Lower Duwamish Waterway Group

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

Lower Duwamish Waterway Remedial Investigation

DATA REPORT:

ROUND 1 SURFACE SEDIMENT SAMPLING FOR CHEMICAL ANALYSES AND TOXICITY TESTING 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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Supporting documentation

The following appendices, plus the GIS maps and the photo album for this data report, may be viewed at http://www.ldwg.org/rifs_docs.htm; the links are found in the Data Report section under the heading **Task 10: Results of Phase 2 fieldwork**. The appendices, maps, and photo album are also found on the CD included with some hard copies of this document.

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Acronyms

ACRONYM	Definition
%RSD	percent relative standard deviation
ACG	analytical concentration goal
AET	apparent effects threshold
ARI	Analytical Resources, Inc.
Axys	Axys Analytical Services, Ltd
BEHP	bis(2-ethylhexyl)phthalate
CRQL	contract required quantitation limits
CSL	cleanup screening level
DMMP	Dredged Material Management Program
DMR	Dinnel Marine Resources
DO	dissolved oxygen
dw	dry weight
Ecology	Washington Department of Ecology
EPA	US Environmental Protection Agency
ERA	ecological risk assessment
HHRA	human health risk assessment
LCS/	laboratory control sample
LCSD	laboratory control sample duplicate
LDC	Laboratory Data Consultants
LDW	Lower Duwamish Waterway
LDWG	Lower Duwamish Waterway Group
MDL	method detection limit
ML	maximum level
MLLW	mean lower low water
MS	matrix spike
MSD	matrix spike duplicate
NAS	Northwestern Aquatic Sciences
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PCP	pentachlorophenol
ppt	parts per thousand
PSEP	Puget Sound Estuary Program
QAPP	Quality Assurance Project Plan
QC	quality control

ACRONYM	Definition
RI	Remedial Investigation
RL	reporting limit
RM	river mile
RPD	relative percent difference
RSD	relative standard deviation
SDG	sample delivery group
SIM	selected ion monitoring
SL	screening level
SMS	Washington State Sediment Management Standards
SOP	standard operating procedure
SQS	Washington State Sediment Quality Standards
SRM	standard reference material
SVOC	semivolatile organic compound
TOC	total organic carbon
TBT	tributyltin
Weston	Weston Solutions, Inc.
Windward	Windward Environmental LLC

1.0 Introduction

This data report presents the results of chemical analyses and toxicity tests conducted with surface sediment samples collected from the Lower Duwamish Waterway (LDW) as part of the Phase 2 Remedial Investigation (RI). The surface sediment Quality Assurance Project Plan (QAPP) (Windward 2005c) presented the design for the sampling and analysis of Round 1 and Round 2 samples, including details on project organization, field data collection, laboratory analyses, and data management. Results from Round 1 are presented in this data report.[1] Round 2 results will be presented in a separate data report. As described in the Phase 2 RI work plan (Windward 2004), the Round 1 and 2 surface sediment data will be used to support the Phase 2 ecological and human health risk assessments (ERA and HHRA) and the Phase 2 RI/FS.

Surface (0 - 10 cm) sediment samples were collected at 81 locations in the LDW during Round 1 in January/February 2005. All samples were analyzed for the chemicals listed in the Washington State Sediment Management Standards (SMS), and a subset of samples was analyzed for organochlorine pesticides, dioxins/furans, polychlorinated biphenyl (PCB) congeners, butyltins, and semivolatile organic compounds (SVOCs) using selected ion monitoring (SIM). Splits of the sediment samples from 27 of the 81 locations were also submitted for laboratory toxicity testing based on an evaluation of preliminary, unvalidated sediment chemical concentrations.

In addition to the samples collected from the LDW, surface sediment samples were also collected from eight areas upstream of the LDW for arsenic and grain size analysis. Also, surface sediment samples were collected from nine locations in the greater Seattle metropolitan area during Round 1 for analysis of dioxins/furans, PCBs, and pentachlorophenol (PCP). This data report presents all Round 1 data, with the exception of dioxin/furan and PCB congener data for LDW sediment samples and data for the nine sediment samples collected in the greater Seattle metropolitan area. Those results will be presented in the Round 2 surface sediment data report.

The remainder of this report is organized into the following sections:

- Section 2 – Surface sediment collection methods
- Section 3 – Laboratory methods
- Section 4 – Selection of samples for laboratory toxicity testing
- Section 5 – Results
- Section 6 – References

The text of this report is supported by the following appendices:

[1] Sampling was conducted in two rounds because of the limit on the number of sediment samples that could be tested for toxicity at one time.

- Appendix A – data tables
- Appendix B – data management
- Appendix C – data validation reports
- Appendix D - raw analytical laboratory data
- Appendix E – collection forms and field notes
- Appendix F – chain-of-custody forms

Appendices C through F, which consist of detailed validation reports and scanned original field and laboratory documents for this data report, plus an album of photographs of surface sediment sampling, may be viewed online at http://www.ldwg.org/rifs_docs.htm; the links to these resources are found in the Data Report section of that web page under the heading **Task 10: Results of Phase 2 fieldwork**. These materials are also available on compact disk on request, and will be provided to the US Environmental Protection Agency (EPA) and the Washington Department of Ecology (Ecology).

2.0 Surface Sediment Collection Methods

This section describes the methods used to collect surface sediment samples in the LDW (Section 2.1) and at upstream Duwamish River locations (Section 2.2).[2] Additional details regarding the surface sediment collection methods are presented in the QAPP (Windward 2005c). Copies of field notes, surface sediment collection forms, and protocol modification forms are presented in Appendix E. Copies of completed chain-of-custody (COC) forms used to track sample custody are presented in Appendix F.

2.1 LDW Surface Sediment

This section presents the Round 1 surface sediment sample identification scheme, sample locations, collection methods, and field deviations from the QAPP for samples collected in the LDW.

2.1.1 Sample identification scheme

Each sediment sampling location was assigned a unique alphanumeric location ID number. The first three characters of the location ID were "LDW" to identify the Lower Duwamish Waterway project area. The next characters indicated the type of samples collected. All locations were designated with an "SS" to indicate surface sediment, followed by a number indicating a unique sampling location. For example,

[2] Methods used to collect the dioxin/furan surface sediment samples from the greater Seattle metropolitan area will be presented in the Round 2 data report.

sampling location 1 was identified as LDW-SS1. Four field duplicate samples were identified using the sampling location numbers LDW-SS200 throughLDW-SS203.

The Carr Inlet locations where reference samples were collected for toxicity testing had existing location IDs from previous sampling for other projects. For this sampling effort, those existing IDs were preceded with "LDW." For example, the sample collected from existing location SSCR23B was identified as LDW-SSCR23B.

The sample ID was similar to the location ID, but included the suffix of "010" to indicate that sediment samples were collected from the 0-10 cm depth range (i.e., LDW-SS1-010). Rinsate blanks were identified by the location identifier followed by the suffix "RB" (i.e., LDW-SS1-RB).

2.1.2 Sample locations

The rationale for selecting sediment sampling locations is presented in the QAPP (Windward 2005c). Round 1 surface sediment samples and four field duplicate samples were collected from 79 sampling locations over eight days from January 17 to 26, 2005 (Table 2-1). In addition, two locations were sampled by King County on February 1 and February 2, 2005 (King County DUD-11C and DUD-9C) for analysis of metals, SVOCs, PCBs, and organochlorine pesticides by King County. Round 1 sampling locations are shown in Figures 2-1a and b (located in the map folio at the end of this report). Reference samples for toxicity testing were collected from three locations in Carr Inlet.

Splits of the King County samples were delivered to Windward for analyses of additional parameters at Analytical Resources, Inc. (ARI) or Axys Analytical Services, Ltd. (Axys) along with the other Round 1 samples. These split samples were identified as LDW-SS18-010 (DUD-11C) and LDW-SS20-010 (DUD-9C). The additional parameters analyzed in LDW-SS18-010 were dioxins/furans and SIM SVOCs, and those analyzed in LDW-SS20-010 were dioxins/furans and butyltins. Results of the SVOC-SIM and butyltin analyses are presented in this data report, and results of the dioxin/furan analyses will be presented in the Round 2 data report. The results for the metals, SVOCs, PCBs, and organochlorine pesticide analyses of the split samples will be provided separately.

Table 2-1. LDW surface sediment sampling locations

Location	Date	Time (PST)	Target Location[a] (X)	Target Location[a] (Y)	Actual Location[a] (X)	Actual Location[a] (Y)	Distance from Target (m)	Depth Above (+) or Below (-) MLLW (ft)
LDW-SS1	01.17.2005	0802	1266032	211372	1266032	211372	0.0	-16.7
LDW-SS4	01.17.2005	0844	1266883	211229	1266882	211231	0.7	-29.8
LDW-SS5	01.17.2005	0948	1265996	211210	1265995	211209	0.4	-36.1
LDW-SS10	01.17.2005	1056	1266258	210286	1266257	210287	0.4	-28.9
LDW-SS12	01.17.2005	1118	1266104	210194	1266102	210192	0.9	-11.8

Location	Date	Time (PST)	Target Location[a]		Actual Location[a]		Distance from Target (m)	Depth Above (+) or Below (-) MLLW (ft)
			(X)	(Y)	(X)	(Y)		
LDW-SS13	01.17.2005	1514	1266934	210046	1266935	210045	0.4	-23.6
LDW-SS14	01.17.2005	1204	1266179	209915	1266193	209894	7.7	-3.0
LDW-SS15	01.17.2005	1230	1266467	209860	1266465	209859	0.7	-40.0
LDW-SS17[b]	01.24.2005	0857	1266880	209785	1266877	209786	1.0	-26.6
LDW-SS18[c]	02.01.2005	1254	1266844	209535	1266844	209531	1.2	na
LDW-SS20[c]	02.02.2005	1307	1266784	209157	1266779	209158	1.6	na
LDW-SS22	01.17.2005	1440	1267168	208754	1267170	208754	0.6	-17.7
LDW-SS23	01.18.2005	0755	1266583	208452	1266583	208453	0.3	-10.5
LDW-SS26	01.18.2005	0906	1267288	207661	1267286	207662	0.7	-31.5
LDW-SS27[d]	01.18.2005	0930	1267542	207310	1267545	207314	1.5	-12.5
LDW-SS28	01.24.2005	1345	1265916	207206	1265966	207219	15.7[e]	2.3
LDW-SS31[b]	01.21.2005	1303	1268450	206549	1268449	206550	0.4	-16.7
LDW-SS32	01.18.2005	0951	1268204	206530	1268204	206530	0.0	-24.3
LDW-SS33	01.26.2005	0815	1266292	206479	1266283	206526	14.6[e]	4.3
LDW-SS36	01.24.2005	1050	1267007	206188	1267011	206189	1.3	-5.6
LDW-SS37	01.18.2005	1042	1267735	206171	1267737	206172	0.7	-35.4
LDW-SS38	01.18.2005	1215	1267635	205939	1267634	205939	0.3	-30.5
LDW-SS40	01.18.2005	1315	1267960	205507	1267959	205507	0.3	-35.1
LDW-SS42	01.24.2005	1307	1268296	205276	1268262	205297	12.2[e]	-17.1
LDW-SS43	01.21.2005	0757	1267881	205161	1267881	205162	0.3	-28.9
LDW-SS44	01.21.2005	0826	1267941	204908	1267942	204907	0.4	-19.7
LDW-SS48	01.18.2005	1356	1268050	204599	1268049	204598	0.4	-5.9
LDW-SS49	01.26.2005	0907	1268107	204476	1268100	204472	2.5	-14.1
LDW-SS50[f]	01.24.2005	0925	1268521	204436	1268520	204435	0.4	-11.2
LDW-SS51	01.18.2005	1452	1268236	204365	1268234	204366	0.7	-31.2
LDW-SS52	01.25.2005	1043	1268452	204315	1268452	204314	0.3	-29.5
LDW-SS54	01.24.2005	1203	1268592	204287	1268568	204284	7.4	-9.5
LDW-SS55	01.24.2005	1000	1268184	204181	1268182	204179	0.9	-34.1
LDW-SS56	01.24.2005	1300	1268055	204058	1268032	204056	7.0	-1.3
LDW-SS57	01.24.2005	1235	1267968	203890	1267971	203884	2.0	-3.3
LDW-SS58	01.24.2005	1150	1267841	203787	1267841	203783	1.2	-0.3
LDW-SS60	01.19.2005	1221	1268802	203596	1268801	203593	1.0	-3.0
LDW-SS63	01.21.2005	1455	1269601	203350	1269530	203294	27.6[e]	-11.2
LDW-SS64	01.24.2005	0855	1269008	203158	1268974	203190	14.2[e]	-4.3
LDW-SS67	01.21.2005	1414	1269384	202808	1269384	202805	0.9	-2.0
LDW-SS70	01.21.2005	1516	1268809	201998	1268808	201999	0.4	-10.8
LDW-SS72	01.24.2005	1042	1269160	201710	1269161	201711	0.4	-18.0
LDW-SS75	01.21.2005	1537	1269271	201578	1269266	201575	1.8	-7.2
LDW-SS76	01.20.2005	1553	1270217	201545	1270219	201544	0.7	-16.4

