble NT300D differential global positioning system (DGPS). The DGPS includes a global positioning system (GPS) receiver unit onboard the sampling vessel and a US Coast Guard (USCG) beacon

differential receiver. The GPS unit will receive radio broadcasts of GPS signals from satellites. The USCG beacon receiver will acquire corrections to the GPS signals to produce positioning accuracy to within 1 to 2 m.

Northing and easting coordinates of the vessel will be processed in real time and stored at the time of sampling using the positioning data management software package. Washington State Plane, North (NAD83), coordinates will be used for the horizontal datum. The vertical datum will be the National Oceanic and Atmospheric Administration's (NOAA's) National Ocean Service mean lower low water (MLLW) datum. Vertical control will be provided by the ship's depth finder and corrected for tidal influence after sampling is completed. Tidal elevation will be determined by calling the NOAA National Ocean Service (206.749.9218) for data from their automated tide gage located at Pier 54.

At intertidal locations sampled at low tide, vertical elevations will be estimated by noting the tide level at the time of sampling, along with the approximate elevation of the sampling location relative to water level. A hand-held GPS unit will be used to locate the intertidal sampling location. Further details are discussed in the original QAPP (Windward 2005).

3.2.3 Surface sediment collection

Surface sediment collection and processing will follow standardized procedures for the Puget Sound area that have been developed by the Puget Sound Estuary Program (PSEP; 1997). Surface sediments will be collected from each location shown in Figures 3-1a through 3-1d using a van Veen grab sampler from a sampling vessel, if feasible. Some intertidal locations may be too shallow to access from the sampling vessel, in which case surface sediments will be sampled during low tide, with access from the shoreline. Sediment from the 0- to 10-cm sediment interval will be collected to represent the biologically active horizon and to compare directly with previous surface sediment studies conducted in the LDW.

Step-by-step methods for using the van Veen grab sampler are described in the original QAPP (Windward 2005). If the sample acceptance criteria described in the original QAPP are not achieved, the sample will be rejected. If an acceptable grab sample cannot be obtained in three attempts, the target sampling location will be moved as close as possible to the original location, but no further than 10 m away. If it is not possible to obtain a sample at this second location, EPA and Ecology will be consulted to discuss repositioning the station.

After sample acceptance, the following observations will be noted in the field logbook:

- ◆ GPS location
- ◆ Depth as read by the boat's depth sounder

- ◆ At intertidal locations sampled at low tide, the tide level at the time of sampling, along with the approximate elevation of the sampling location relative to the water level
- ◆ Gross characteristics of the surficial sediment, including texture, color, biological structures, odor, and presence of debris or oily sheen
- ◆ Gross characteristics of the vertical profile (i.e., changes in sediment characteristics and redox layer, if visible)
- ◆ Maximum penetration depth (nearest 0.5 cm)
- ◆ Comments relative to sample quality

For intertidal locations that must be sampled from the shoreline, sediment will be collected by scooping sediment from a depth of 10 cm with a clean, stainless steel spoon. Sediment from each grab at each location will be transferred directly from the sampler into a pre-cleaned stainless steel bowl and homogenized as described in the original QAPP (Windward 2005; PSEP 1997). For intertidal samples collected by hand at low tide, sediment from the 0- to 10-cm depth will be spooned by hand into a pre-cleaned stainless steel bowl and similarly homogenized. Any large non-sediment items such as rocks, shells, wood chips, or organisms (e.g., clams) will be removed prior to homogenization. Homogenized sediment will then be split into the appropriate sample containers as described in Section 3.3.1. Excess sediment will be returned to the sampling location. For decontamination procedures between collection activities, refer to Section 3.2.5.

3.2.4 Field equipment

The following items will be needed in the field for sediment collection:

- ◆ QAPP addendum and original QAPP
- ◆ Field forms
- ◆ Study area maps
- ◆ Field notebooks and pens/pencils/Sharpies®
- ◆ Mobile phone
- ◆ Digital camera
- ◆ GPS
- ◆ Batteries
- ◆ Stainless steel bowls and spoons
- ◆ Stainless steel ruler
- ◆ Rubber tubing/turkey basters (used to decant surface water from the van Veen grab sampler)
- ◆ Alconox® detergent
- ◆ Scrub brushes

- ◆ Distilled water
- ◆ Spray bottles for distilled water
- ◆ Coolers
- ◆ Powder-free nitrile exam gloves and rubber work gloves
- ◆ Boots or waders
- ◆ Duct tape
- ◆ Zip-lock bags
- ◆ Aluminum foil
- ◆ Paper towels
- ◆ First aid kit
- ◆ 0.1-m² van Veen grab sampler
- ◆ Wet ice
- ◆ Personal flotation devices
- ◆ Hard hats
- ◆ Safety glasses
- ◆ Foul weather gear (rain jacket/pants)
- ◆ Waterproof labels
- ◆ Clear packing tape
- ◆ Box cutters
- ◆ Bubble wrap
- ◆ Chain-of-custody (COC) forms
- ◆ Flashlights and temporary work lights
- ◆ Sample jars
- ◆ Custody seals

Prior to mobilization, this list will be consulted to ensure that all equipment is available and pre-cleaned. As part of the mobilization process, each item will be double-checked by the FC.

3.2.5 Decontamination procedures

All sediment sampling and homogenizing equipment, including the mixing bowl and stainless steel implements, will be decontaminated following PSEP (1997) guidelines between locations or samples using the following procedures:

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

3. Rinse with site water.
4. Rinse with distilled water.

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

3.2.6 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 nitrile 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 SAMPLE HANDLING AND CUSTODY REQUIREMENTS

This section describes how individual samples will be processed, labeled, tracked, stored, and transported to the laboratory for analyses. In addition, this section describes 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 for chemical analyses will be placed in appropriately sized, certified-clean, labeled, wide-mouth glass or high-density polyethylene (HDPE) jars and capped with Teflon[®]-lined lids (Table 3-4). All sediment sample containers will be filled leaving a minimum of 1 cm of headspace to prevent breakage during shipping and storage. Prior to shipment, each sample container will be wrapped in bubble wrap and placed in a cooler with wet ice. Remaining sediment will be archived frozen at the laboratories in the event that additional chemical analyses are necessary, and surface sediment samples 315, 316, and 317 will be archived for potential dioxin and furan analyses pending the results from the analysis of sample 318.

Table 3-4. Sample containers and laboratory conducting chemical analyses

PARAMETER	CONTAINER	LABORATORY
Sediment Samples		
Dioxins/furans	8-oz glass jar	Axys
PCBs (as Aroclors), SVOCs, and butyltins ^a	16-oz glass jar	ARI
Metals including mercury, TOC, and total solids	8-oz glass jar	ARI
Grain size ^b	16-oz WM HDPE jar	ARI
Aqueous Samples (rinsate blanks)		
PCBs (as Aroclors), SVOCs, and butyltins	5 500-mL glass amber jars	ARI
Metals including mercury	500-mL HDPE jar	ARI

^a Duplicate sample volume should be collected at a rate of one per 20 samples for MS/MSD.

^b Triplicate sample volume should be collected at a rate of one per 20 samples for lab replicates.

ARI – Analytical Resources, Inc.

SVOC – semivolatile organic compound

Axys – Axys Analytical Services, Ltd.

TOC – total organic carbon

HDPE –high-density polyethylene

WM HDPE – wide-mouth high-density polyethylene

PCB – polychlorinated biphenyl

Sample labels will be waterproof and self-adhering. Each sample label will contain the project number, sample identification, preservation technique, 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 individuals responsible for performing the analyses, dates of sample extraction/preparation and analyses, and the type of analyses being performed.

3.3.2 Sample custody procedures

Custody procedures will be used for all samples throughout the collection, transport, and analyses, and for all data and data documentation, whether in hard copy or electronic format. Custody procedures will be initiated during sediment sample collection. 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 details of COC procedures and documentation practices, as well as sample shipping procedures are described in the original QAPP (Windward 2005).

3.3.3 Shipping requirements

Coolers containing samples for analysis at ARI will be hand delivered to the laboratory; samples for analysis at Axys will be stored frozen at Windward, and all samples will be shipped to Axys overnight at the end of the sampling effort. The temperature inside the cooler(s) containing sediment samples will be checked upon receipt at the laboratory using an infrared device. The laboratory will specifically note any coolers that do not contain ice packs or that are not sufficiently cold ($4^{\circ} \pm 2^{\circ}\text{C}$) upon receipt.