Location	Date	Time (PST)	Target Location[a]		Actual Location[a]		Distance from Target (m)	Depth Above (+) or Below (-) MLLW (ft)
			(X)	(Y)	(X)	(Y)		
LDW-SS79	01.24.2005	1100	1269902	201244	1269901	201243	0.4	-25.3
LDW-SS83	01.24.2005	0945	1271225	200364	1271225	200361	0.9	-3.6
LDW-SS84	01.19.2005	1720	1270005	200340	1269997	200324	5.5	na
LDW-SS87	01.21.2005	0919	1271624	199612	1271608	199617	5.1	-12.5
LDW-SS88	01.25.2005	1755	1271869	199309	1271865	199304	2.0	1.0
LDW-SS89[g]	01.19.2005	1441	1272015	199092	1272011	199091	1.3	-9.2
LDW-SS92[b]	01.25.2005	1151	1272435	198751	1272437	198751	0.6	-5.2
LDW-SS94	01.21.2005	1000	1272581	198641	1272581	198641	0.0	-8.2
LDW-SS96	01.21.2005	1025	1272751	198348	1272753	198348	0.6	-18.0
LDW-SS97	01.21.2005	1121	1272522	198224	1272542	198248	9.5	-22.0
LDW-SS99	01.19.2005	1346	1273135	197679	1273131	197712	10.1[e]	-4.6
LDW-SS101	01.20.2005	1915	1273283	197433	1273285	197451	5.5	na
LDW-SS102	01.24.2005	1405	1273506	197314	1273508	197312	0.9	-0.3
LDW-SS104	01.25.2005	1306	1273815	197040	1273815	197042	0.6	-0.7
LDW-SS109	01.25.2005	1528	1275743	195745	1275746	195745	0.9	-3.9
LDW-SS110[b]	01.25.2005	1456	1275877	195533	1275947	195351	59.4[e]	-1.0
LDW-SS111	01.19.2005	0805	1275958	195288	1275958	195287	0.3	-2.3
LDW-SS112	01.19.2005	0843	1276028	195023	1276032	195022	1.3	-3.3
LDW-SS113b[b]	01.20.2005	0916	1275822	194662	1275773	194956	90.8[e]	-1.3
LDW-SS114	01.20.2005	0803	1276044	194872	1276045	194871	0.4	-4.9
LDW-SS115	01.25.2005	1622	1276156	194765	1276134	194727	13.4[e]	-0.7
LDW-SS116	01.20.2005	1200	1276203	194573	1276177	194577	8.0	0.7
LDW-SS117	01.20.2005	0829	1275818	194553	1275819	194552	0.4	-2.6
LDW-SS118	01.20.2005	1528	1276096	194552	1276092	194553	1.3	-10.8
LDW-SS119	01.19.2005	0938	1276226	194391	1276228	194389	0.9	1.3
LDW-SS120	01.19.2005	1021	1276295	194179	1276295	194178	0.3	1.6
LDW-SS121	01.25.2005	1701	1276332	194079	1276328	194079	1.2	2.6
LDW-SS123[h]	01.24.2005	1635	1276329	193933	1276329	193932	0.3	0.3
LDW-SS125	01.20.2005	1043	1276577	193348	1276577	193347	0.3	3.0
LDW-SS126	01.20.2005	1106	1276637	193145	1276639	193145	0.6	2.6
LDW-SS127	01.20.2005	1334	1277453	193044	1277454	193043	0.4	-7.2
LDW-SS128	01.24.2005	1540	1277368	193013	1277381	193000	5.6	1.0
LDW-SS129	01.20.2005	1447	1277567	192917	1277559	192920	2.6	-4.6
LDW-SS130	01.20.2005	1406	1277407	192810	1277407	192810	0.0	-8.2
LDW-SS134	01.24.2005	1550	1276278	192169	1276280	192176	2.2	1.3
LDW-SS142	01.24.2005	1601	1277873	190498	1277874	190492	1.9	-3.9
LDW-SS143[b]	01.26.2005	1144	1278260	190396	1278267	190387	3.5	2.3
LDW-SSCR20[i]	01.28.2005	0830	na	na	1102225	736759	na	na
LDW-SSCR23[i]	01.28.2005	0930	na	na	1100878	736684	na	na

Location	Date	Time (PST)	Target Location[a]		Actual Location[a]		Distance from Target (m)	Depth Above (+) or Below (-) MLLW (ft)
			(X)	(Y)	(X)	(Y)		
LDW-SSMSMP43[i]	01.28.2005	0700	na	na	1084070	724326	na	na

[a] Coordinates given in NAD83 horizontal datum; X-Y coordinates in Washington State Plane N (US ft)

[b] Target coordinates at these locations differ from Table 3-2 of the QAPP (Windward 2005c) because those coordinates for these locations were incorrectly reported in the QAPP, but were corrected prior to sample collection and are correctly identified in this data report

[c] Collected by King County

[d] Field duplicate LDW-SS200-010 was also collected at this location

[e] These eight locations could not be sampled within 10 m of the targeted location, as specified in the QAPP, for reasons presented in Table 2-2.

[f] Field duplicate LDW-SS202-010 was also collected at this location

[g] Field duplicate LDW-SS201-010 was also collected at this location

[h] Field duplicate LDW-SS203-010 was also collected at this location

[i] Reference area sample for toxicity testing

na – not available

MLLW – mean lower low water

PST – Pacific Standard Time

2.1.3 Sample collection methods

Round 1 sediment samples were collected following standardized procedures from the Puget Sound Estuary Program (PSEP 1997). Surface sediments were collected from each location using a 0.1-m^2 single or double van Veen grab sampler, or using a Young grab sampler[3] at locations where successful van Veen grabs could not be collected because sediment bottom conditions (e.g., sloped surface, rocky substrate) interfered with the closing of the sampler. The weighted frame of the Young grab sampler allowed the sampler to settle more firmly on the bottom surface so that the jaws could close. In addition, at two intertidal locations (LDW-SS84 and LDW-SS101), sediment was collected by hand using a pre-cleaned stainless steel spoon.

Each successful grab sample was evaluated for acceptability in accordance with the QAPP. Sediment was collected for sulfide analysis from the first acceptable grab at each location prior to collecting and homogenizing sediment for the remaining chemical and toxicity analyses. At each grab location, one to three acceptable grab samples were collected, depending on the volume of sediments retrieved in the grab sampler and the volume needed for chemical analyses (e.g., extra volume was needed at locations where field duplicates were collected). At all locations, sediment was taken from the 0-10 cm interval and homogenized in a clean, stainless steel bowl or stockpot using a stainless steel spoon or a drill with stainless steel mixing paddles,

[3] The Young-modified van Veen grab sampler, or "Young grab," consists of a steel conical frame encasing a hinged bucket that splits apart at the center to scoop sediment from a 0.04-m^2 area. Weights on the frame improve the ability of the bucket to penetrate into the sediment.

until texture and color were homogenous. Homogenized sediment was then split into the appropriate sampling containers for chemical and toxicity analyses.

King County samples were collected according to the *Duwamish/Diagonal Sediment Remediation, Dredging and Capping Operations, Sediment Monitoring, Sampling and Analysis Plan* (Romberg 2003). For that sampling program, samples were collected with a 0.1-m^2 double van Veen grab sampler at a targeted depth of 0-10 cm. At location LDW-SS18-010, sediment aliquots were collected from ten individual grabs, with an equal amount of material collected from each grab using a 10-in. long and 2.5-in. diameter stainless steel core. Each of the aliquots was placed into a stainless-steel bowl, which was covered with aluminum foil between grab deployments. After collecting aliquots from 10 grabs, the composite sediment sample was thoroughly homogenized and sample aliquots split out into appropriate sampling containers. King County collected the other sample (LDW-SS20-010) using this sampling method for chemical analyses conducted by King County. However, the jars for the butyltin analysis conducted as part of this QAPP were not available at the time of sampling on January 31, 2005. Therefore, a single grab sample was collected separately on February 2, 2005 at LDW-SS20-010 for butyltin analysis. Sediment characteristics were noted in the field logbook or in the field collection forms at each sampling location. Table E-1 in Appendix E contains summaries of sediment characteristics, redox potential depth, and penetration depth for each Round 1 surface sediment sample.

2.1.4 Field deviations from the QAPP

Field deviations from the QAPP (Windward 2005c) included modifications to collection methods and locations. These field deviations did not affect the data quality. EPA and Ecology were consulted on deviations that involved a change in study design. The deviations were as follows:

- Nine samples could not be collected from a distance ≤10 m from the target location. Table 2-2 presents the rationale for sampling the revised locations. Representatives from EPA and Ecology were consulted during the sampling event regarding the revised locations.

Table 2-2. Round 1 locations where actual sampling locations were > 10 m from their target sampling locations

Location	Distance from Target (m)	Rationale
LDW-SS28	15.7	Wood debris and low recovery encountered at target location, so location was moved away from the target location until acceptable grabs were collected
LDW-SS33	14.6	Wood debris and low recovery encountered at target location during sampling attempts on both January 24 and January 26; sample was collected at a location closest to the target location where van Veen jaws could close and collect acceptable grabs

Location	Distance from Target (m)	Rationale
LDW-SS42	12.2	Unable to collect sediment at target location, which was near outfall located on rocky rip rap slope; sample was collected at a location closest to the target location where van Veen jaws could close and collect acceptable grabs
LDW-SS63	27.6	Unable to collect sediment at target location, which was near outfall in Slip 2 within rocky substrate; sample was collected at a location closest to the target location where van Veen jaws could close and collect acceptable grabs
LDW-SS64	14.2	Unable to collect sediment at target location reoccupying historical location 8995 because 1) pipe and rocks in van Veen jaws prevented successful grabs, and 2) difficult to access because sample location was under a pier; sample was collected at a location closest to the target location where van Veen jaws could close and collect acceptable grabs
LDW-SS99	10.1	Unable to collect sediment at target location because the presence of rocks resulted in low recovery and prevented successful grabs; sample was collected at a location closest to the target location where van Veen jaws could close and collect acceptable grabs
LDWS-SS110	59.4	Target location reoccupying historical location 505 was changed to reoccupy USACE 323 (X = 1275948, Y = 195355) based on PCB concentration data from this area made available in January 2005 (actual sampling location was 1.2 m from new target location)
LDW-SS113	90.8	Unable to access the target location reoccupying historical location 776 because of debris in water; instead, historical location 898 was reoccupied (X =1275772, Y = 194955) and designated 113b (actual sampling location was 0.3 m from new target location)
LDW-SS115	13.4	Coordinates for target location reoccupying historical location 900 were on land; revised location (X = 1276134, Y = 194730) was placed as close as possible to the outfall in the same area

- The minimum penetration depth of 11 cm (as defined in the QAPP) was not achieved at eight sampling locations (LDW-SS1, LDW-SS5, LDW-SS36, LDW-SS48, LDW-SS64, LDW-SS101, LDW-SS116, and LDW-SS120) despite efforts involving numerous grabs where low recovery of sediment was consistently observed because of hard-packed native sediment or obstructions such as rocks or wood debris. Instead, the penetration depth at these eight locations was 8 to 10 cm, and the entire depth of the grab was collected with the exception of a small amount of sediment in contact with the sampler.
- A Young grab sampler was used in place of the 0.1-m^2 van Veen grab sampler at LDW-SS88, LDW-SS92, LDW-SS115, LDW-SS121, and LDW-SS123 because of rocky substrate and sloped sediment surfaces.
- LDW-SS81 was not collected during the Round 1 sediment collection effort because the target location was occupied by a barge. This location was sampled during Round 2.
- Split sediment samples were collected by King County at locations LDW-SS18 and LDW-SS20 during Round 1 rather than Round 2 to accommodate the King County sampling schedule.

2.2 UPSTREAM DUWAMISH RIVER SURFACE SEDIMENT

Surface sediment samples were collected in the Duwamish River upstream of the LDW site. These samples were collected to supplement the existing upstream sediment dataset for arsenic. Sampling locations were selected based on grain size and spatial coverage of the targeted upstream sampling area (from river mile [RM] [4] 6.1 to 6.6), as specified in the QAPP. The target grain size of the samples was more than 60% fines.

2.2.1 Sample identification scheme

Each upstream sampling location was assigned a unique alphanumeric location ID number. The first two characters of the location ID were "DR" to identify the Duwamish River location of the sampling. The next characters indicated the type of samples collected. All locations were designated with an "SS" to indicate surface sediment, followed by a number indicating a unique sampling location. For example, the first upstream sampling location was identified as DR-SS1.

The sample ID was similar to the location ID, but included the suffix of "010" to indicate that sediment samples were collected from the 0-10 cm depth range (e.g., DR-SS1-010). The one field duplicate sample collected was assigned sample number DR-SS9-010.

2.2.2 Sediment sample collection

Surface sediment samples were collected for potential arsenic analysis from 16 sampling locations over approximately a one-mile area between RM 6.1 and RM 7.2 on February 1 and February 9, 2005. Eight of these samples were submitted for arsenic analysis based on targeted grain size and spatial coverage of the targeted area (Table 2-3).

Table 2-3. Surface sediment sampling locations for arsenic analysis upstream of the LDW

Location ID	Date	Time (PST)	Actual Location[a]		Apparent Fines (%)[b]	Submitted for Chemical Analysis?
			X	Y		
DR-SS1	02.01.2005	1353	1282453	185723	40	no
DR-SS2	02.01.2005	1411	1282371	185755	42	no
DR-SS3	02.01.2005	1435	1281671	186005	42	no
DR-SS4	02.01.2005	1457	1280677	185927	40	no
DR-SS5	02.01.2005	1513	1280652	186146	54	yes
DR-SS6[c]	02.01.2005	1528	1280429	185889	48	yes
DR-SS7	02.01.2005	1551	1280058	186091	56	yes
DR-SS8	02.01.2005	1605	1279793	185834	40	no

[4] River miles within the LDW are referenced to the southern end of Harbor Island (RM 0.0).

Location ID	Date	Time (PST)	Actual Location[a]		Apparent Fines (%)[b]	Submitted for Chemical Analysis?
			X	Y		
DR-SS10	02.09.2005	1034	1282223	185788	55	yes
DR-SS11	02.09.2005	1045	1282600	185878	50	yes
DR-SS12	02.09.2005	1051	1282633	185422	45-50	no
DR-SS13	02.09.2005	1057	1282445	184848	55-60	yes
DR-SS14	02.09.2005	1114	1282509	183655	55	yes
DR-SS15	02.09.2005	1124	1282659	183555	60	yes
DR-SS16	02.09.2005	1217	1282823	182165	40	no
DR-SS17	02.09.2005	1238	1282675	182861	40	no

a Coordinates given in NAD83 horizontal datum; X-Y coordinates in Washington State Plane N (US feet)

b Apparent percent fines based on field screening (see text)

c Field duplicate sample DR-SS9-010 was also collected at this location

PST – Pacific Standard Time

Surface sediment samples upstream of the LDW were collected by hand at intertidal locations using a stainless steel spoon where possible, and using a 0.02-m^2 Ekman grab sampler or a 0.1-m^2 single van Veen grab sampler in deeper locations. At each location, sediment was collected from the 0–10 cm horizon and homogenized in a clean stainless steel bowl using a stainless steel spoon until texture and color were homogenous. A portion of the homogenized sediment was assessed for grain size using a 63-µm sieve. Field screening of grain size was completed at each prospective sampling location.

Locations for sampling were selected in the field to obtain spatial coverage and targeted grain size (> 60% fines) at locations between RM 6.1 and RM 6.6. On the first day of sampling, the percent fines ranged from approximately 40 to 56% at 12 prospective sampling locations; the field crew was unable to find sampling areas within the targeted area with higher percent fines even at targeted mudflats and intertidal areas. Eight samples and one duplicate sample were collected on February 1, 2005.

On the second day of the sampling, the targeted area was extended upstream from RM 6.6 to RM 7.2 in an attempt to sample areas with higher percent fines, including additional intertidal areas. Sixteen additional prospective locations were sampled using the 0.02-m^2 Ekman grab sampler and a 0.1-m^2 single van Veen grab sampler where the water depth allowed, and using a stainless steel spoon by hand at shallow intertidal areas. Percent fines ranged from less than 40% to approximately 60%. Sediment was collected from eight additional locations where percent fines was at least 40%, because the field crew was unable to find sampling areas with higher percent fines.

In total, sediment was archived from 16 upstream locations from RM 6.1 to 7.2 where percent fines ranged from 40% to 60%. Eight samples and one duplicate sample were selected from the 16 archived samples in consultation with EPA and Ecology, and submitted for analysis. Figure 2-2 (located in the map folio) presents the locations of the arsenic samples. Selection of samples was based on spatial coverage of the area between RM 6.1 and 7.2, and field screening of grain size.

Observations were noted in the field logbook or in the field collection forms at each sampling location. Table E-2 in Appendix E summarizes the collected sediment characteristics and redox potential depth for each of the upstream surface sediment samples.

2.2.3 Field deviations from the QAPP during upstream sampling

Field deviations from the QAPP (Windward 2005c) included modifications to the location of the target upstream area, target grain size, and sampling dates. These field deviations (listed below) did not affect the data quality and are discussed in detail below. EPA and Ecology were consulted on these changes.

- The > 60% fines target was not met in the upstream arsenic sampling area, despite an extensive effort and attempts at numerous prospective sampling locations. Apparent percent fines based on field screening was close to or more than 50% in all samples submitted for analysis.
- Collection of upstream arsenic surface sediment samples began on February 1, 2005, instead of the targeted sampling start date of January 31, as specified in the QAPP. Sampling was delayed one day because of inclement weather on January 31.
- The upstream sampling area was expanded from RM 6.1 - RM 6.6 to RM 6.1 - RM 7.2 to search for sediment with grain size equal to or higher than the target of 60% fines.

3.0 Laboratory Methods

The methods used to chemically analyze sediment samples and to conduct sediment toxicity testing are described briefly in this section and in detail in the surface sediment QAPP. This section also summarizes any laboratory deviations from the QAPP.

3.1 Methods for Chemical Analyses

Table 3-1 summarizes the number of sediment samples analyzed for the various chemical analytes in the Round 1 sampling event. Table 3-2 lists the analyses conducted for each sample.

Table 3-1. Summary of surface sediment samples and analyses

Analyses	# of Samples Collected by Windward	# of Samples Collected by King County[a]	# of Field Duplicate Samples	Total Number of Samples
Chemical analyses of LDW samples collected during Round 1				
SMS chemicals (SVOCs, metals, PCBs as Aroclors), total solids, TOC, grain size, ammonia, and sulfides	79	2	4	85
Dioxins/furans	18[b]	0	1	19
PCB congeners	18[b]	0	0	18
Organochlorine pesticides	33	2	2	37
TBT	18	0	1	19
SVOC-SIM	60[c]	1	3	64
Chemical analyses of samples collected outside the LDW				
Arsenic, grain size, and total solids	8	0	1	9
Dioxins/furans, PCBs as Aroclors, total solids, TOC, grain size	13[b]	0	1	14
Pentachlorophenol	2 [b]	0	0	2

[a] Samples collected by King County were not analyzed for ammonia or sulfides; King County data will be provided separately

[b] Data will be presented in the Round 2 data report

[c] Includes archived sediment sample LDW-B9a-S from the benthic invertebrate sampling (Windward 2005a) which was only analyzed for SVOC-SIM

Table 3-2. Surface sediment chemical analyses

Location	SMS Chemicals	Organo-chlorine Pesticides	Dioxins/ Furans	PCB Congeners	TBT	SVOC GC/MS SIM
LDW-SS-1	x					x[a]
LDW-SS-4	x				x	x
LDW-SS-5	x	x				x[a]
LDW-SS-10	x					x
LDW-SS-12	x					x[a]
LDW-SS-13	x	x				x[a]
LDW-SS-14	x		x	x	x	x
LDW-SS-15	x				x	
LDW-SS-17	x			x		
LDW-SS-18	x[b]	x[b]	x			x
LDW-SS-20	x[b]	x[b]	x		x	
LDW-SS-22	x		x			x
LDW-SS-23	x					x
LDW-SS-26	x					x
LDW-SS-27 [c]	x	x			x	x
LDW-SS-28	x	x	x	x	x	x
LDW-SS-31	x				x	
LDW-SS-32	x	x			x	
LDW-SS-33	x				x	x[a]
LDW-SS-36	x	x	x			x[a]

Location	SMS Chemicals	Organo-chlorine Pesticides	Dioxins/ Furans	PCB Congeners	TBT	SVOC GC/MS SIM
LDW-SS-37	x		x	x		x
LDW-SS-38	x				x	x
LDW-SS-40	x					
LDW-SS-42	x	x				x[a]
LDW-SS-43	x		x		x	x
LDW-SS-44	x					x[a]
LDW-SS-48	x					
LDW-SS-49	x				x	
LDW-SS-50[d]	x	x				x
LDW-SS-51	x				x	x[a]
LDW-SS-52	x					x[a]
LDW-SS-54	x	x				x[a]
LDW-SS-55	x	x			x	x[a]
LDW-SS-56	x		x	x	x	x
LDW-SS-57	x		x			
LDW-SS-58	x	x	x		x	
LDW-SS-60	x					x
LDW-SS-63	x	x				x
LDW-SS-64	x	x	x	x		x
LDW-SS-67	x	x		x	x	x[a]
LDW-SS-70	x	x				
LDW-SS-72	x	x		x		x
LDW-SS-75	x					
LDW-SS-76	x	x				x[a]
LDW-SS-79	x	x			x	x
LDW-SS-83	x		x	x		x
LDW-SS-84	x	x	x	x		
LDW-SS-87	x	x				x[a]
LDW-SS-88	x					x
LDW-SS-89 [e]	x					x
LDW-SS-92	x	x		x		x
LDW-SS-94	x					x[a]
LDW-SS-96	x	x				x[a]
LDW-SS-97	x					x
LDW-SS-99	x	x				x
LDW-SS-101	x			x		x[a]
LDW-SS-102	x					x
LDW-SS-104	x	x				x
LDW-SS-109	x		x	x		
LDW-SS-110	x			x		x
LDW-SS-111	x					
LDW-SS-112	x					
LDW-SS-113	x	x				x
LDW-SS-114	x					
LDW-SS-115	x	x				
LDW-SS-116	x	x				x[a]

Location	SMS Chemicals	Organo-chlorine Pesticides	Dioxins/ Furans	PCB Congeners	TBT	SVOC GC/MS SIM
LDW-SS-117	x					x
LDW-SS-118	x					x[a]
LDW-SS-119	x					x
LDW-SS-120	x			x		x
LDW-SS-121	x					
LDW-SS-123 [f]	x		x			x
LDW-SS-125	x	x				x
LDW-SS-126	x	x				x
LDW-SS-127	x	x	x			
LDW-SS-128	x	x				x[a]
LDW-SS-129	x	x				x
LDW-SS-130	x			x		
LDW-SS-134	x	x				
LDW-SS-142	x			x		x
LDW-SS-143	x		x	x		x
LDW-B9a [g]						x
Total number of analyses	**81**	**35**	**18**	**18**	**18**	**60**

a SVOC-SIM was analyzed on these samples after review of preliminary, unvalidated data, as described in Section 4.0

b SMS and pesticide analyses are being conducted by King County and will be provided separately

c Field duplicate sample LDW-SS200-010 was collected at this location

d Field duplicate sample LDW-SS202-010 was collected at this location

e Field duplicate sample LDW-SS201-010 was collected at this location

f Field duplicate sample LDW-SS203-010 was collected at this location

g As noted in the QAPP, the archived sediment sample from location LDW-B9a (sampled according to the benthic invertebrate QAPP) was analyzed for SVOC-SIM as part of the Round 1 chemical analyses

All chemical analyses of the sediment samples collected by Windward were conducted by ARI, except for the dioxin/furan and PCB congener analyses, which were conducted by Axys. Analytical methods are presented in Table 3-3. The two sediment samples collected by King County (LDW-SS18-101 and LDW-SS20-010) were analyzed for selected SVOCs using SIM by ARI, and for remaining parameters by King County's laboratory according to the *Duwamish/Diagonal Sediment Remediation, Dredging and Capping Operations, Sediment Monitoring, Sampling and Analysis Plan* (Romberg 2003).

Table 3-3. Laboratory analytical methods for sediment samples

Parameter	Laboratory	Method	Reference
PCBs as Aroclors[a]	ARI	GC/ECD	EPA 8082
PCB congeners[b]	Axys	HRGC/HRMS	EPA 1668
Dioxins and furans	Axys	HRGC/HRMS	EPA 1613B
Organochlorine pesticides[c, d]	ARI	GC/ECD	EPA 8081A
SVOCs (including PAHs)[c, e]	ARI	GC/MS	EPA 8270

PARAMETER	LABORATORY	METHOD	REFERENCE
Selected SVOCs[f]	ARI	GC/MS	EPA 8270C-SIM
Mercury	ARI	CVAA	EPA 7471A
Other metals[g]	ARI	ICP-AES and ICP-MS	EPA 6010B and EPA 200.8
TBT, DBT, MBT (as ions)[h]	ARI	GC/FPD	Krone et al. (1989)
Grain size	ARI	sieve/pipette	PSEP (1986)
TOC	ARI	combustion	Plumb (1981)
Total solids	ARI	oven-dried	PSEP (1986)
Total sulfides	ARI	distillation/spectro-photometric	EPA 376.2 (modified)
Ammonia	ARI	automated phenate[i]	EPA 350.1 (modified)

a Extracts underwent sulfur cleanup (EPA 3660B) and sulfuric acid cleanup (EPA 3665A)

b Sediment samples were analyzed for dioxin-like PCB congeners as defined by the World Health Organization (77, 81, 105, 114, 118, 123, 126, 156, 157, 167, 169, 189) and six principal PCB congeners (66, 101, 110, 138, 153, 180) identified in LDW sediments based on Phase 1 data

c Target pesticides include: 4,4'-DDT, 4,4'-DDE, 4,4'-DDD, 2,4'-DDT, 2,4'-DDE, 2,4'-DDD, aldrin, alpha-BHC, beta-BHC, delta-BHC, gamma-BHC, oxychlordane, alpha- and gamma-chlordane, cis- and trans-nonachlor, dieldrin, endosulfan, endosulfan sulfate, endrin, heptachlor, heptachlor epoxide, hexachlorobenzene, methoxychlor, mirex, and toxaphene

d Extracts underwent silica gel cleanup (EPA 3630C) and sulfur cleanup (EPA 3660B)

e Target PAHs include: anthracene, pyrene, dibenzofuran, benzo(g,h,i)perylene, benzo(e)pyrene, indeno(1,2,3-cd)pyrene, perylene, 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, and 2-methylnaphthalene

f Selected semivolatile organic compounds (SVOCs) include: 1,2,4-trichlorobenzene, 1,2-dichlorobenzene, 1,4-dichlorobenzene, 2,4-dimethylphenol, 2-methylphenol, benzoic acid, benzyl alcohol, butyl benzyl phthalate, di-ethyl phthalate, di-methyl phthalate, hexachlorobenzene, hexachlorobutadiene, n-nitrosodimethylamine, n-nitrosodiphenylamine, n-nitroso-di-n-propylamine, and pentachlorophenol

g Arsenic, antimony, and thallium were analyzed by EPA 200.8 using ICP-MS. Cadmium, chromium, cobalt, copper, lead, molybdenum, nickel, selenium, silver, vanadium, and zinc were analyzed by EPA 6010B using ICP-AES.

h Extracts underwent alumina cleanup (EPA 3610B)

i Samples were extracted with potassium chloride

CVAA – cold vapor atomic absorption

DBT – dibutyltin

GC/ECD – gas chromatography electron capture detection

GC/FPD – gas chromatography flame photometric detection

GC/MS – gas chromatography mass spectrometry

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

ICP-AES – inductively coupled plasma atomic emission spectrometry

ICP-MS – inductively coupled plasma mass spectrometry

MBT – monobutyltin; TBT – tributyltin

SIM – selected ion monitoring

3.2 METHODS FOR TOXICITY TESTING

Sediment samples were selected for toxicity testing in consultation with EPA and Ecology based on an evaluation of preliminary, unvalidated chemical concentrations, as discussed in Section 4.0. Three standard SMS sediment toxicity tests were conducted with split sediment samples from each of 27 selected locations in Round 1. These tests were:

- acute 10-day amphipod (*Eohaustorius estuarius*) mortality test
- acute 48-hr bivalve larvae (*Mytilus galloprovincialis*) normal survival test
- chronic 20-day juvenile polychaete (*Neanthes arenaceodentata*) survival and growth test

Northwestern Aquatic Sciences (NAS) conducted the amphipod and polychaete tests, and Weston Solutions, Inc. (Weston) conducted the bivalve larvae tests. The toxicity tests were conducted in accordance with *Recommended Guidelines for Conducting Laboratory Bioassays on Puget Sound Sediments* (PSEP 1995), with modifications as periodically specified in annual Sediment Management Annual Review Meetings. The toxicity test methods are presented in detail in the surface sediment QAPP (Windward 2005c).