3.4 ANALYTICAL METHODS

Chemical analyses of the sediment samples will be conducted at two different laboratories. The chemicals and parameters to be analyzed at each laboratory are presented in Table 3-5.

Table 3-5. Chemicals and parameters to be analyzed at each laboratory

ARI	Axys
PCB Aroclors	Dioxins and furans (subset of samples)
SVOCs (including PAHs and low-level SVOCs by SIM)	
Metals including mercury	
Butyltins (subset of samples)	
TOC, total solids, grain size	

ARI – Analytical Research, Inc.

PAH – polycyclic aromatic hydrocarbon

Axys – Axys Analytical Services, Ltd.

SVOC – semivolatile organic compound

SIM – selected ion monitoring

TOC – total organic carbon

Analytical methods and data quality indicators (DQIs) are summarized in Tables 3-6 and 3-7 and discussed in greater detail in Section 3.4.1 of the original QAPP (Windward 2005).

Table 3-6. Laboratory analytical methods and sample handling requirements for sediment samples

PARAMETER	METHOD	REFERENCE	MAXIMUM SAMPLE HOLDING TIME ^a	PRESERVATIVE
Dioxins and furans	HRGC/HRMS	EPA 1613B	1 year to extract, 40 days to analyze	freeze/-20°C
PCBs as Aroclors	GC/ECD	EPA 8082	14 days to extract, 40 days to analyze ^{b, c}	cool/4°C
SVOCs (including PAHs) ^d	GC/MS	EPA 8270D	14 days to extract, 40 days to analyze ^{b, c}	cool/4°C
Selected SVOCs ^e	GC/MS	EPA 8270D-SIM	14 days to extract, 40 days to analyze ^{b, c}	cool/4°C
TBT, DBT, MBT (as ions)	GC/FPD	Krone et al. (1989)	14 days to extract, 40 days to analyze ^c	cool/4°C
Mercury	CVAA	EPA 7471A	28 days ^g	cool/4°C ^h
Other metals ^f	ICP-OES	EPA 6010B	6 months ^b	cool/4°C ^h
TOC	combustion	Plumb (1981)	28 days	cool/4°C
Total solids	oven-dried	EPA 160.3	7 days ^g	cool/4°C
Grain size	sieve/ hydrometer	PSEP (1986)	none	none

^a All sample extracts will be archived frozen at the laboratory until the Windward PM authorizes their disposal.

^b Sediment may be frozen, with a maximum holding time of 1 year.

^c Aqueous rinsate blanks have a maximum holding time of 7 days to extract and 40 days to analyze, and will be stored at 4°C.

^d Target PAHs include: anthracene, pyrene, dibenzofuran, benzo(g,h,i)perylene, indeno(1,2,3-cd)pyrene, benzo(b)fluoranthene, fluoranthene, benzo(k)fluoranthene, acenaphthylene, chrysene, benzo(a)pyrene, dibenz(a,h)anthracene, benz(a)anthracene, acenaphthene, phenanthrene, fluorene, 1-methylnaphthalene, naphthalene, 2-methylnaphthalene.

^e Selected SVOCs for SIM include: 1,2,4-trichlorobenzene, 1,2-dichlorobenzene, 1,4-dichlorobenzene, 2,4-dimethylphenol, 2-methylphenol, benzyl alcohol, butyl benzyl phthalate, dibenz(a,h)anthracene, dimethyl phthalate, hexachlorobenzene, hexachlorobutadiene, n-nitrosodimethylamine, n-nitrosodiphenylamine, n-nitrosodi-n-propylamine, and pentachlorophenol. Chemicals analyzed using SIM will not be included in the EPA Method 8270D analyte list.

^f Arsenic, antimony, cadmium, chromium, cobalt, copper, lead, molybdenum, nickel, selenium, silver, thallium, vanadium, and zinc. If concentrations of vanadium and zinc are elevated, EPA 6010B (ICP-OES) will be used.

^g Sediment may be frozen, with a maximum holding time of 6 months.

^h Aqueous rinsate blanks will be preserved with nitric acid.

CVAA – cold vapor atomic absorption

ICP-MS – inductively coupled plasma – mass spectrometry

DBT – dibutyltin

MBT – monobutyltin

EPA – US Environmental Protection Agency

PAH – polycyclic aromatic hydrocarbon

GC/ECD – gas chromatography/electron capture detection

PCB – polychlorinated biphenyl

GC/FPD – gas chromatography/flame photometric detection

PSEP – Puget Sound Estuary Program

GC/MS – gas chromatography/mass spectrometry

SIM – selected ion monitoring

HRGC/HRMS – high-resolution gas chromatography/high-resolution mass spectrometry

SVOC – semivolatile organic compound

ICP-OES – inductively coupled plasma – optical emission spectrometry

TBT – tributyltin

TOC – total organic carbon

Table 3-7. Data quality indicators for sediment analyses

PARAMETER	UNITS	SENSITIVITY		PRECISION	ACCURACY	COMPLETENESS
		RL ^a	MDL ^a			
Dioxins and furans	ng/kg dw	1.00 – 10.0	0.0360 – 2.39	±50%	50 – 150%	95%
PCBs as Aroclors	µg/kg dw	4.0 ^b	1.3	±50%	50 – 150%	95%
PAHs	µg/kg dw	20	3.9 – 12	±50%	40 – 130%	95%
SVOCs	µg/kg dw	20 – 625	6.0 – 68 ^c	±50%	40 – 130%	95%
Selected SVOCs – SIM	µg/kg dw	6.7 – 33	1.4 – 24	±50%	40 – 130%	95%
Tributyltin, dibutyltin, monobutyltin (as ions)	µg/kg dw	5.0 – 10	2.1 – 5.4	±50%	20 – 130%	95%
Mercury	mg/kg dw	0.05	0.003	±30%	55 – 137%	95%
Other metals	mg/kg dw	0.2 – 5.0	0.013 – 1.06	±30%	70 – 130%	95%
TOC	% dw	0.02	0.01	±30%	na	95%
Total solids	% ww	0.1	na	±20%	na	95%
Grain size	% dw	0.1	na	±30%	na	95%

^a RLs and MDLs for individual chemicals are presented in Appendix A.

^b Samples will be screened prior to PCB Aroclor analysis. Samples with detected Aroclors greater than 30 µg/kg dw will be prepared using a standard preparatory technique providing an RL of 20 µg/kg dw. Samples with no detected Aroclors or with detected Aroclors at concentrations less than 30 µg/kg dw will be prepared using the low-level method with an RL of 4 µg/kg dw.

^c Method detection limits for SVOCs other than PAHs.

dw – dry weight

MDL – method detection limit

na – not applicable

PAH – polycyclic aromatic hydrocarbon

PCB – polychlorinated biphenyl

RL – reporting limit

SIM – selected ion monitoring

SVOC – semivolatile organic compound

TOC – total organic carbon

3.5 QUALITY ASSURANCE/QUALITY CONTROL

QA/QC for the field and laboratory analyses is discussed in detail in the original QAPP, Section 3.5 (Windward 2005). Documentation requirements and data reduction rules are discussed in Section 2.6 of the original QAPP and in Appendix B of this addendum.

Field duplicate samples will be collected to evaluate variability attributable to sample homogenization and subsequent sample handling. Field duplicate samples will be collected from the same homogenized material as the original sample and analyzed as a separate sample; this type of field QA/QC sample is also referred to as a field split sample (PSEP 1997). A minimum of one field duplicate will be analyzed for each 20 samples. In addition, rinsate blanks will be collected from sampling equipment at a rate of 1 per 20 samples. All field QC samples will be documented in the field logbook and verified by the project QA/QC coordinator or a designee. Table 3-8 summarizes the QC procedures and sample analyses to be performed by the laboratory. The associated control limits for precision and accuracy are summarized in Table 3-7.

Table 3-8. QC sample analysis summary

ANALYSIS TYPE	INITIAL CALIBRATION	SECOND SOURCE INITIAL CALIBRATION VERIFICATION	CONTINUING CALIBRATION VERIFICATION ^a	LABORATORY CONTROL SAMPLES ^a	FIELD REPLICATES	MATRIX REPLICATES ^a	MATRIX SPIKES ^a	MATRIX SPIKE DUPLICATES ^a	METHOD BLANKS ^a	STANDARD REFERENCE MATERIAL	SURROGATE SPIKES
Dioxins/furans	prior to analysis	after initial calibration	Prior to 12 hour analytical batch	1 per prep batch	none	none	na	na	1 per prep batch	1 per 20 samples	each sample
PCB Aroclors	prior to analysis	after initial calibration	every 20 injections or 12 hrs, whichever is more frequent	1 per prep batch	1 per 20 samples	none	1 per prep batch or SDG	1 per prep batch or SDG	1 per prep batch	1 per 20 samples	each sample
SVOCs, including PAHs	prior to analysis	after initial calibration	prior to 12 hour analytical batch	1 per prep batch	1 per 20 samples	none	1 per prep batch or SDG	1 per prep batch or SDG	1 per prep batch	1 per 20 samples	each sample
SVOCs – SIM	prior to analysis	after initial calibration	prior to 12 hour analytical batch	1 per prep batch	1 per 20 samples	none	1 per prep batch or SDG	1 per prep batch or SDG	1 per prep batch	1 per 20 samples	each sample
Butyltins	prior to analysis	after initial calibration	prior to 12 hour analytical batch	1 per prep batch	1 per 20 samples	none	1 per prep batch or SDG	1 per prep batch or SDG	1 per prep batch	1 per 20 samples	each sample
Mercury	daily, prior to analysis	after initial calibration	every 10 samples	1 per prep batch	1 per 20 samples	1 per prep batch or SDG	1 per prep batch or SDG	na	1 per prep batch	1 per 20 samples	na
Other metals	daily, prior to analysis	after initial calibration	every 10 samples	1 per prep batch	1 per 20 samples	1 per prep batch or SDG	1 per prep batch or SDG	na	1 per prep batch	1 per 20 samples	na
Grain size	na	na	na	na	1 per 20 samples	1 per batch or SDG	na	na	na	na	na
TOC	daily, prior to analysis	after initial calibration	every 10 samples	na	1 per 20 samples	1 per batch or SDG	1 per batch or SDG	na	1 per prep batch	na	na
Total solids	na	na	na	na	1 per 20 samples	1 per batch or SDG	na	na	na	na	na

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

na – not applicable

SDG – sample delivery group

TOC – total organic carbon

PCB – polychlorinated biphenyl

SIM – selected ion monitoring

PAH – polycyclic aromatic hydrocarbon

SVOC – semivolatile organic compound

4.0 Assessment and Oversight

EPA, Ecology, or their designees may observe field activities during each sampling event, as needed. If situations arise in which there is an inability to follow QAPP methods precisely, the Windward PM will determine the appropriate actions or consult with EPA and Ecology if the issue is significant. Additional details regarding project assessment and oversight are presented in the original QAPP (Windward 2005).

5.0 Data Validation and Usability

Data are not considered final until validated. Data validation will be conducted following EPA (1999; 2004) guidance, and in the case of multiple results for an analyte in a single sample, the data management rules for best result selection presented in Appendix B will be followed.

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 data quality objectives specified in the original QAPP (Windward 2005).

Independent third-party data review and summary validation of the analytical data will be conducted by LDC. For analytical chemistry data, a minimum of 20% of samples or one sample delivery group (SDG) will undergo full data validation. Full data validation parameters include:

- ◆ Quality control analysis frequencies
- ◆ Evaluation of COC and sample handling procedures
- ◆ Analysis holding times
- ◆ Laboratory blank contamination
- ◆ Instrument calibration
- ◆ Surrogate recoveries
- ◆ Laboratory control sample recoveries
- ◆ Matrix spike recoveries
- ◆ Matrix spike/matrix spike duplicate relative percent differences
- ◆ Standard reference material recoveries

- ◆ Compound identifications
- ◆ Compound quantifications
- ◆ Instrument performance check (tune) ion abundances
- ◆ Internal standard areas and retention time shifts

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 the QC forms submitted in the laboratory data package. As part of the summary validation, all summary forms for calibrations, instrument performance, and internal standard summaries will be reviewed. QA review of the sediment chemistry data will be performed in accordance with the requirements of the project, the technical specifications of the analytical methods indicated in Tables 3-6, and EPA guidance for organic and inorganic data review (EPA 1999, 2004). The EPA PM may have EPA peer review the third-party validation or perform data assessment/validation on a percentage of the data. In addition, dioxin and furan data will undergo full validation following EPA Region 10 guidance for validation of dioxin and furan data (EPA 1996) and EPA national functional guidelines for dioxin and furan data review (EPA 2005).

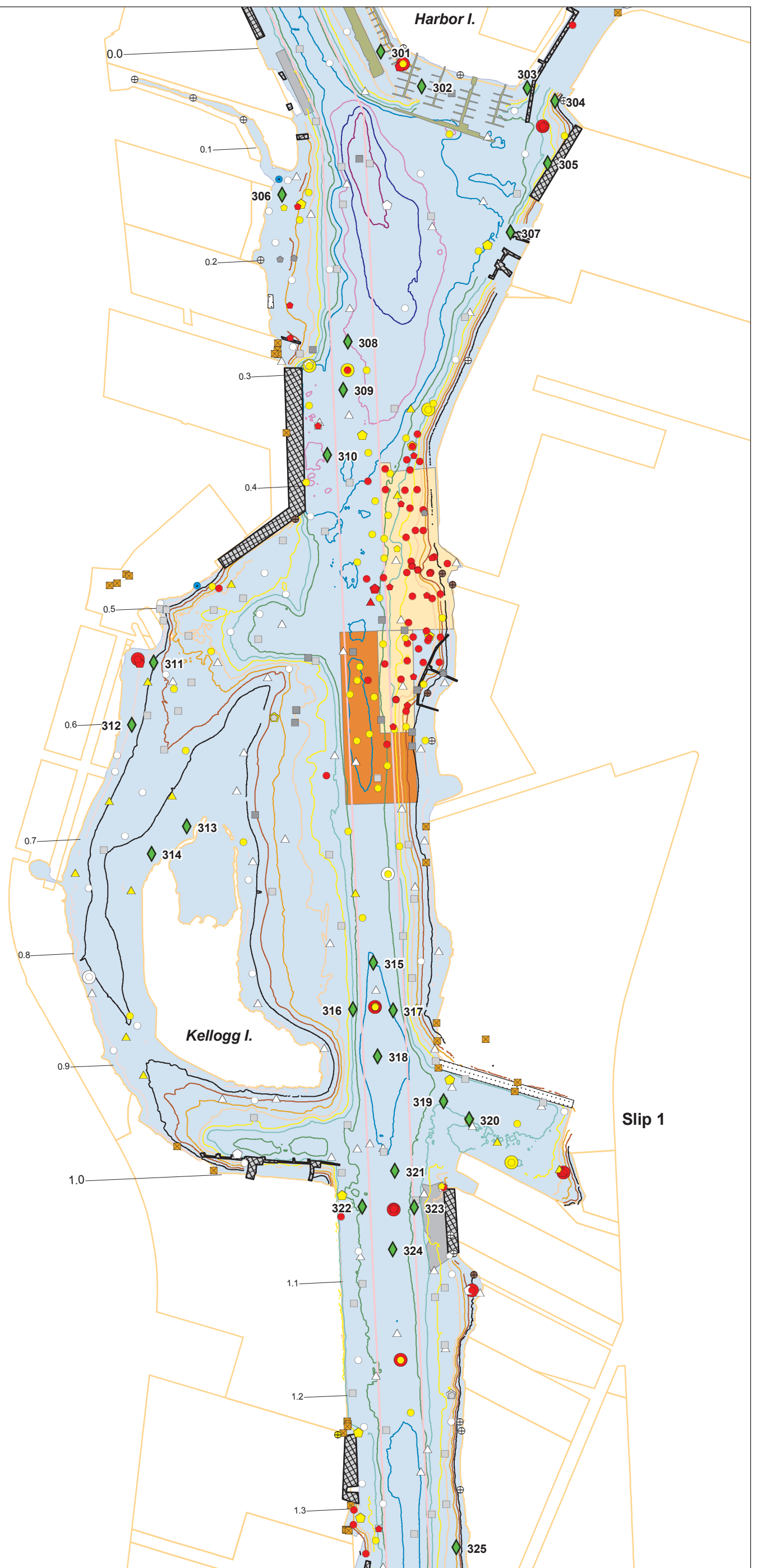
Data quality assessment will be conducted by the project QA/QC coordinator in consultation with EPA guidelines. The results of the third-party independent review and validation will be reviewed, and cases where the projects DQIs were not met will be identified. Any data qualification resulting from the data validation will be noted in a validation report submitted to the Windward QA/QC coordinator. The usability of the data will be determined in terms of the magnitude of the DQI exceedance.