The amphipod and polychaete tests were conducted in three batches and the bivalve larvae tests were conducted in two batches (Table 3-4).

Table 3-4. Toxicity test schedule

Test Batch	Amphipod and Polychaete Tests Conducted by NAS	Bivalve Larvae Tests Conducted by Weston
Batch 1	Start Date: March 4, 2005 LDW-SS15-010 LDW-SS17-010 LDW-SS22-010 LDW-SS26-010 LDW-SS31-010 LDW-SS32-010 LDW-SS37-010 LDW-SS40-010 LDW-SS49-010 LDW-SS50-010 LDW-SS56-010 LDW-SS57-010 LDW-SS58-010	Start Date: March 9, 2005 LDW-SS15-010 LDW-SS17-010 LDW-SS22-010 LDW-SS26-010 LDW-SS31-010 LDW-SS32-010 LDW-SS37-010 LDW-SS40-010 LDW-SS49-010 LDW-SS50-010 LDW-SS56-010 LDW-SS57-010 LDW-SS58-010 LDW-SS60-010 LDW-SS70-010 LDW-SS75-010 LDW-SS88-010 LDW-SS89-010 LDW-SS92-010 LDW-SS112-010

TEST BATCH	AMPHIPOD AND POLYCHAETE TESTS CONDUCTED BY NAS	BIVALVE LARVAE TESTS CONDUCTED BY WESTON
Batch 2	Start Date: March 8, 2005 LDW-SS60-010 LDW-SS70-010 LDW-SS75-010 LDW-SS88-010 LDW-SS89-010 LDW-SS92-010 LDW-SS112-010 LDW-SS114-010 LDW-SS115-010 LDW-SS119-010 LDW-SS120-010 LDW-SS121-010 LDW-SS143-010	Start Date: March 15, 2005 LDW-SS63-010 LDW-SS114-010 LDW-SS115-010 LDW-SS119-010 LDW-SS120-010 LDW-SS121-010 LDW-SS143-010
Batch 3	Start Date: March 11, 2005 LDW-SS63-010	no samples

Salinity adjustments were performed using methods described in the QAPP prior to the amphipod and polychaete tests for 12 sediment samples with interstitial salinities less than 20 ppt to provide a preferred salinity of at least 20 ppt and a more consistent salinity for all tests (Windward 2005c). Table 3-5 presents interstitial salinity measurements before and after adjustment in these sediment samples.

Table 3-5. Interstitial salinity measurements before and after adjustment

SAMPLE ID	INITIAL INTERSTITIAL SALINITY (ppt)	INTERSTITIAL SALINITY AFTER ADJUSTMENT (ppt)	
		AMPHIPOD TEST	POLYCHAETE TEST
LDW-SS56-010	19.5	25.0	25.0
LDW-SS58-010	19.0	22.5	25.0
LDW-SS60-010	15.0	25.0	25.0
LDW-SS88-010	14.0	25.0	25.0
LDW-SS92-010	17.0	26.0	26.0
LDW-SS112-010	11.0	24.5	22.0
LDW-SS114-010	5.5	23.0	24.5
LDW-SS115-010	10.0	25.0	26.0
LDW-SS119-010	10.0	24.0	25.0
LDW-SS120-010	9.0	23.0	24.0
LDW-SS121-010	5.0	22.5	22.0
LDW-SS143-010	5.5	20.0	22.5

ppt – parts per thousand

None of the samples were purged prior to conducting toxicity tests. All samples were aerated during testing, according to the QAPP (Windward 2005c).

The negative control sediment for the amphipod and polychaete tests was collected in the lower Yaquina Bay, Oregon, sieved through a 0.5-mm stainless steel screen, and stored at 4°C in the dark until test initiation. The negative control for the bivalve larvae test was 0.45-µm filtered seawater from San Francisco Bay, collected using the Weston laboratory's flowing seawater system.

The positive control tests were performed concurrently with the sediment toxicity tests. Reference toxicants were cadmium chloride for the amphipod and polychaete tests and copper sulfate for the bivalve larvae tests. The positive control test duration was 4 days for the amphipod and polychaete tests and 48 hours for the bivalve larvae tests. In addition, concurrent positive control tests using ammonium chloride as a reference toxicant were conducted with the three test organisms.

Toxicity testing protocols require that test sediments be matched and tested simultaneously with appropriate reference sediment to account for potential sediment grain-size and total organic carbon (TOC) effects on test organisms (PSEP 1995). Reference sediments are then used in statistical comparisons to determine whether test sediments are toxic. Three reference sediment samples (LDW-SSMSMP43-010, LDW-SSCR20-010, and LDW-SSCR23-010) were collected from the northern end of Carr Inlet on January 28, 2005 by Biomarine Enterprises. The percent fines of the reference samples LDW-SSCR20-010, LDW-SSCR23-010, and LDW-SSMSMP43-010 were 77.7%, 48.6%, and 6.9%, respectively. Each of the LDW sediment samples was matched with the reference sediment sample with the most similar percent fines, as shown in Table 3-6. The test samples were not matched to reference samples according to TOC content because of the very small range of TOC content in reference samples (0.478% to 0.632%) compared to the range in test samples (0.39 to 4.12%). The reference samples were also analyzed by ARI for SMS chemicals.

Table 3-6. LDW sediment samples matched with reference sediment samples based on percent fines

LDW Sample		Reference Sample	
Sample ID	**Percent Fines**	**Matched Sample ID**	**Percent Fines**
LDW-SS15-010	74.0	LDW-SSCR20-010	77.7
LDW-SS17-010	62.0	LDW-SSCR23-010	48.6
LDW-SS22-010	52.6	LDW-SSCR23-010	48.6
LDW-SS26-010	66.0	LDW-SSCR20-010	77.7
LDW-SS31-010	77.0	LDW-SSCR20-010	77.7
LDW-SS32-010	68.0	LDW-SSCR20-010	77.7
LDW-SS37-010	63.7	LDW-SSCR20-010	77.7
LDW-SS40-010	58.0	LDW-SSCR23-010	48.6
LDW-SS49-010	57.8	LDW-SSCR23-010	48.6
LDW-SS50-010	67.4	LDW-SSCR20-010	77.7
LDW-SS56-010	21.3	LDW-SSMSMP43-010[a]	6.9
LDW-SS57-010	69.0	LDW-SSCR20-010	77.7
LDW-SS58-010	66.2	LDW-SSCR20-010	77.7
LDW-SS60-010	14.8	LDW-SSMSMP43-010	6.9
LDW-SS63-010	20.5	LDW-SSMSMP43-010	6.9

LDW Sample		Reference Sample	
Sample ID	Percent Fines	Matched Sample ID	Percent Fines
LDW-SS70-010	39.4	LDW- SSCR23-010	48.6
LDW-SS75-010	27.6	LDW-SSMSMP43-010	6.9
LDW-SS88-010	52.8	LDW-SSCR23-010	48.6
LDW-SS89-010	16.5	LDW-SSMSMP43-010	6.9
LDW-SS92-010	25.0	LDW-SSMSMP43-010	6.9
LDW-SS112-010	38.1	LDW-SSCR23-010	48.6
LDW-SS114-010	45.0	LDW-SSCR23-010	48.6
LDW-SS115-010	12.0	LDW-SSMSMP43-010	6.9
LDW-SS119-010	48.0	LDW-SSCR23-010	48.6
LDW-SS120-010	54.0	LDW-SSCR23-010	48.6
LDW-SS121-010	25.2	LDW-SSMSMP43-010	6.9
LDW-SS143-010	44.4	LDW-SSCR23-010	48.6

[a] This reference sediment did not meet the performance criterion in Batch 1 of the polychaete test, so sample LDW-SS56-010 was compared to reference sample LDW-SSCR23-010 for the polychaete test, as discussed in Section 5.5.2.

All three reference sediment samples were included in the first two batches of toxicity tests. In the last batch, only the reference sediment sample that was the appropriate match for the test sediment sample was tested (LDW-SSMSMP43-010).

The results from the three sediment toxicity tests were evaluated using the SMS rules for marine toxicity tests (Ecology 2003). The performance standards and biological effects criteria (sediment quality standards [SQS] and cleanup screening levels [CSLs] of the SMS) are summarized in Table 3-7. The statistical analyses were conducted using the statistical package included in SedQual Release 5 (Ecology 2004).[5] Table 3-8 compares the results of the negative control and reference sediment toxicity tests to the SMS performance standards.

[5] Statistical analyses include Wilk-Shapiro test for normality and Levene's test for equality of variances, followed by the appropriate statistical test for significance (i.e., Student's t-test, approximate t-test, or Mann-Whitney)

Table 3-7. SMS performance standards and biological effects criteria for marine sediment toxicity tests

Toxicity Test	Negative Control	Reference Sediment	Biological Effects Criteria	
			SQS	CSL
Amphipod	less than 10% mortality	less than 25% mortality	mean mortality > 25% on an absolute basis, and statistically different from the reference sediment ($p \leq 0.05$)	mean mortality greater than the value in the reference sediment plus 30%, and statistically different from the reference sediment ($p \leq 0.05$)
Polychaete	less than 10% mortality; mean individual growth rate ≥ 0.72 mg/day (test failure if mean individual growth rate < 0.38 mg/day)	mean individual growth rate of at least 80% of that of the negative control	mean individual growth rate < 70% of that of the reference sediment and statistically different ($p \leq 0.05$)	mean individual growth rate < 50% of that of the reference sediment and statistically different ($p \leq 0.05$)
Bivalve larvae	> 70% normal survivorship	no criterion[a]	mean normal survivorship < 85% of that of the reference sediment and statistically different ($p \leq 0.10$)	mean normal survivorship <70% of that of the reference sediment and statistically different ($p \leq 0.10$)

[a] Ecology has guidance that states that reference sample normal development must be ≥ 65% of the normal development of the negative control

Table 3-8. Toxicity test results for the negative control and reference sediments compared to SMS performance standards

Toxicity Test	Negative Controls		Reference Sediments	
	Test Results	Performance Standards	Test Results	Performance Standards
Amphipod	mortality ranged from 1.0 ± 2.2 to 2.0 ± 2.7%	< 10% mortality	mortality ranged from 0.0 ± 0.0 to 7.0 ± 5.7% in three reference samples	< 25% mortality
Polychaete	mortality ranged from 0.0 ± 4.0 to 8.9 ± 0.0%; mean individual growth rate ranged from 0.87 ± 0.13 to 1.12 ± 0.10 mg/day	< 10% mortality; mean individual growth rate ≥ 0.72 mg/day	mean individual growth rate ranged from 77 to 102% of that of the negative control in the three reference samples[a]	mean individual growth rate of at least 80% of that of the negative control
Bivalve larvae	normal survivorship ranged from 85.4 ± 11.6 to 98.2 ± 2.1%	> 70% normal survivorship	not applicable	no criterion[b]

[a] One reference sediment sample had a mean individual growth rate of 77%, which did not meet the criterion of 80%; this result is discussed in Section 5.5.2

[b] Ecology has guidance for reference sediments of ≥ 65% of the normal development exhibited by the negative control; normal development in the reference sediments ranged from 100 to 105% of that of the negative control (see Appendix D-2)

3.3 LABORATORY DEVIATIONS FROM THE QAPP

This section discusses laboratory deviations from the QAPP for sediment chemical analyses and for sediment toxicity testing.

3.3.1 Surface sediment chemical analysis

The laboratory followed the methods and procedures described in the QAPP (Windward 2005c), with the following exceptions:

- Antimony, arsenic, and thallium were analyzed by EPA Method 200.8 rather than EPA Method 6020, as specified in the QAPP. Both methods are comparable, using ICP-MS. There is no effect on the overall quality of the data
- Although the QAPP stated that a standard reference material (SRM) sample would be analyzed for total sulfides, this analysis was not conducted because there is no SRM available for sulfides in sediment

3.3.2 Sediment toxicity testing

The laboratories followed the methods and procedures described in the QAPP, with the exceptions summarized below. The deviations were all assessed by Dinnel Marine Resources, the independent QA reviewer; the reviewer concluded that none of the deviations would affect data quality. Further discussion of deviations and data quality is provided in Section 5.5 and Appendix C-3.