6.0 References

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- PSEP. 1997. Recommended guidelines for sampling marine sediment, water column, and tissue in Puget Sound. Final report. Prepared for the US Environmental Protection Agency, Seattle, WA. Puget Sound Water Quality Action Team, Olympia, WA.
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- Windward. 2005. Quality assurance project plan: surface sediment sampling for chemical analyses and toxicity testing of the Lower Duwamish Waterway. Prepared for the Lower Duwamish Waterway Group. Windward Environmental LLC, Seattle, WA.
- Windward, DEA. 2004. Lower Duwamish Waterway remedial investigation. Bathymetric survey. Prepared for Lower Duwamish Waterway Group. Windward Environmental LLC, Seattle, WA and David Evans and Associates, Portland, OR.

Oversize Figures



- ◆ Round 3 sampling locations
- Bathymetry (feet relative to MLLW)**
- 50
- 45
- 40
- 35
- 30
- 25
- 20
- 15
- 10
- 5
- 0
- 5
- SMS exceedance level in surface interval of subsurface core - historical**
- > CSL, detected
- > SQS and ≤ CSL, detected
- > CSL, non-detect
- > SQS and ≤ CSL, non-detect
- ≤ SQS, detected
- SMS exceedance level in surface interval of subsurface core - Phase 2**
- > CSL, detected
- > SQS and ≤ CSL, detected
- > CSL, non-detect
- > SQS and ≤ CSL, non-detect
- ≤ SQS, detected
- SMS exceedance levels in baseline surface sediments - all chemicals**
- > CSL, detected
- > SQS and ≤ CSL, detected
- > CSL, non-detect
- > SQS and ≤ CSL, non-detect
- ≤ SQS, detected
- SMS exceedance levels in surface sediments where only PCBs were analyzed**
- ▲ > CSL, detected
- ▲ > SQS and ≤ CSL, detected
- △ ≤ SQS, detected
- Phase 2 Bioassay results**
- CSL
- SQS
- no hit
- Dredged area
- Dredged and capped area
- Dredged and thin-layer placement
- Thin-layer placement
- EOF, CSO, or CSO/SD
- Pipe of unknown use
- Private outfall
- ⊕ Publicly owned storm drain
- Stream, channel, or swale
- ▨ Bridge
- ▨ Building
- ▨ Dock/Pier
- ▨ Marina
- ▨ Navigation channel
- ▨ Tax parcel
- River mile

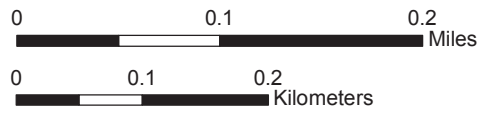


Figure 3-1a. Round 3 surface sediment sampling locations - RM 0.0 - 1.3

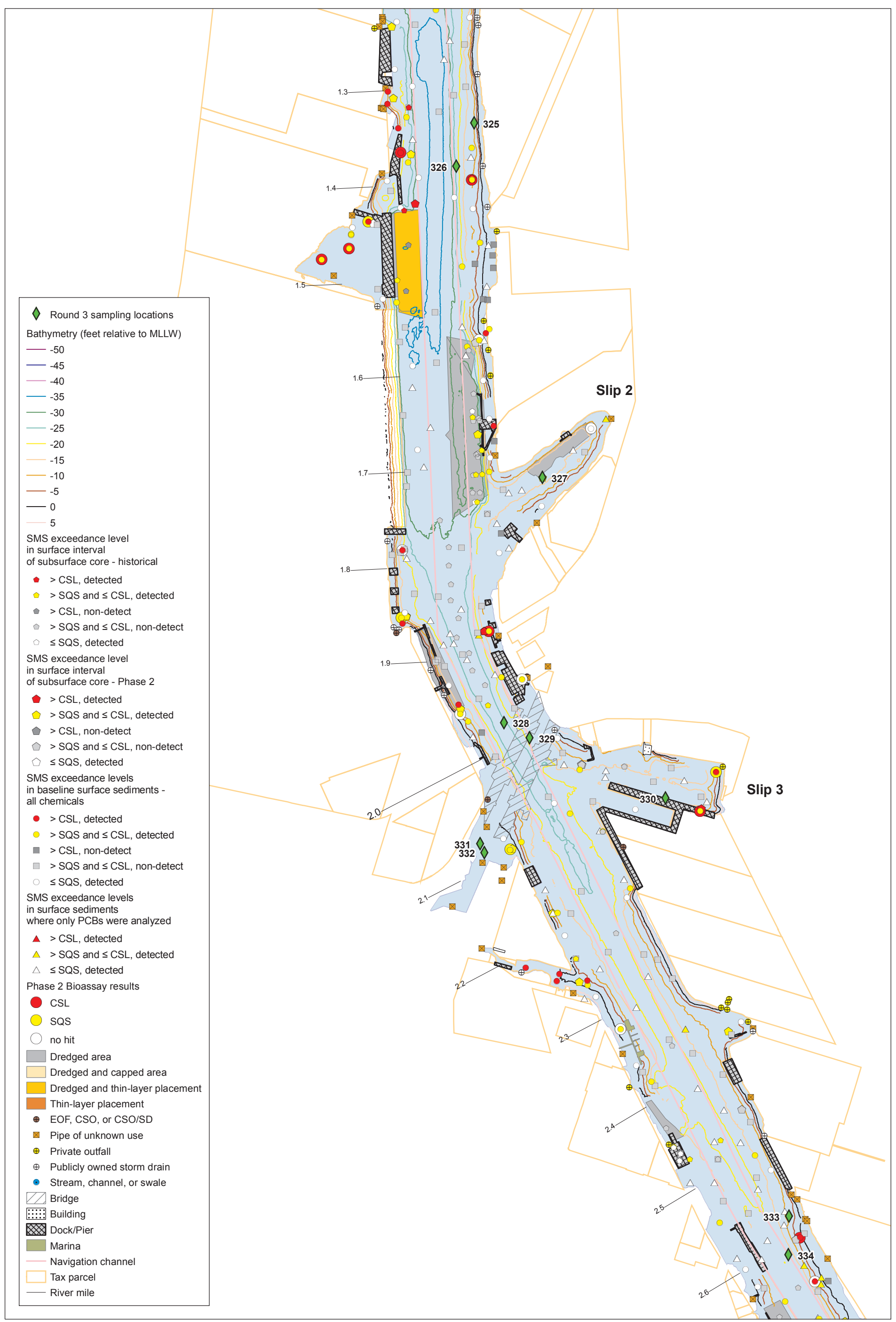
Prepared by AMW, 09-26-06; MAP 2428; W:\Projects\00-06-06_Duwamish_RI\data\GIS\Surface_Sediment\Round3

Source information provided by EPA and Ecology based on a preliminary file search. Tax parcel information provided by Seattle Public Utilities, May 2002. Some tax parcel polygons were edited by Windward to conform to the LDW shoreline for the purpose of map presentation. The locations of outfalls and other pipes shown on this figure were identified during a City of Seattle survey conducted during May-June 2003 (Herrera 2004). As part of the survey, the locations of permitted outfalls were first identified using available drainage and outfall maps for waterfront properties obtained from the Washington

Department of Ecology National Pollutant Discharge Elimination System (NPDES) permit files. Outfalls and pipes that were observed in the field during low tides were then surveyed in the field to establish their locations. The status of permitted outfalls is currently being verified by the Lower Duwamish Waterway Group (LDWG) through interviews with agency personnel and individual LDWG members' staff, as appropriate. In the future, known outfalls will be designated as either "combined sewer overflow, combined sewer overflow/storm drains, or emergency overflows,"

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Prepared by AMW, 09-26-06, MAP 24.35, W:\Projects\00-06-06_Duwamish_RI\data\GIS\Surface_SedimentRound3



- ◆ Round 3 sampling locations
- Bathymetry (feet relative to MLLW)
 - 50
 - 45
 - 40
 - 35
 - 30
 - 25
 - 20
 - 15
 - 10
 - 5
 - 0
 - 5
- SMS exceedance level in surface interval of subsurface core - historical
 - ◆ > CSL, detected
 - ◆ > SQS and ≤ CSL, detected
 - ◆ > CSL, non-detect
 - ◆ > SQS and ≤ CSL, non-detect
 - ≤ SQS, detected
- SMS exceedance level in surface interval of subsurface core - Phase 2
 - ◆ > CSL, detected
 - ◆ > SQS and ≤ CSL, detected
 - ◆ > CSL, non-detect
 - ◆ > SQS and ≤ CSL, non-detect
 - ≤ SQS, detected
- SMS exceedance levels in baseline surface sediments - all chemicals
 - > CSL, detected
 - > SQS and ≤ CSL, detected
 - > CSL, non-detect
 - > SQS and ≤ CSL, non-detect
 - ≤ SQS, detected
- SMS exceedance levels in surface sediments where only PCBs were analyzed
 - ▲ > CSL, detected
 - ▲ > SQS and ≤ CSL, detected
 - △ ≤ SQS, detected
- Phase 2 Bioassay results
 - CSL
 - SQS
 - no hit
- Dredged area
- Dredged and capped area
- Dredged and thin-layer placement
- Thin-layer placement
- EOF, CSO, or CSO/SD
- Pipe of unknown use
- Private outfall
- Publicly owned storm drain
- Stream, channel, or swale
- Bridge
- Building
- Dock/Pier
- Marina
- Navigation channel
- Tax parcel
- River mile

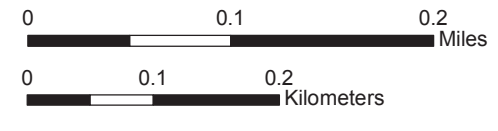


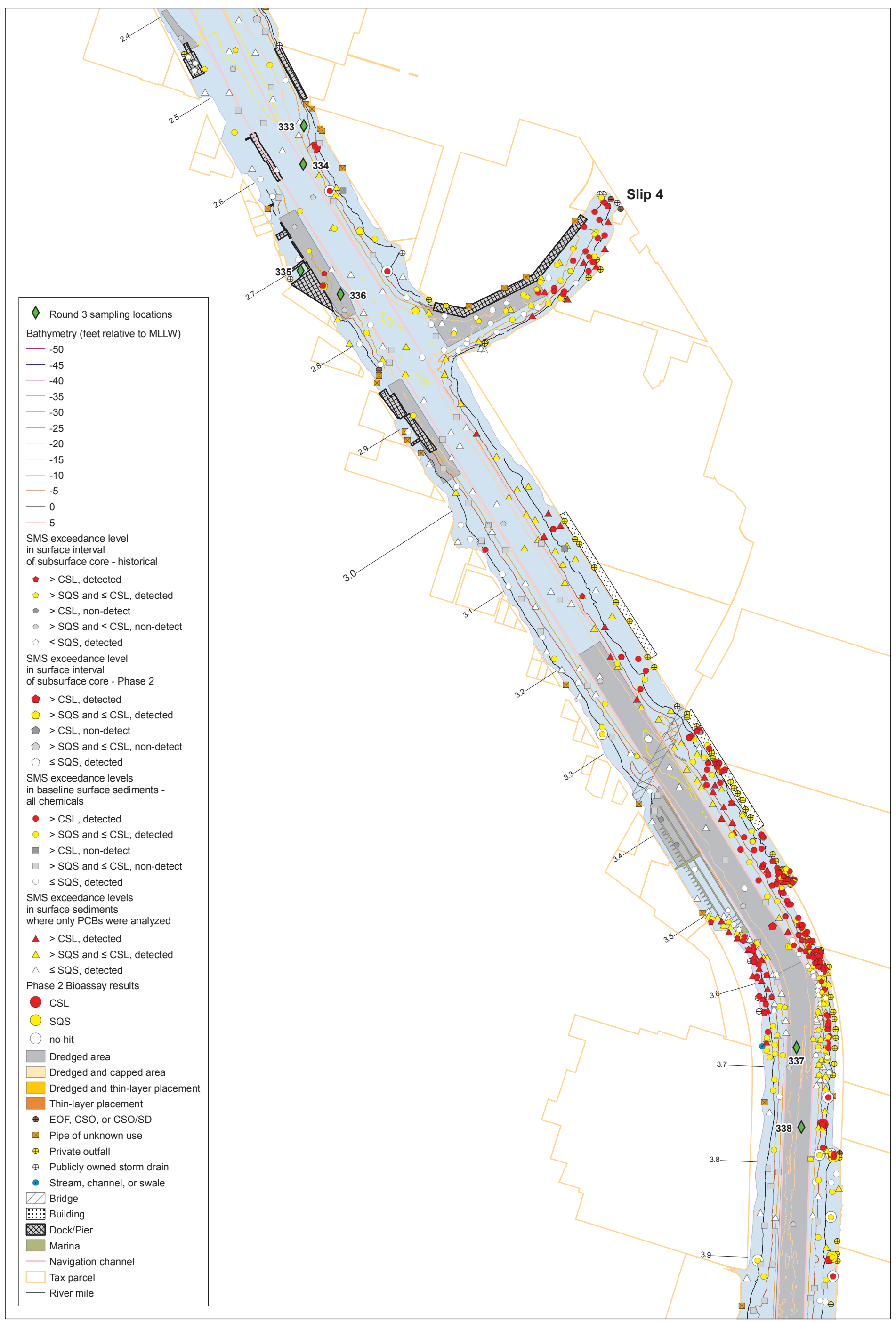
Figure 3-1b. Round 3 surface sediment sampling locations - RM 1.3 - 2.5

Source information provided by EPA and Ecology based on a preliminary file search. Tax parcel information provided by Seattle Public Utilities, May 2002. Some tax parcel polygons were edited by Windward to conform to the LDW shoreline for the purpose of map presentation. The locations of outfalls and other pipes shown on this figure were identified during a City of Seattle survey conducted during May-June 2003 (Herrera 2004). As part of the survey, the locations of permitted outfalls were first identified using available drainage and outfall maps for waterfront properties obtained from the Washington

Department of Ecology National Pollutant Discharge Elimination System (NPDES) permit files. Outfalls and pipes that were observed in the field during low tides were then surveyed in the field to establish their locations. The status of permitted outfalls is currently being verified by the Lower Duwamish Waterway Group (LDWG) through interviews with agency personnel and individual LDWG members' staff, as appropriate. In the future, known outfalls will be designated as either "combined sewer overflow, combined sewer overflow/storm drains, or emergency overflows,"

"publicly owned storm drains," or "private outfalls." Private outfalls will include two categories: 1) NPDES-permitted outfalls (e.g., storm drains, non-contact cooling water, process wastewater), and 2) other outfalls that are not included under an active NPDES permit. Outfalls whose discharge has been terminated and that are no longer included under an active NPDES permit will be identified as "formerly permitted outfalls." Pipes that cannot be identified as an outfall through agency permit file records review will be identified as "pipes of unknown use." A comprehensive survey of property owners will not be conducted.