Amphipod tests:

- Batch 1: beginning on day 5, several overlying water salinity measurements exceeded the protocol-specified 28.0 ± 1.0 ppt, with a maximum salinity of 30.5 ppt
- Batch 1: one dissolved oxygen measurement was inadvertently omitted on day 8 (LDW-SS26-010); the dissolved oxygen concentrations were 7.7 and 7.8 mg/L on days 7 and 9, respectively
- Batch 2: day 0 overlying water salinity was below the protocol-specified 28.0 ± 1.0 ppt for LDW-SS120-010, LDW-SS114-010, and LDW-SS121-010, with a minimum salinity of 26.0 ppt. All three sediments had low initial interstitial salinity, and the slightly lower overlying water salinity was attributed to the salinity adjustment procedure
- Batch 2: beginning on day 3, several overlying water salinity measurements exceeded the protocol-specified 28.0 ± 1.0 ppt with a maximum salinity of 31.5 ppt. ASTM standard guide for sediment testing with amphipods (ASTM 2004) states that *E. estuarius* has been reported in areas where porewater salinity ranges from 1 to 35 ppt, and also states that laboratory studies with *E. estuarius* have shown a salinity application range in control sediments from 0 to 34 ppt.
- Batch 2: test water was 3 days old instead of the protocol-specified ≤ 2 days

- Batch 3: beginning on day 7, several overlying water salinity measurements exceeded the protocol-specified 28.0 ± 1.0 ppt with a maximum salinity of 30.5 ppt

Polychaete tests:

- Batch 1: on day 3, the salinity measurement for LDW-SS15-010 exceeded the protocol-specified 28.0 ± 2.0 ppt with a maximum salinity of 30.5 ppt
- Batch 1: on day 13, no notation was made on the bench sheet that aeration was working correctly
- Batch 1: one reference sediment (LDW-SSMSMP43-010) did not meet the SMS reference sediment performance standard of mean growth rate ≥ 80% of the negative control growth rate.
- Batch 2: day 0 overlying water salinity was below the protocol-specified 28.0 ± 2.0 ppt for LDW-SS112-010, LDW-SS120-010, LDW-SS114-010, LDW-SS121-010, and LDW-SS143-010, with a minimum salinity of 25.0 ppt. All these sediments had low initial interstitial salinity, and the slightly lower overlying water salinity was attributed to the salinity adjustment procedure
- Batch 2: one dissolved oxygen measurement was inadvertently omitted on Day 0 (LDW-SSCR23-010)
- Batch 2: on day 3, overlying ammonia samples were collected after water renewal, instead of before, as specified in the protocol
- Batch 2: on day 6, the salinity measurement for LDW-SSMSMP43-010 was below the protocol-specified 28.0 ± 2.0 ppt, with a minimum salinity of 25.0 ppt
- Batch 2: on day 12, the salinity measurement for LDW-SS88-010 and LDW-SSMSMP43-010 exceeded the protocol-specified 28.0 ± 2.0 ppt, with a maximum salinity of 30.5 ppt
- Batch 2, on day 20, interstitial salinity and pH were not measured for LDW-SSMSMP43-010. Consequently, an un-ionized ammonia value could not be calculated
- Batch 3: on day 15, water quality measurements were taken after, instead of before, water renewal as specified in the protocol
- Batch 3: on day 18, the salinity measurements for LDW-SS63-010 and the negative control exceeded the protocol-specified 28.0 ± 2.0 ppt, with maximum salinities of 30.5 ppt and 31.0 ppt, respectively

Bivalve larvae tests:

- Batch 1: two test chambers (LDW-SS22-010 replicate 5 and LDW-SS32-010 replicate 5) were double inoculated and two test chambers (LDW-SS89-010 replicate 1 and LDW-SS37-010 replicate 1) were not inoculated at test initiation. These replicates were not included in the analyses of the data

- Batch 2: the stocking density at test initiation of 13.4 larvae/mL was below the recommended 20 to 40 larvae/mL
- Batch 2: the test temperature fell below 15°C on Days 1 and 2. Deviations were ≤0.6°C throughout the test

4.0 Selection of Sediment Samples for Toxicity Testing and Additional Analyses

Sediment samples for toxicity testing were selected by comparing preliminary, unvalidated surface sediment chemistry data with the SQS and CSL of the SMS, and with the screening levels (SLs) and maximum levels (MLs) of the Dredged Material Management Program (DMMP) for 14 chemicals without SQS/CSL values. This review had to be conducted using preliminary, unvalidated data to stay within the maximum holding times for toxicity testing. The unvalidated chemistry data were received from the laboratory on February 12, 2005 and a summary of these data was delivered to EPA and Ecology on February 22, 2005. The Lower Duwamish Waterway Group (LDWG) met with EPA and Ecology on March 1, 2005 to discuss these data, and 27 samples were selected for toxicity testing. Evaluation of the preliminary data also resulted in the identification of samples associated with reporting limits (RLs) for certain chemicals that exceeded SMS. Additional laboratory analyses were conducted to attempt to achieve lower RLs for those samples. The remainder of this section describes the process for selecting samples for toxicity testing or additional laboratory analyses, and presents the actions taken, if any, for each sample.

The process for deciding whether to conduct toxicity tests or additional analyses is depicted in Figure 4-1. Data from 81 locations[6] were evaluated for either toxicity testing or additional analyses. The preliminary, unvalidated chemical concentrations for the 81 samples were first compared to the SQS and CSL of the SMS and to the SLs and MLs of the DMMP. Thirty-one samples had detected chemical concentrations above the corresponding SQS or SL concentrations. Of these 31 samples, 26 were selected for toxicity testing; these sample location IDs are listed in Table 4-1. The remaining five samples were not tested for toxicity because they either were assumed to be toxic based on highly elevated chemical concentrations, or were located in early action areas. In addition to the 26 samples submitted for toxicity testing, Ecology

[6] Eighty-two locations were included in Round 1 (see Table 3-2). However, none of the data were available for LDW-SS20, and only SIM data were available for LDW-SS18 by March 1, 2005; only SIM data were evaluated for LDW-B9a. Thus, LDW-SS20 was not evaluated for potential toxicity testing, and only SIM results were evaluated for LDW-SS18 and LDW-SSB9a. The SIM analysis for LDW-SSB9a was conducted using an archived sample, so if toxicity testing had been deemed necessary for this location, additional sampling would have been conducted.

requested that one more sample (LDW-SS63) be tested because, although it did not have any detected chemical concentrations exceeding an SQS/SL, it was located near an uncharacterized potential source.[7] Thus, a total of 27 samples were selected for toxicity testing.

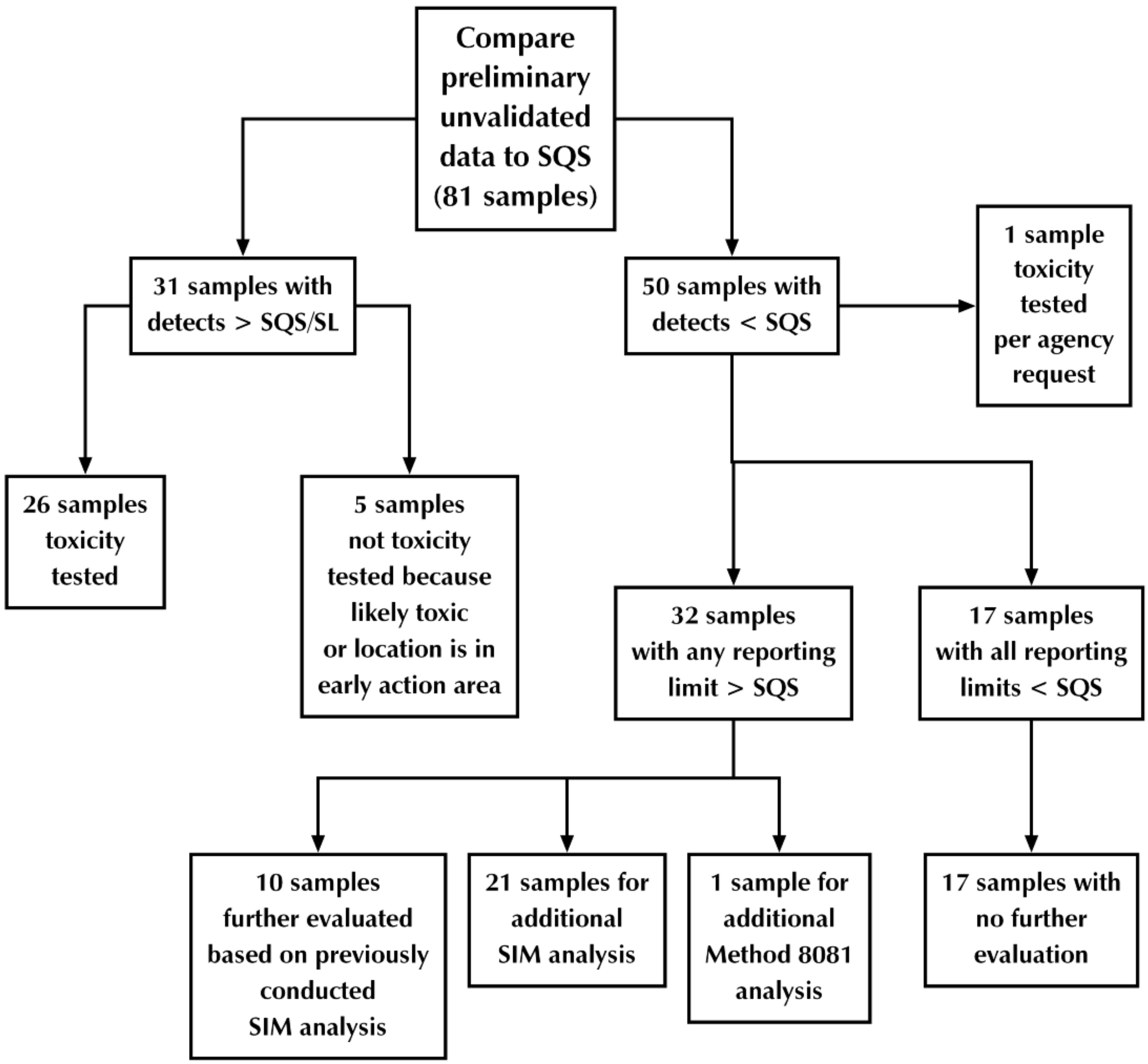

Figure 4-1. Flow chart for decisions regarding toxicity testing and additional chemical analyses

7 LDW-SS63 was located near an outfall where a non-aqueous phase liquid substance had been cited in an outfall survey conducted by the City of Seattle.

Table 4-1. Actions for each sample based on evaluation of preliminary data

Action	Location	Final Number of Values > SQS/SL and ≤ CSL/ML		Final Number of Values > CSL/ML	
		Detects	RLs [a]	Detects	RLs [a]
Toxicity testing (27)					
Testing of samples with detected concentrations > SQS/SL or CSL/ML (26)	LDW-SS15		2	1	
	LDW-SS17	1	3		7
	LDW-SS22	2	2		
	LDW-SS26	2	1		
	LDW-SS31		3	2	7
	LDW-SS32	2	1		
	LDW-SS37		2	2	
	LDW-SS40	1	2		
	LDW-SS49	1	3	2	7
	LDW-SS50	1	1		
	LDW-SS56	1	1	2	
	LDW-SS57	1	2		9
	LDW-SS58	1	3		7
	LDW-SS60	1	1		
	LDW-SS70	1	3		7
	LDW-SS75	1	2		
	LDW-SS88	1		1	
	LDW-SS89		1	1	
	LDW-SS92			1	
	LDW-SS112	3	3	1	7
	LDW-SS114	5	3	2	8
	LDW-SS115	5	3		8
	LDW-SS119	2	1		
	LDW-SS120	2	2		1
	LDW-SS121	2	1	1	10
	LDW-SS143		5	1	
Testing of sample with no detected concentrations > SQS/SL or CSL/ML, but tested based on agency request (1)	LDW-SS63				
Additional SIM analyses or laboratory evaluation (32)					
Laboratory evaluation of existing SIM RLs because they were > SQS/SL or CSL/ML (10)	LDW-SS4				
	LDW-SS10		2		
	LDW-SS14				
	LDW-SS23				
	LDW-SS27				
	LDW-SS38				
	LDW-SS43				
	LDW-SS97				
	LDW-SS102				
	LDW-SS117				

Action	Location	Final Number of Values > SQS/SL and ≤ CSL/ML		Final Number of Values > CSL/ML	
		Detects	RLs [a]	Detects	RLs [a]
Additional SIM analyses for samples that had RLs > SQS/SL or CSL/ML but no initial SIM analysis (21)	LDW-SS1				
	LDW-SS5				
	LDW-SS12				
	LDW-SS13				
	LDW-SS33				
	LDW-SS36				
	LDW-SS42		1[b]		
	LDW-SS44				
	LDW-SS51				
	LDW-SS52				
	LDW-SS54				
	LDW-SS55				
	LDW-SS67				
	LDW-SS76				
	LDW-SS87				
	LDW-SS94				
	LDW-SS96				
	LDW-SS101				
	LDW-SS116				
	LDW-SS118				
	LDW-SS128				
Additional Method 8081 analysis for one sample that had initial SIM analysis, but the hexachlorobenzene RL still exceeded the SQS/SL (1)	LDW-SS130				
No further action (22)					
No action on samples that had detected concentrations > SQS/SL or CSL/ML, because they were assumed to be toxic or were located in areas to be remediated (5)	LDW-SS48	6	2	5	
	LDW-SS84	1	9	4	8
	LDW-SS109		3	2	9
	LDW-SS110			2	
	LDW-SS111	3	3	4	9

Action	Location	Final Number of Values > SQS/SL and ≤ CSL/ML		Final Number of Values > CSL/ML	
		Detects	RLs [a]	Detects	RLs [a]
No action on samples that had no detected concentrations or RLs > SQS/SL or CSL/ML (17)	LDW-SS18				
	LDW-SS28				
	LDW-SS64				
	LDW-SS72				
	LDW-SS79				
	LDW-SS83				
	LDW-SS99				
	LDW-SS104				
	LDW-SS113b				
	LDW-SS123				
	LDW-SS125				
	LDW-SS126				
	LDW-SS127				
	LDW-SS129				
	LDW-SS134				
	LDW-SS142				
	LDW-B9a				

[a] Reporting limits (RLs) listed for non-detects

[b] Total DDT RL of 7.3 µg/kg dw slightly exceeded the SL of 6.9 µg/kg dw

All detected chemical concentrations from 50 samples were below the SQS/SL. Excluding the one additional sample (LDW-SS63-010) that was selected for toxicity testing as described above, the remaining 49 samples were evaluated to determine whether non-detected chemicals had RLs above the SQS/SL. Seventeen samples had no RLs exceeding the SQS/SL and required no further evaluation (Table 4-1). Thirty-two samples had at least one RL exceeding the SQS/SL. Ten of these 32 samples had previously been analyzed by SIM. For these 10 samples, the laboratory was able to estimate even lower RLs by re-evaluating the existing GC/MS chromatograms to determine with reasonable certainty that the compound was not present at the lower RL.[8] In one of the samples previously analyzed by SIM (LDW-SS117-010), benzoic acid and butyl benzyl phthalate were detected at concentrations exceeding their CSL and SQS values, respectively, using Method 8270. However, these compounds were not detected using Method 8270-SIM. Because of this discrepancy, the sample was reanalyzed in duplicate using both methods, and neither compound was detected at a concentration above the SQS using either method.