Prepared by AMW, 09-26-08, MAP 2436, W:\Projects\09-08-06_Duwanah_R\ldata\gis\Surface_Sediment\Round3



- ◆ Round 3 sampling locations
- Bathymetry (feet relative to MLLW)
 - 50
 - 45
 - 40
 - 35
 - 30
 - 25
 - 20
 - 15
 - 10
 - 5
 - 0
 - 5
- SMS exceedance level in surface interval of subsurface core - historical
 - ◆ > CSL, detected
 - ◆ > SQS and ≤ CSL, detected
 - ◆ > CSL, non-detect
 - ◆ > SQS and ≤ CSL, non-detect
 - ≤ SQS, detected
- SMS exceedance level in surface interval of subsurface core - Phase 2
 - ◆ > CSL, detected
 - ◆ > SQS and ≤ CSL, detected
 - ◆ > CSL, non-detect
 - ◆ > SQS and ≤ CSL, non-detect
 - ≤ SQS, detected
- SMS exceedance levels in baseline surface sediments - all chemicals
 - > CSL, detected
 - > SQS and ≤ CSL, detected
 - > CSL, non-detect
 - > SQS and ≤ CSL, non-detect
 - ≤ SQS, detected
- SMS exceedance levels in surface sediments where only PCBs were analyzed
 - ▲ > CSL, detected
 - ▲ > SQS and ≤ CSL, detected
 - △ ≤ SQS, detected
- Phase 2 Bioassay results
 - CSL
 - SQS
 - no hit
- Dredged area
- Dredged and capped area
- Dredged and thin-layer placement
- Thin-layer placement
- EOF, CSO, or CSO/SD
- Pipe of unknown use
- Private outfall
- Publicly owned storm drain
- Stream, channel, or swale
- Bridge
- Building
- Dock/Pier
- Marina
- Navigation channel
- Tax parcel
- River mile

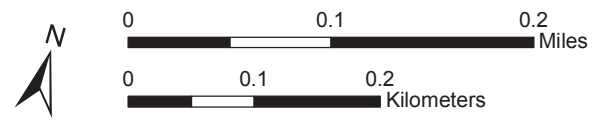


Figure 3-1c. Round 3 surface sediment sampling locations - RM 2.5 - 3.8

Source information provided by EPA and Ecology based on a preliminary file search. Tax parcel information provided by Seattle Public Utilities, May 2002. Some tax parcel polygons were edited by Windward to conform to the LDW shoreline for the purpose of map presentation. The locations of outfalls and other pipes shown on this figure were identified during a City of Seattle survey conducted during May-June 2003 (Herrera 2004). As part of the survey, the locations of permitted outfalls were first identified using available drainage and outfall maps for waterfront properties obtained from the Washington

Department of Ecology National Pollutant Discharge Elimination System (NPDES) permit files. Outfalls and pipes that were observed in the field during low tides were then surveyed in the field to establish their locations. The status of permitted outfalls is currently being verified by the Lower Duwamish Waterway Group (LDWG) through interviews with agency personnel and individual LDWG members' staff, as appropriate. In the future, known outfalls will be designated as either "combined sewer overflow, combined sewer overflow/storm drains, or emergency overflows;"

"publicly owned storm drains;" or "private outfalls." Private outfalls will include two categories: 1) NPDES-permitted outfalls (e.g., storm drains, non-contact cooling water, process wastewater), and 2) other outfalls that are not included under an active NPDES permit. Outfalls whose discharge has been terminated and that are no longer included under an active NPDES permit will be identified as "formerly permitted outfalls." Pipes that cannot be identified as an outfall through agency permit file records review will be identified as "pipes of unknown use." A comprehensive survey of property owners will not be conducted.

Prepared by AMW, 09-28-06, MAP 2437, W:\Projects\09-08-06_Duwamish_RIdata\GIS\Surface_SedimentRound3

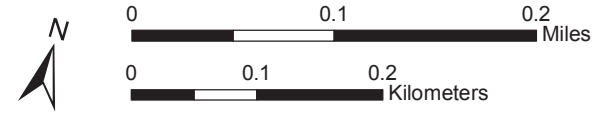
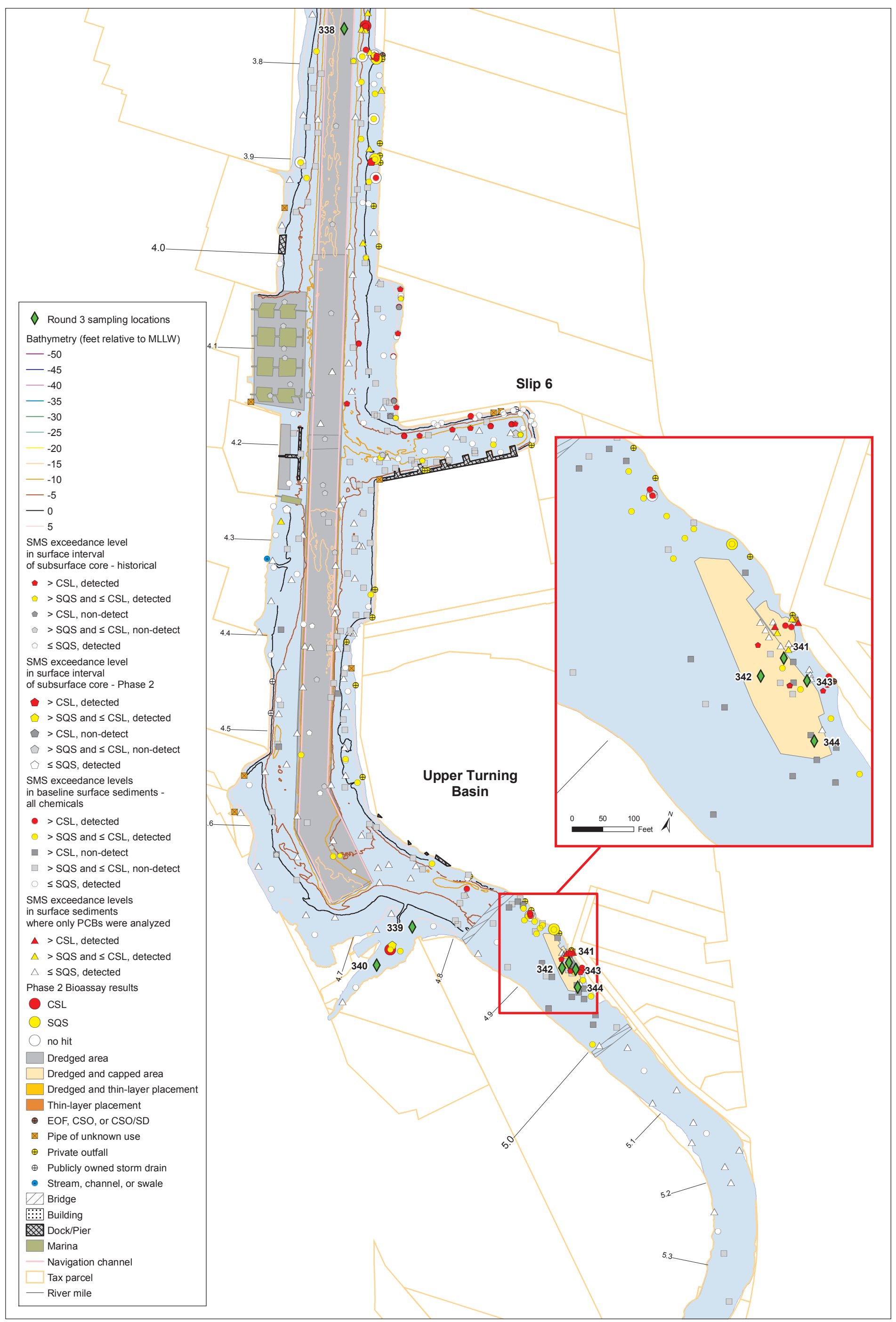


Figure 3-1d. Round 3 surface sediment sampling locations - RM 3.8 - 5.0

Source information provided by EPA and Ecology based on a preliminary file search. Tax parcel information provided by Seattle Public Utilities, May 2002. Some tax parcel polygons were edited by Windward to conform to the LDW shoreline for the purpose of map presentation. The locations of outfalls and other pipes shown on this figure were identified during a City of Seattle survey conducted during May-June 2003 (Herrera 2004). As part of the survey, the locations of permitted outfalls were first identified using available drainage and outfall maps for waterfront properties obtained from the Washington

Department of Ecology National Pollutant Discharge Elimination System (NPDES) permit files. Outfalls and pipes that were observed in the field during low tides were then surveyed in the field to establish their locations. The status of permitted outfalls is currently being verified by the Lower Duwamish Waterway Group (LDWG) through interviews with agency personnel and individual LDWG members' staff, as appropriate. In the future, known outfalls will be designated as either "combined sewer overflow, combined sewer overflow/storm drains, or emergency overflows;"

"publicly owned storm drains;" or "private outfalls." Private outfalls will include two categories: 1) NPDES-permitted outfalls (e.g., storm drains, non-contact cooling water, process wastewater), and 2) other outfalls that are not included under an active NPDES permit. Outfalls whose discharge has been terminated and that are no longer included under an active NPDES permit will be identified as "formerly permitted outfalls." Pipes that cannot be identified as an outfall through agency permit file records review will be identified as "pipes of unknown use." A comprehensive survey of property owners will not be conducted.

Appendix A. Laboratory Method Detection Limits and Reporting Limits

Table A-1. Surface sediment chemistry analytes and method detection limits and reporting limits

METHOD AND ANALYTE	UNIT	METHOD DETECTION LIMIT ^a	REPORTING LIMIT ^a
EPA 1613B – Dioxins/furans^b			
2,3,7,8-TCDD	ng/kg dw	0.036	1.0
1,2,3,7,8-PeCDD	ng/kg dw	0.069	5.0
1,2,3,4,7,8-HxCDD	ng/kg dw	0.095	5.0
1,2,3,6,7,8-HxCDD	ng/kg dw	0.114	5.0
1,2,3,7,8,9-HxCDD	ng/kg dw	0.081	5.0
1,2,3,4,6,7,8-HpCDD	ng/kg dw	0.246	5.0
OCDD	ng/kg dw	2.390	10
2,3,7,8-TCDF	ng/kg dw	0.025	1.0
1,2,3,7,8-PeCDF	ng/kg dw	0.085	5.0
2,3,4,7,8-PeCDF	ng/kg dw	0.101	5.0
1,2,3,4,7,8-HxCDF	ng/kg dw	0.101	5.0
1,2,3,6,7,8-HxCDF	ng/kg dw	0.078	5.0
1,2,3,7,8,9-HxCDF	ng/kg dw	0.076	5.0
2,3,4,6,7,8-HxCDF	ng/kg dw	0.056	5.0
1,2,3,4,6,7,8-HpCDF	ng/kg dw	0.129	5.0
1,2,3,4,7,8,9-HpCDF	ng/kg dw	0.134	5.0
OCDF	ng/kg dw	0.150	10
EPA 8082 – PCB Aroclors^c			
Aroclor 1260	µg/kg dw	1.33	4
Aroclor 1016	µg/kg dw	1.33	4
Aroclor 1254	µg/kg dw	1.33	4
Aroclor 1221	µg/kg dw	1.33	4
Aroclor 1232	µg/kg dw	1.33	4
Aroclor 1248	µg/kg dw	1.33	4
Aroclor 1242	µg/kg dw	1.33	4
EPA 8270D– SVOCs^d			
1,3-Dichlorobenzene	mg/kg dw	0.00840	0.02
1-Methylnaphthalene	mg/kg dw	0.00691	0.02
2,4,5-Trichlorophenol	mg/kg dw	0.00595	0.10
2,4,6-Trichlorophenol	mg/kg dw	0.00878	0.10
2,4-Dichlorophenol	mg/kg dw	0.00830	0.10
2,4-Dinitrophenol	mg/kg dw	0.0294	0.20
2,4-Dinitrotoluene	mg/kg dw	0.0103	0.10
2,6-Dinitrotoluene	mg/kg dw	0.0122	0.10
2-Chloronaphthalene	mg/kg dw	0.00916	0.02
2-Chlorophenol	mg/kg dw	0.00902	0.20
2-Methyl-4,6-dinitrophenol	mg/kg dw	0.110	0.20

METHOD AND ANALYTE	UNIT	METHOD DETECTION LIMIT ^a	REPORTING LIMIT ^a
2-Methylnaphthalene	mg/kg dw	0.0183	0.02
2-Nitroaniline	mg/kg dw	0.0542	0.10
2-Nitrophenol	mg/kg dw	0.00878	0.10
3,3'-Dichlorobenzidine	mg/kg dw	0.0474	0.10
3-Nitroaniline	mg/kg dw	0.0532	0.10
4-Bromophenyl phenyl ether	mg/kg dw	0.0129	0.02
4-Chloro-3-methylphenol	mg/kg dw	0.0101	0.10
4-Chloroaniline	mg/kg dw	0.0399	0.10
4-Chlorophenyl phenyl ether	mg/kg dw	0.0120	0.02
4-Methylphenol	mg/kg dw	0.00730	0.02
4-Nitroaniline	mg/kg dw	0.0255	0.10
4-Nitrophenol	mg/kg dw	0.0370	0.10
Acenaphthene	mg/kg dw	0.0104	0.02
Acenaphthylene	mg/kg dw	0.00938	0.02
Aniline	mg/kg dw	0.00964	0.02
Anthracene	mg/kg dw	0.00795	0.02
Benz(a)anthracene	mg/kg dw	0.00867	0.02
Benzo(a)pyrene	mg/kg dw	0.00805	0.02
Benzo(b)fluoranthene	mg/kg dw	0.00863	0.02
Benzo(g,h,i)perylene	mg/kg dw	0.00852	0.02
Benzo(k)fluoranthene	mg/kg dw	0.00798	0.02
Benzoic acid	mg/kg dw	0.148	0.625
Bis(2-chloroethoxy)methane	mg/kg dw	0.0123	0.02
Bis(2-chloroethyl) ether	mg/kg dw	0.0119	0.02
Bis(2-chloroisopropyl) ether	mg/kg dw	0.0120	0.02
Bis(2-ethylhexyl) phthalate	mg/kg dw	0.0110	0.02
Chrysene	mg/kg dw	0.00965	0.02
Dibenzofuran	mg/kg dw	0.0171	0.02
Diethyl phthalate	mg/kg dw	0.0106	0.02
Di-n-butyl phthalate	mg/kg dw	0.00664	0.02
Di-n-octyl phthalate	mg/kg dw	0.0102	0.02
Fluoranthene	mg/kg dw	0.00857	0.02
Fluorene	mg/kg dw	0.0116	0.02
Hexachlorocyclopentadiene	mg/kg dw	0.0445	0.10
Hexachloroethane	mg/kg dw	0.00968	0.02
Indeno(1,2,3-cd)pyrene	mg/kg dw	0.00618	0.02
Isophorone	mg/kg dw	0.0110	0.02
Naphthalene	mg/kg dw	0.0117	0.02
Nitrobenzene	mg/kg dw	0.0105	0.02
Phenanthrene	mg/kg dw	0.0103	0.02
Phenol	mg/kg dw	0.0122	0.02
Pyrene	mg/kg dw	0.00938	0.02
EPA 8270-SIM – SVOCs			
1,2,4-Trichlorobenzene	mg/kg dw	0.001638	0.0067
1,2-Dichlorobenzene	mg/kg dw	0.001347	0.0067

METHOD AND ANALYTE	UNIT	METHOD DETECTION LIMIT ^a	REPORTING LIMIT ^a
1,4-Dichlorobenzene	mg/kg dw	0.002205	0.0067
2,4-Dimethylphenol	mg/kg dw	0.003856	0.0067
2-Methylphenol	mg/kg dw	0.003379	0.0067
Benzyl alcohol	mg/kg dw	0.015547	0.033
Butyl benzyl phthalate	mg/kg dw	0.004000	0.0067
Dibenz(a,h)anthracene	mg/kg dw	0.00050	0.0063
Dimethyl phthalate	mg/kg dw	0.0017	0.0065
Hexachlorobenzene	mg/kg dw	0.001966	0.0067
Hexachlorobutadiene	mg/kg dw	0.002878	0.0067
n-Nitrosodiphenylamine	mg/kg dw	0.003054	0.0067
N-Nitrosodimethylamine	mg/kg dw	0.023871	0.033
N-Nitrosodi-n-propylamine	mg/kg dw	0.002680	0.033
Pentachlorophenol	mg/kg dw	0.013126	0.033
Krone et al (1989) – Butyltins			
Di-n-butyltin	µg/kg dw	2.18	10.0
n-Butyltin	µg/kg dw	5.36	10.0
Tri-n-butyltin	µg/kg dw	2.08	5.0
EPA 6010B or EPA 6020 – Metals			
Antimony	mg/kg dw	0.62	5.0
Arsenic	mg/kg dw	0.83	5.0
Cadmium	mg/kg dw	0.013	0.2
Chromium	mg/kg dw	0.09	0.5
Cobalt	mg/kg dw	0.03	0.3
Copper	mg/kg dw	0.021	0.2
Lead	mg/kg dw	0.116	2.0
Molybdenum	mg/kg dw	0.088	0.5
Nickel	mg/kg dw	0.21	1.0
Selenium	mg/kg dw	0.98	5.0
Silver	mg/kg dw	0.032	0.3
Thallium	mg/kg dw	0.446	5.0
Vanadium	mg/kg dw	0.018	0.3
Zinc	mg/kg dw	1.06	2.0
EPA 7471A – Mercury			
Mercury	µg/kg dw	0.0025	0.05