For 21 of the 32 samples with RLs above the SQS/SL, SIM analyses had not been conducted, so archived sediments for these samples were submitted to the laboratory for SIM analyses and, if necessary, additional RL evaluation. In addition, one sample (LDW-SS130-010) with an elevated hexachlorobenzene RL, even after SIM analysis,

[8] These lower RLs were identified with a UJ qualifier.

was submitted for analysis by Method 8081 to obtain an RL below its corresponding SQS (the reanalysis was performed on archived sediment from this location).

The additional SIM analyses and/or RL evaluations for the 32 samples that had RLs exceeding an SQS or SL produced final RLs for those samples that were lower than the SQS or SL, with one exception. This exception was the total DDT RL of 7.3 µg/kg dw in sample LDW-SS42-010, which was slightly higher than the SL of 6.9 µg/kg dw.

5.0 Results

This section presents results of chemical analyses and toxicity testing conducted on Round 1 surface sediment samples (Section 5.1), as well as the arsenic and grain size results for surface sediment samples collected from upstream Duwamish River locations (Section 5.2). Only the final RLs and analytical results (following any re-analyses described in Section 4.1) are presented in tables in this section. The results of the data validation, conducted by Laboratory Data Consultants (LDC), are discussed in Section 5.3 and are presented in full in Appendix C. Section 5.4 presents results of the toxicity tests conducted on 27 Round 1 surface sediment samples collected from the LDW. Results of the toxicity test data validation, conducted by Dinnel Marine Resources, are discussed in Section 5.5 and are presented in full in Appendix C.

Complete data tables and raw laboratory data are presented in Appendices A and D, respectively. A detailed discussion of the approach used to average laboratory replicates is presented in Appendix B. Methods for calculating concentrations for total PCBs, total polycyclic aromatic hydrocarbons (PAHs), total DDTs, and total chlordane are also presented in Appendix B. The number of significant figures shown for each concentration in all results tables in this section was specified by the analytical laboratory, as described in Appendix B. There was no additional manipulation of significant figures.

5.1 LDW Surface Sediment Chemistry Results

All surface sediment samples collected from the LDW were analyzed by ARI for metals, SVOCs (including PAHs), PCBs as Aroclors, grain size, TOC, and percent solids; a subset of these samples was also analyzed for butyltins, organochlorine pesticides, and SIM. The results of the analyses are discussed separately below by analyte group. A subset of samples was also analyzed for dioxins/furans and PCB congeners by Axys (see Section 3.0); those results will be presented in the Round 2 surface sediment data report. In this section, the field duplicate results are averaged with the original sample results for each of the four locations where field duplicates were collected. Results for each duplicate sample are presented in Appendix A.

Tables in this section include comparisons of sediment concentrations for 47 chemicals or groups of chemicals to the SQS and CSL of the SMS. Concentrations of 14 chemicals not included in the SMS are compared to the SL and ML of the DMMP. If the TOC of a sediment sample is less than 0.5%, the dry weight concentrations of those chemicals whose SQS/CSL are expressed on an organic carbon-normalized basis were compared instead to the lowest and second lowest apparent effects thresholds (AETs), which are analogous to the SQS and CSL, respectively. Appendix A contains detailed tables with results for each location compared to SMS, DMMP, or AET values.

5.1.1 Metals

Table 5-1 presents a summary of results for the 79 LDW surface sediment locations[9] that were analyzed for metals, including the number of detections, the range of detected concentrations, the mean of detected concentrations, and the range of RLs for chemicals reported as non-detects. Data tables containing metals results for each sample, including field duplicate samples, are presented in Appendix A. Figures 5-1a through 5-1c (located in the map folio) present arsenic results by location. Table 5-1 also presents SQS/SL and CSL/ML values for comparison purposes.

Table 5-1. Summary of metal results in Round 1 LDW surface sediment samples

Analyte	Unit	Detection Frequency	Detected Concentration			Reporting Limit[a]		SQS/ SL	CSL/ ML
			Minimum	Maximum	Mean[b]	Minimum	Maximum		
Antimony	mg/kg dw	7/79	0.4 J	6.8 J	2	0.2	0.6	150	200
Arsenic	mg/kg dw	79/79	2.4	1,100	49	na	na	57	93
Cadmium	mg/kg dw	43/79	0.3	3.6	1	0.2	0.8	5.1	6.7
Chromium	mg/kg dw	79/79	11.2	455	45	na	na	260	270
Cobalt	mg/kg dw	79/79	4.4	50	9.7	na	na	nv	nv
Copper	mg/kg dw	79/79	16.9	1,420	110	na	na	390	390
Lead	mg/kg dw	79/79	4	870	100	na	na	450	530
Mercury	mg/kg dw	67/79	0.05	2.46	0.3	0.05	0.1	0.41	0.59
Molybdenum	mg/kg dw	79/79	0.7	75	4	na	na	nv	nv
Nickel	mg/kg dw	79/79	8	387	30	na	na	140	370
Selenium	mg/kg dw	0/79	nd	nd	nd	6	40	nv	nv
Silver	mg/kg dw	32/79	0.5	3.9	1	0.4	2	6.1	6.1
Thallium	mg/kg dw	1/79	0.4	0.4	0.4	0.2	0.6	nv	nv
Vanadium	mg/kg dw	79/79	37.1	89.6	64	na	na	nv	nv
Zinc	mg/kg dw	79/79	38.0	2,830	240	na	na	410	960

[a] RL range for nondetect samples

[b] Reported mean concentration is the average of the detected concentrations only; RLs were not included in calculation of the mean concentration

na – not applicable

nd – not detected

nv – no value available

[9] Metals were also analyzed in the two split samples collected by King County (LDW-SS18-010 and LDW-SS20-010); the results will be provided separately.

Nine metals (arsenic, chromium, cobalt, copper, lead, molybdenum, nickel, vanadium, and zinc) were detected in all of these surface sediment samples. Selenium was not detected in any of these sediment samples. The sample collected at location LDW-SS48 contained the highest concentrations of copper (1,420 mg/kg dw), zinc (2,830 mg/kg dw), antimony (6.8 mg/kg dw), and molybdenum (75 mg/kg dw). The sample collected at location LDW-SS111 contained the highest concentrations of chromium (455 mg/kg dw) and nickel (387 mg/kg dw). The highest concentration of arsenic (1,100 mg/kg dw) was detected at location LDW-SS114.

Table 5-2 presents the number of samples with detected concentrations or RLs (for non-detected results) above the SQS/SL or CSL/ML for the 10 metals with SMS or DMMP values. Table A-1 in Appendix A presents the results for each sample, including field duplicate samples, and indicates which detected concentrations or RLs exceed the SQS/SL or CSL/ML. Of the 10 metals with SMS or DMMP values, three had detected concentrations that never exceeded the SQS/SL, and seven had one or more detected concentrations that exceeded the CSL/ML.

Table 5-2. Number of samples in each SQS/SL or CSL/ML category for detected concentrations and reporting limits for metals

Metal	Detected Concentrations			Reporting Limits when Undetected		
	≤ SQS/SL	> SQS/SL ≤CSL/ML	> CSL/ML	≤ SQS/SL	> SQS/SL ≤CSL/ML	> CSL/ML
Antimony	7			72		
Arsenic	73		6			
Cadmium	43			36		
Chromium	78		1			
Copper	77		2			
Lead	74		5			
Mercury	62		5	12		
Nickel	77	1	1			
Silver	32			47		
Zinc	71	5	3			

5.1.2 Butyltins

Table 5-3 presents a summary of results for the 18 LDW surface sediment samples analyzed for butyltins. Data tables containing butyltin results for each sample, including field duplicate samples, are presented in Appendix A. Figures 5-2a through 5-2c (located in the map folio) present the tributyltin results by location. Tributyltin was detected in 14 of the 18 samples analyzed. Dibutyltin and monobutyltin were detected less frequently in 11 and 2 samples, respectively. The highest tributyltin, dibutyltin, and monobutyltin concentrations were detected in the sample collected at LDW-SS49.

Table 5-3. Summary of butyltin results in Round 1 LDW surface sediment samples

Analyte	Unit	Detection Frequency	Detected Concentration			Reporting Limit[a]	
			Minimum	Maximum	Mean[b]	Minimum	Maximum
Monobutyltin as ion	µg/kg dw	2/2[c]	4.8 J	8.0 J	6.4	na	na
Dibutyltin as ion	µg/kg dw	11/18	3.9 J	59	17	5.5	5.8
Tributyltin as ion	µg/kg dw	14/18	7.5	140	46	3.7	3.9

a RL range for nondetect samples

b Reported mean concentration is the average of the detected concentrations only; RLs were not included in calculation of the mean concentration

c Rejected values are not included in sample totals

5.1.3 SVOCs

Table 5-4 presents a summary of results for the 79 LDW surface sediment samples[10] that were analyzed for SVOCs. This table summarizes results from either Method 8270 or Method 8270-SIM according to rules presented in Appendix B for selecting a value when multiple results are reported for a single analyte in a single sample. Table 5-4 also includes one King County split sample (LDW-SS18-010) and one surface sediment sample from the benthic invertebrate sampling event (LDW-B9a-S) that were analyzed for a subset of SVOCs using SIM. Data tables containing SVOC results for each sample, including the four field duplicates, are presented in Appendix A.

All individual PAH compounds were detected in at least one sample, with the exception of 2-chloronaphthalene, which was never detected. The 11 PAHs most frequently detected (each detected in at least 45 samples) were anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, fluoranthene, indeno(1,2,3-cd)pyrene, phenanthrene, and pyrene. The remaining eight PAHs were each detected in 14 or fewer samples. Detected concentrations of total LPAHs ranged from 21 to 5,200 µg/kg dw, with the highest concentration detected in the sample collected at LDW-SS111. Detected concentrations of total HPAHs ranged from 42 to 19,000 µg/kg dw, with the highest concentration detected in the sample collected at LDW-SS115.

Table 5-4. Summary of SVOC results in Round 1 LDW surface sediment samples

Analyte	Unit	Detection Frequency	Detected Concentration			Reporting Limit[a]	
			Minimum	Maximum	Mean[b]	Minimum	Maximum
PAHs							
2-Chloronaphthalene	µg/kg dw	0/79	nd	nd	nd	19	290
2-Methylnaphthalene	µg/kg dw	4/79	21	260	99	19	290

[10] SVOCs were also analyzed in the two split samples collected by King County (LDW-SS18-010 and LDW-SS20-010); the results will be provided separately.

Analyte	Unit	Detection Frequency	Detected Concentration			Reporting Limit[a]	
			Minimum	Maximum	Mean[b]	Minimum	Maximum
Acenaphthene	µg/kg dw	12/79	21	330	120	19	290
Acenaphthylene	µg/kg dw	3/79	54	88 J	73	19	290
Anthracene	µg/kg dw	45/79	21	650	110	19	290
Benzo(a)anthracene	µg/kg dw	79/81	7.8	1,500	230	19	200
Benzo(a)pyrene	µg/kg dw	80/81	6.5	1,700	250	19	19
Benzo(b)fluoranthene	µg/kg dw	80/81	9.1	1,900	310	19	19
Benzo(g,h,i)perylene	µg/kg dw	49/79	16 J	490	120	19	200
Benzo(k)fluoranthene	µg/kg dw	70/79	23 J	1,700	290	19	200
Total benzofluoranthenes (calc'd)	µg/kg dw	78/79	20	3,600	580	nc	nc
Chrysene	µg/kg dw	78/79	23	2,500	410	19	19
Dibenzo(a,h)anthracene	µg/kg dw	7/79	22	240	110	19	290
Dibenzofuran	µg/kg dw	3/79	100	140	120	19	290
Fluoranthene	µg/kg dw	78/79	33	5,200	660	19	19
Fluorene	µg/kg dw	14/79	21	640	130	19	290
Indeno(1,2,3-cd)pyrene	µg/kg dw	74/81	6.4	600	100	6.5	200
Naphthalene	µg/kg dw	4/79	34	360	160	19	290
Phenanthrene	µg/kg dw	76/79	22	3,200	310	19	200
Pyrene	µg/kg dw	78/79	28	3,400	550	19	19
Total HPAH (calc'd)	µg/kg dw	78/79	160	19,000	2,900	nc	nc
Total LPAH (calc'd)	µg/kg dw	76/79	22	5,200	430	nc	nc
Total PAH (calc'd)	µg/kg dw	78/79	160	22,200 J	3,000	nc	nc
Phthalates							
Bis(2-ethylhexyl)phthalate	µg/kg dw	65/79	20	4,200	320	19	200
Butyl benzyl phthalate	µg/kg dw	25/81	7.0	350	77	6.4	290
Diethyl phthalate	µg/kg dw	9/81	6.6	110	42	6.3	290
Dimethyl phthalate	µg/kg dw	8/81	7.3	120	31	6.4	290
Di-n-butyl phthalate	µg/kg dw	5/79	83 J	380	200	19	200
Di-n-octyl phthalate	µg/kg dw	2/79	36 J	1,000	520	19	290
Other SVOCs							
1,2,4-Trichlorobenzene	µg/kg dw	0/81	nd	nd	nd	3.3	290
1,2-Dichlorobenzene	µg/kg dw	0/81	nd	nd	nd	6.3	290
1,3-Dichlorobenzene	µg/kg dw	0/79	nd	nd	nd	19	290
1,4-Dichlorobenzene	µg/kg dw	0/81	nd	nd	nd	6.3	290
2,4,5-Trichlorophenol	µg/kg dw	0/79	nd	nd	nd	96	1,400
2,4,6-Trichlorophenol	µg/kg dw	0/79	nd	nd	nd	96	1,400
2,4-Dichlorophenol	µg/kg dw	0/79	nd	nd	nd	96	1,400
2,4-Dimethylphenol	µg/kg dw	0/81	nd	nd	nd	6.3	290
2,4-Dinitrophenol	µg/kg dw	0/79	nd	nd	nd	190	2,900
2,4-Dinitrotoluene	µg/kg dw	0/79	nd	nd	nd	96	1,400
2,6-Dinitrotoluene	µg/kg dw	0/79	nd	nd	nd	96	1,400

Analyte	Unit	Detection Frequency	Detected Concentration			Reporting Limit[a]	
			Minimum	Maximum	Mean[b]	Minimum	Maximum
2-Chlorophenol	µg/kg dw	0/79	nd	nd	nd	19	290
2-Methylphenol	µg/kg dw	1/81	21	21	21	6.3	290
2-Nitroaniline	µg/kg dw	0/79	nd	nd	nd	96	1,400
2-Nitrophenol	µg/kg dw	0/79	nd	nd	nd	96	1,400
3,3'-Dichlorobenzidine	µg/kg dw	0/79	nd	nd	nd	96	1,400
3-Nitroaniline	µg/kg dw	0/79	nd	nd	nd	96	1,400
4,6-Dinitro-o-cresol	µg/kg dw	0/79	nd	nd	nd	190	2,900
4-Bromophenyl phenyl ether	µg/kg dw	1/79	31	31	31	19	290
4-Chloro-3-methylphenol	µg/kg dw	0/79	nd	nd	nd	96	1,400
4-Chloroaniline	µg/kg dw	0/79	nd	nd	nd	96	1,400
4-Chlorophenyl phenyl ether	µg/kg dw	0/79	nd	nd	nd	19	290
4-Methylphenol[c]	µg/kg dw	3/79	23 J	88	45	19	290
4-Nitroaniline	µg/kg dw	0/79	nd	nd	nd	96	1,400
4-Nitrophenol	µg/kg dw	0/79	nd	nd	nd	96	1,400
Aniline	µg/kg dw	0/79	nd	nd	nd	19	290
Benzoic acid	µg/kg dw	10/81	54 J	250	120	63	2,900
Benzyl alcohol	µg/kg dw	0/81	nd	nd	nd	19	290
bis(2-chloroethoxy)methane	µg/kg dw	0/79	nd	nd	nd	19	290
bis(2-chloroethyl)ether	µg/kg dw	0/79	nd	nd	nd	19	290
bis(2-chloroisopropyl)ether	µg/kg dw	0/79	nd	nd	nd	19	290
Carbazole	µg/kg dw	19/79	21	350	130	19	290
Hexachlorobenzene	µg/kg dw	1/81	1.4 J	1.4 J	1.4 J	0.96	200
Hexachlorobutadiene	µg/kg dw	0/81	nd	nd	nd	0.96	200
Hexachlorocyclopentadiene	µg/kg dw	0/79	nd	nd	nd	96	1,400
Hexachloroethane	µg/kg dw	0/79	nd	nd	nd	19	290
Isophorone	µg/kg dw	1/79	26	26	26	19	290
Nitrobenzene	µg/kg dw	0/79	nd	nd	nd	19	290
N-Nitrosodimethylamine	µg/kg dw	0/81	nd	nd	nd	32	1,000
N-Nitroso-di-n-propylamine	µg/kg dw	0/81	nd	nd	nd	20	1,400
N-Nitrosodiphenylamine	µg/kg dw	4/81	6.5	7.2	6.7	6.3	290
Pentachlorophenol	µg/kg dw	0/81	nd	nd	nd	32	1,400
Phenol	µg/kg dw	8/79	22	370	130	19	290

a RL range for nondetect samples

b Reported mean concentration is the average of the detected concentrations only; RLs were not included in calculation of the mean concentration

c 4-methylphenol co-elutes with 3-methylphenol

nc – not calculated

nd – not detected

All six phthalates were detected in at least one sample. Bis(2-ethylhexyl)phthalate (BEHP), the most frequently detected phthalate compound, was detected in 65 of the

79 samples, with a maximum concentration of 4,200 µg/kg detected in the sample collected at location LDW-SS84.

Eight other SVOCs were detected in the surface sediment samples infrequently: 2-methylphenol (1/81), 4-bromophenyl phenyl ether (1/79), 4-methylphenol (3/79), benzoic acid (10/81), carbazole (19/79), hexachlorobenzene (1/81), isophorone (1/79), N-nitrosodiphenylamine (4/81), and phenol (8/79). The remaining 35 SVOCs were not detected in any sample.

Table 5-5 presents a summary of SVOC results expressed in appropriate units for comparison to SQS/SL and CSL/ML (i.e., organic-carbon normalized for most of the SVOCs and dry weight for the remainder) for those samples with TOC contents more than 0.5%. Tables A-5-1 through A-5-7 in Appendix A present the SVOC results for each sample, including field duplicate samples, and indicate which concentrations exceeded the SQS/SL or CSL/ML. Two samples (LDW-SS18-010 and LDW-SS134-010) had TOC contents of less than 0.5%,[11] so they were not compared to SQS or CSL values that are organic-carbon normalized. Instead, the dry weight concentrations of the chemicals for those samples were compared to the lowest AET and second-lowest AET values, as presented in Table A-5-8 of Appendix A.

Table 5-5. Summary of SVOC results in Round 1 LDW surface sediment samples in comparison to SQS/SL and CSL/ML

Analyte	Unit	Detection Frequency	Detected Concentration			Reporting Limit[a]		SQS/SL	CSL/ML
			Minimum	Maximum	Mean[b]	Minimum	Maximum		
PAHs									
2-Methylnaphthalene	mg/kg OC	4/78	1.7	11	5.2	0.60	17	38	64
Acenaphthene	mg/kg OC	12/78	0.72	17	6.6	0.70	17	16	57
Acenaphthylene	mg/kg OC	3/78	4.0	6.8 J	5.1	0.60	17	66	66
Anthracene	mg/kg OC	45/78	0.86	39	5.8	0.91	17	220	1,200
Benzo(a)anthracene	mg/kg OC	78/79	0.54	88	13	11	11	110	270
Benzo(a)pyrene	mg/kg OC	79/79	0.45	89	13	na	na	99	210
Benzo(g,h,i)perylene	mg/kg OC	49/78	0.96 J	30	6.3	0.91	17	31	78
Benzofluoranthenes (total-calc'd)	mg/kg OC	78/78	2.6 J	190	31	nc	nc	230	450
Chrysene	mg/kg OC	78/78	1.6 J	140	22	na	na	110	460
Dibenzo(a,h)anthracene	mg/kg OC	7/78	0.84	13	5.8	0.70	17	12	33
Dibenzofuran	mg/kg OC	3/78	6.9	9.2	7.8	0.60	17	15	58
Fluoranthene	mg/kg OC	78/78	3.3	270	36	na	na	160	1,200
Fluorene	mg/kg OC	14/78	0.93	28	7.1	0.70	17	23	79
Indeno(1,2,3-cd)pyrene	mg/kg OC	73/79	0.46	37	5.6	0.45	11	34	88
Naphthalene	mg/kg OC	4/78	4.6	16	9.4	0.60	17	99	170

[11] LDW-SS18-010 was analyzed for TOC by King County. The TOC content in this sample was 0.122%. The full King County results will be provided separately.

Analyte	Unit	Detection frequency	Detected concentration			Reporting limit[a]		SQS/SL	CSL/ML
			Minimum	Maximum	Mean[b]	Minimum	Maximum		
Phenanthrene	mg/kg OC	76/78	1.3	140	17	3.1	11	100	480
Pyrene	mg/kg OC	78/78	2.3	170	30	na	na	1,000	1,400
Total HPAH (calc'd)	mg/kg OC	78/78	14 J	990	150	nc	nc	960	5,300
Total LPAH (calc'd)	mg/kg OC	76/78	1.3	220	23	nc	nc	370	780
Phthalates									
Bis(2-ethylhexyl)phthalate	mg/kg OC	65/78	1.5	100	16	1.5	17	47	78
Butyl benzyl phthalate	mg/kg OC	25/79	0.31	19	4.3	0.25	10	4.9	64
Diethyl phthalate	mg/kg OC	9/79	0.33	7.3	2.5	0.26	11	61	110
Dimethyl phthalate	mg/kg OC	8/79	0.36	15	2.8	0.25	11	53	53
Di-n-butyl phthalate	mg/kg OC	5/78	5.4 J	12	7.9	0.60	17	220	1,700
Di-n-octyl phthalate	mg/kg OC	2/78	3.3 J	33	18	0.60	17	58	4,500
Other SVOCs									
1,2,4-Trichlorobenzene	mg/kg OC	0/79	nd	nd	nd	0.22	11	0.81	1.8
1,2-Dichlorobenzene	mg/kg OC	0/79	nd	nd	nd	0.22	11	2.3	2.3
1,3-Dichlorobenzene	µg/kg dw	0/78	nd	nd	nd	19	290	170	nv
1,4-Dichlorobenzene	mg/kg OC	0/79	nd	nd	nd	0.22	11	3.1	9
2,4-Dimethylphenol	µg/kg dw	0/79	nd	nd	nd	6.3	290	29	29
2-Methylphenol	µg/kg dw	1/79	21	21	21	6.3	290	63	63
4-Methylphenol	µg/kg dw	3/78	23 J	88	45	19	290	670	670
Benzoic acid	µg/kg dw	10/79	54 J	250	120	63	2,900	650	650
Benzyl alcohol	µg/kg dw	0/79	nd	nd	nd	19	290	57	73
Hexachlorobenzene	mg/kg OC	1/79	0.065 J	0.065 J	0.065 J	0.028	11	0.38	2.3
Hexachlorobutadiene	mg/kg OC	0/79	nd	nd	nd	0.028	11	3.9	6.2
Hexachloroethane	µg/kg dw	0/78	nd	nd	nd	19	290	1,400	14,000
N-Nitrosodiphenylamine	mg/kg OC	4/79	0.32	0.37	0.34	0.22	11	11	11
Pentachlorophenol	µg/kg dw	0/79	nd	nd	nd	32	1,400	360	690
Phenol	µg/kg dw	8/78	22	370	130	19	290	420	1,200

[a] RL range for nondetect samples

[b] Reported mean concentration is the average of the detected concentrations only; RLs were not included in calculation of the mean concentration

na – not applicable

nc – not calculated

nd – not detected

nv – no value

Table 5-6 presents the numbers of samples with detected concentrations (including J-qualified results) or final RLs (for non-detected results) above the SQS/SL or CSL/ML for the 40 SVOCs with SMS or DMMP values. Of the 40 SVOCs with SMS or DMMP values, 29 never had detected concentrations exceeding the SQS/SL, nine had detected concentrations exceeding the SQS/SL only, and two had detected concentrations exceeding the CSL/ML.