- ^a Actual reporting limits and MDLs will vary based on the amount of sample volume used for each analysis, the analytical dilution, and the amount of total solids in the sample.
- ^b Reporting limits for dioxin/furan congeners analyzed by Axys are equivalent to lower calibration limits.
- ^c Samples will be screened prior to PCB Aroclor analysis. Samples with detected Aroclors greater than 30 µg/kg dw will be prepared using a standard preparatory technique providing an RL of 20 µg/kg dw. Samples with no detected Aroclors or with detected Aroclors at concentrations less than 30 µg/kg dw will be prepared using the low-level method with an RL of 4 µg/kg dw.
- ^d The SVOC method will be calibrated to quantify DDT isomers in addition to standard SVOC analytes. These data will be used to confirm higher concentrations reported by Method 8081A because of the possible interference in the DDT quantifications due to the presence of PCB congeners. For DDT isomer MDLs and RLs, please refer to those presented for Method 8081A.

Appendix B. Data Management

B.1 LABORATORY REPLICATES

Chemical concentrations obtained from the analysis of laboratory duplicates or replicates (two or more analyses on the same sample) are averaged for a closer representation of the “true” concentration as compared to the results of a single analysis. Averaging rules are dependent on whether the individual results are detects or non-detects. If all concentrations are detects for a given parameter, the values are simply averaged arithmetically. If all concentrations are undetected for a given parameter, the minimum detection limit is reported. If the concentrations are a mixture of detects and non-detects, any two or more detected concentrations are averaged arithmetically and detection limits ignored. If there is a single detected concentration and one or more non-detects, the detected concentration is reported. The latter two rules are applied regardless of whether the detection limits are higher or lower than the detected concentration.

B.2 SIGNIFICANT FIGURES AND ROUNDING

The laboratory reports results with different numbers of significant figures depending on the instrument, parameter, and the concentration relative to the reporting limit (RL). The reported (or assessed) precision of each observation is explicitly stored in the project database as a record of the number of significant figures assigned by the laboratory. The tracking of significant figures becomes important when calculating averages and performing other data summaries.

When a calculation involves addition, such as totaling polychlorinated biphenyls (PCBs) or polycyclic aromatic hydrocarbons (PAHs), the calculation can only be as precise as the least precise number that went into the calculation. For example (assuming two significant figures):

$210 + 19 = 229$, but this would be reported as 230 because the trailing zero in the number 210 is not significant

When a calculation involves multiplication or division, such as when carbon normalizing is used, all significant figures are carried through the calculation, and then the total result is rounded at the end of the calculation to reflect the value used in the calculation with the fewest significant figures. For example:

$59.9 \times 1.2 = 71.88$, to be reported as 72 because there are two significant figures in the number 1.2

When rounding, if the number following the last significant figure is less than 5, the digit is left unchanged. If the number following the last significant figure is equal to or greater than 5, the digit is increased by 1.

B.3 DILUTIONS

All analyte concentrations within the calibration range of the instrument in the lowest analytical dilution are selected as the final result. Any analyte concentrations that exceed the calibration range and are qualified as estimated by the laboratory as an exceedance (E-qualified) are rejected by the data validator. The values for these analytes are selected from the analysis of the sample dilution in which the analyte concentration is within the calibration range of the instrument. In cases where the result from the lowest analytical dilution is qualified by the laboratory or the validator, the validator uses best professional judgment to determine whether or not the qualification warrants the selection of the result from another analytical dilution as the final result.

B.4 MULTIPLE RESULTS FOR THE SAME ANALYTE USING ONE ANALYTICAL METHOD

Multiple analyses of a sample for a group of analytes can occur as a result of laboratory quality assurance (QA) issues that may only affect a subset of the analyte group. In these cases, there may be multiple results for certain analytes. The data validator uses the following rules to select a single value when multiple results are reported by the laboratory for a single analyte in a single sample using the same method.

- ◆ If all results are detected without qualification as an estimated value (i.e., J- or E-qualifier), then the result from the lowest analytical dilution is selected. If multiple, unqualified results from the same analytical dilution are available, the highest concentration is selected as a health-protective approach.
- ◆ If a mixture of estimated (i.e., J-qualified) and unqualified detected results are reported, then the unqualified detected result is selected.
- ◆ If all results are reported as detected with estimated qualification, the “best result” is selected using best professional, technical judgment.
- ◆ If both non-detected and detected results are reported, then the detected result is selected.
- ◆ If all results are reported as non-detected, then the lowest RL is selected.

B.5 MULTIPLE RESULTS FOR AN ANALYTE DETERMINED BY DIFFERENT ANALYTICAL METHODS

In cases where a single analyte is reported by more than one method, the preferred method is identified in the quality assurance project plan (QAPP). The results of this method are selected as the final value by the data validator unless the validator identifies a QA issue that warrants the selection of the results from an alternative method. These instances and the justification for decisions are documented in the data validation report. In cases where the results are generated in two separate analytical groups that are not submitted to the validator together, the QA manager is responsible for evaluating the results and determining the most appropriate final result.

B.6 CALCULATING TOTALS

Concentrations for analyte sums are calculated as follows:

- ◆ **Total PCBs** are calculated, in accordance with the methods of the Washington State Sediment Management Standards (SMS), using only detected values for seven Aroclor mixtures.² For individual samples in which none of the seven Aroclor mixtures is detected, total PCBs are given a value equal to the highest RL of the seven Aroclors and assigned a U-qualifier indicating the lack of detected concentrations.
- ◆ **Total low-molecular-weight PAHs (LPAHs), high-molecular-weight PAHs (HPAHs), PAHs, and benzofluoranthenes** are also calculated in accordance with the methods of the SMS. Total LPAHs are the sum of detected concentrations for naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, and anthracene. Total HPAHs are the sum of detected concentrations for fluoranthene, pyrene, benzo(a)anthracene, chrysene, total benzofluoranthenes, benzo(a)pyrene, indeno(1,2,3,-c,d)pyrene, dibenzo(a,h)anthracene, and benzo(g,h,i)perylene. Total benzofluoranthenes are the sum of the b (i.e., benzo(b)fluoranthene), j, and k isomers. Because the j isomer is rarely quantified, this sum is typically calculated with only the b and k isomers. For samples in which all individual compounds within any of the three groups described above are undetected, the single highest RL for that sample represents the sum.

B.7 CALCULATION OF DIOXIN/FURAN CONGENERS TEQS

Dioxin/furan congener toxic equivalents (TEQs) are calculated using the WHO consensus toxic equivalent factor (TEF) values (Van den Berg et al. 1998) for mammals as presented in Table B-1. The TEQ is calculated as the sum of each congener

² Aroclors 1016, 1221, 1232, 1242, 1248, 1254, and 1260.

concentration multiplied by the corresponding TEF value. When the congener concentration is reported as non-detected, then the TEF is multiplied by zero, half the RL, or the full RL, depending on the calculation method specified.

Table B-1. Dioxin/furan congener TEF values for mammals

DIOXIN/FURAN CONGENER	TEF VALUE (unitless)
1,2,3,4,6,7,8-Heptachlorodibenzofuran	0.01
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	0.01
1,2,3,4,7,8,9-Heptachlorodibenzofuran	0.01
1,2,3,4,7,8-Hexachlorodibenzofuran	0.1
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	0.1
1,2,3,6,7,8-Hexachlorodibenzofuran	0.1
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	0.1
1,2,3,7,8,9-Hexachlorodibenzofuran	0.1
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	0.1
1,2,3,7,8-Pentachlorodibenzofuran	0.05
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	1
2,3,4,6,7,8-Hexachlorodibenzofuran	0.1
2,3,4,7,8-Pentachlorodibenzofuran	0.5
2,3,7,8-Tetrachlorodibenzofuran	0.1
2,3,7,8-Tetrachlorodibenzo-p-dioxin	1
Octachlorodibenzofuran	0.0001
Octachlorodibenzo-p-dioxin	0.0001

B.8 REFERENCES

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