Table 5-6. Numbers of samples in each SQS/SL or CSL/ML category for detected concentrations and reporting limits for SVOCs

SVOC	Detected Concentrations			Reporting Limits when Undetected [a]		
	≤ SQS/SL	> SQS/SL ≤CSL/ML	> CSL/ML	≤ SQS/SL	> SQS/SL ≤CSL/ML	> CSL/ML
PAHs						
2-Methylnaphthalene	4			75		
Acenaphthene	11	1		66	1	
Acenaphthylene	3			76		
Anthracene	45			34		
Benzo(a)anthracene	79			2		
Benzo(a)pyrene	80			1		
Benzo(g,h,i)perylene	49			30		
Total benzofluoranthenes (calc'd)	78			1		
Chrysene	75	3		1		
Dibenzo(a,h)anthracene	6	1		71	1	
Dibenzofuran	3			75	1	
Fluoranthene	74	4		1		
Fluorene	13	1		65		
Indeno(1,2,3-cd)pyrene	72	1		7		
Naphthalene	4			75		
Phenanthrene	72	4		3		
Pyrene	78			1		
Total HPAH (calc'd)	77	1		1		
Total LPAH (calc'd)	76			3		
Phthalates						
Bis(2-ethylhexyl) phthalate	59	4	2	14		
Butyl benzyl phthalate	19	6		48	8	
Diethyl phthalate	9			72		
Dimethyl phthalate	8			73		
Di-n-butyl phthalate	5			74		
Di-n-octyl phthalate	2			77		
Other SVOCs						
1,2,4-Trichlorobenzene				58	10	13
1,2-Dichlorobenzene				68		13
1,3-Dichlorobenzene				73	6	
1,4-Dichlorobenzene				68	11	2
2,4-Dimethylphenol				68		13
2-Methylphenol	1			67		13
4-Methylphenol	3			76		
Benzoic acid	10			58		13
Benzyl alcohol				67		14

SVOC	Detected Concentrations			Reporting Limits when Undetected [a]		
	≤ SQS/SL	> SQS/SL ≤CSL/ML	> CSL/ML	≤ SQS/SL	> SQS/SL ≤CSL/ML	> CSL/ML
Hexachlorobenzene	1			55	16	9
Hexachlorobutadiene				72	4	5
Hexachloroethane				79		
N-Nitrosodiphenylamine	4			77		
Pentachlorophenol				68	5	8
Phenol	8			71		

[a] All samples with RLs > SQS are either being tested for toxicity or will be evaluated in the Phase 2 ERA based on chemical concentrations

Seven individual PAHs had a total of 15 detected concentrations that exceeded their respective SQS. The concentration of total HPAHs exceeded the SQS in one sample (LDW-SS115-010). In addition, three individual PAHs were not detected but had RLs exceeding their respective SQSs in the sample collected at location LDW-SS143. That sample was tested for toxicity.

BEHP and butyl benzyl phthalate had a total of 11 detected concentrations that exceeded their SQS but not their CSL. Detected concentrations of BEHP exceeded the CSL in the samples collected at locations LDW-SS84 and LDW-SS114. Butyl benzyl phthalate was not detected but had RLs exceeding the SQS in the samples collected at eight locations. Those samples were either tested for toxicity or will be evaluated in the Phase 2 ERA based on chemical concentrations.

Only one other SVOC, benzoic acid, was detected at a concentration exceeding its SQS/SL or CSL/ML. The concentration of benzoic acid exceeded the CSL in the sample collected at one location (LDW-SS117). Eleven other SVOCs were not detected but had RLs exceeding their SQS/SL or CSL/ML values; these samples were either tested for toxicity or will be evaluated in the Phase 2 ERA based on chemical concentrations.

5.1.4 PCB Aroclors

Table 5-7 presents a summary of results for the 79 LDW surface sediment samples[12] that were analyzed for PCB Aroclors. Results are presented for both individual Aroclors and total PCBs. Data tables containing results for each sample, including field duplicates, for PCB Aroclors and total PCBs are presented in Appendix A. Table 5-8 presents a summary of organic carbon-normalized results and the total PCB SQS/CSL for the 78 samples with TOC contents > 0.5%. Figures 5-3a through 5-3c (located in the map folio) present the total PCB results by location.

[12] PCB Aroclors were also analyzed in the two split samples collected by King County (LDW-SS18-010 and LDW-SS20-010); the results will be provided separately.

Table 5-7. Summary of PCB results in Round 1 LDW surface sediment samples

Analyte	Unit	Detection Frequency	Detected Concentration			Reporting Limit[a]	
			Minimum	Maximum	Mean[b]	Minimum	Maximum
Aroclor-1016	µg/kg dw	0/79	nd	nd	nd	16	1,100
Aroclor-1221	µg/kg dw	0/79	nd	nd	nd	16	1,100
Aroclor-1232	µg/kg dw	0/79	nd	nd	nd	16	1,100
Aroclor-1242	µg/kg dw	12/79	21 J	2,700	280	19	2,100
Aroclor-1248	µg/kg dw	24/79	20 J	12,000	560	16	4,300
Aroclor-1254	µg/kg dw	70/79	18 J	110,000	2,000	19	20
Aroclor-1260	µg/kg dw	57/79	27	4,300	290	19	8,100
Total PCBs (calc'd)	µg/kg dw	71/79	18 J	110,000	2,400	nc	nc

[a] RL range for nondetect samples

[b] Reported mean concentration is the average of the detected concentrations only; RLs were not included in calculation of the mean concentration.

nc – not calculated

Table 5-8. Summary of PCB results in Round 1 LDW surface sediment samples in comparison to SQS/SL and CSL/ML

Analyte	Unit	Detection Frequency	Detected concentration			Reporting limit[A]		SQS	CSL
			Minimum	Maximum	Mean[b]	Minimum	Maximum		
Total PCBs (calc'd)	mg/kg OC	71/78	0.91	3,700	94	nc	nc	12	65

[a] RL range for nondetect samples

[b] Reported mean concentration is the average of the detected concentrations only; RLs were not included in calculation of the mean concentration.

nc – not calculated

Four of the seven different Aroclors were detected in at least one sediment sample. The most frequently detected Aroclors were 1254 (in 70 of 79 samples) and 1260 (in 57 of 79 samples). The maximum total PCB concentration (110,000 µg/kg dw) was detected in the sample collected at location LDW-SS109. None of the Aroclors were detected at eight locations (see Figures 5-3a through 5-3c).

Table 5-9 presents the numbers of samples with detected PCB concentrations or RLs (for non-detected results) above the SQS or CSL. Table A-1 in Appendix A presents the results for each sample, including field duplicate samples, and indicates which detected concentrations or RLs exceed the SQS or CSL. Total PCBs exceeded the SQS in 14 samples and exceeded the CSL in nine samples. RLs for non-detected total PCBs were all less than the SQS.

Table 5-9. Numbers of samples in each SQS or CSL category for detected concentrations and reporting limits for PCBs

Analyte	Detected Concentrations			Reporting Limits		
	≤ SQS	> SQS ≤CSL	> CSL	≤ SQS	> SQS ≤CSL	> CSL
Total PCBs	48	14	9	8[a]		

[a] The RL for total PCBs was given a value equal to the highest RL of the seven Aroclors for a given sample

5.1.5 Organochlorine pesticides

Table 5-10 presents a summary of results for the 33 LDW surface sediment samples[13] that were analyzed for organochlorine pesticides. Data tables containing results for each sample, including field duplicates, for pesticides are presented in Appendix A. Table 5-10 also presents SL and ML values for comparison purposes. No organochlorine pesticides were detected in surface sediment samples.

Table 5-10. Summary of organochlorine pesticide results in Round 1 LDW surface sediment samples

Analyte	Unit	Detection Frequency	Detected Concentration			Reporting Limit [a]		SL	ML
			Minimum	Maximum	Mean[b]	Minimum	Maximum		
2,4'-DDD	µg/kg dw	0/33	nd	nd	nd	1.9	34	nv	nv
2,4'-DDE	µg/kg dw	0/33	nd	nd	nd	1.9	34	nv	nv
2,4'-DDT	µg/kg dw	0/33	nd	nd	nd	1.9	460	nv	nv
4,4'-DDD	µg/kg dw	0/33	nd	nd	nd	1.9	540	nv	nv
4,4'-DDE	µg/kg dw	0/33	nd	nd	nd	1.9	800	nv	nv
4,4'-DDT	µg/kg dw	0/33	nd	nd	nd	1.9	34	nv	nv
Total DDTs (calc'd)	µg/kg dw	0/33	nd	nd	nd	nc	nc	6.9	69
Aldrin	µg/kg dw	0/33	nd	nd	nd	0.96	17	10	nv
Dieldrin	µg/kg dw	0/33	nd	nd	nd	1.9	34	10	nv
alpha-BHC	µg/kg dw	0/33	nd	nd	nd	0.96	17	nv	nv
beta-BHC	µg/kg dw	0/33	nd	nd	nd	0.96	17	nv	nv
delta-BHC	µg/kg dw	0/33	nd	nd	nd	0.96	17	nv	nv
gamma-BHC (Lindane)	µg/kg dw	0/33	nd	nd	nd	0.96	17	10	nv
alpha-Chlordane	µg/kg dw	0/33	nd	nd	nd	0.96	17	nv	nv
gamma-Chlordane	µg/kg dw	0/33	nd	nd	nd	0.96	17	nv	nv
Total chlordane (calc'd)	µg/kg dw	0/33	nd	nd	nd	nc	nc	10	nv
alpha-Endosulfan	µg/kg dw	0/33	nd	nd	nd	0.96	17	nv	nv
beta-Endosulfan	µg/kg dw	0/33	nd	nd	nd	1.9	34	nv	nv
Endosulfan sulfate	µg/kg dw	0/33	nd	nd	nd	1.9	34	nv	nv
Endrin	µg/kg dw	0/33	nd	nd	nd	1.9	34	nv	nv

[13] Organochlorine pesticides were also analyzed in the two split samples collected by King County (LDW-SS18-010 and LDW-SS20-010); the results will be provided separately.

ANALYTE	UNIT	DETECTION FREQUENCY	DETECTED CONCENTRATION			REPORTING LIMIT [a]		SL	ML
			MINIMUM	MAXIMUM	MEAN[b]	MINIMUM	MAXIMUM		
Endrin aldehyde	µg/kg dw	0/33	nd	nd	nd	1.9	250	nv	nv
Endrin ketone	µg/kg dw	0/33	nd	nd	nd	1.9	34	nv	nv
Heptachlor	µg/kg dw	0/33	nd	nd	nd	0.96	70	10	nv
Heptachlor epoxide	µg/kg dw	0/33	nd	nd	nd	0.96	510	nv	nv
Methoxychlor	µg/kg dw	0/33	nd	nd	nd	9.6	170	nv	nv
Mirex	µg/kg dw	0/33	nd	nd	nd	1.9	34	nv	nv
Cis-Nonachlor	µg/kg dw	0/33	nd	nd	nd	1.9	330	nv	nv
Oxychlordane	µg/kg dw	0/33	nd	nd	nd	1.9	34	nv	nv
Toxaphene	µg/kg dw	0/33	nd	nd	nd	96	1,700	nv	nv
Trans-Nonachlor	µg/kg dw	0/33	nd	nd	nd	1.9	34	nv	nv

a RL range for nondetect samples

b Reported mean concentration is the average of the detected concentrations only; RLs were not included in calculation of the mean concentration

nc – not calculated

nd – not detected

nv – no value available

There are no SMS values for pesticides; results were compared instead to the SL or ML values available for six pesticides. Table 5-11 presents the number of samples with detected pesticide concentrations or RLs (for non-detected results) above the SL or ML. Table A-1 in Appendix A presents the results for each sample, including field duplicate samples, and indicates that no detected concentrations exceeded the SL or ML. RLs for pesticides exceeded the SL, but not the ML, at four locations, and exceeded the ML at one location. Samples from all of these locations were either tested for toxicity or will be evaluated in the Phase 2 ERA based on chemical concentrations.[14]

Table 5-11. Numbers of samples in each SL or /ML category for detected concentrations and reporting limits for organochlorine pesticides

ANALYTE	DETECTED CONCENTRATIONS			REPORTING LIMITS		
	≤ SL	> SL ≤ ML	> ML	≤ SL	> SL ≤ ML	>ML
Total DDTs (calc'd)				28[a]	4[a]	1
Aldrin				32	1	
Dieldrin				32	1	
gamma-BHC (Lindane)				32	1	
Total chlordane (calc'd)				31[b]	2[b]	
Heptachlor				32	1	

[14] Toxicity literature for DDT and the other pesticides listed in Table 5-9 will be reviewed in the Phase 2 ERA to evaluate any RLs exceeding DMMP guidelines

a The RL for total DDTs was assigned a concentration equal to the highest RL of the six DDT isomers for a given sample

b The RL for total chlordane was assigned a concentration equal to the highest RL of the chlordane components for a given sample

5.1.6 Conventional parameters

Table 5-12 presents a summary of results for 79 LDW surface sediment samples[15] for the following conventional parameters: grain size, TOC, total solids, sulfides, and ammonia. Data tables containing results for each sample, including field duplicates, are presented in Appendix A.

Table 5-12. Summary of grain size, TOC, and total solids results in Round 1 LDW surface sediment samples

Analyte	Unit	Detection Frequency	Detected Concentration			Reporting Limit[a]	
			Minimum	Maximum	Mean[b]	Minimum	Maximum
Sediment grain size							
Rocks (total calc'd)	% dw	73/79	0.1	61.7	6	0.1	0.1
Sand (total calc'd)	% dw	79/79	4.9	93.3	50	na	na
Silt (total calc'd)	% dw	79/79	1.4	71.2	40	na	na
Clay (total calc'd)	% dw	79/79	1.4	28.5	10	na	na
Fines (percent silt+clay)	% dw	79/79	2.8	95.1	50	na	na
Conventional parameters							
Total organic carbon (TOC)	% dw	79/79	0.39	4.12	1.8	na	na
Total solids	% ww	79/79	33.50	78.70	55.80	na	na
Sulfides (total)	mg/kg dw	54/79	4.0 J	1,300 J	220	2.2	14
Ammonia (total as nitrogen)	mg-N/kg dw	79/79	0.25	39.1	8.9	na	na

a RL range for nondetect samples

b Reported mean concentration is the average of the detected concentrations only; RLs were not included in calculation of the mean concentration

na – not applicable

Percent fines in surface sediment samples ranged widely from 2.8 (at LDW-SS5-010) to 95.1% (at LDW-SS128-010), with a mean of 50%. TOC ranged from 0.39 (at LDW-SS134-010) to 4.12% (at LDW-SS84-010), with a mean of 1.8%. One sample (LDW-SS134-010) had a TOC content of less than 0.5% (0.39%).[16] The maximum concentration of sulfides was 1,300 mg/kg dw, detected in the sample collected at location LDW-SS43. The maximum ammonia concentration (39.1 mg-N/kg) was detected in the sample collected at location LDW-SS72.

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[15] Grain size, TOC, and total solids were also analyzed in the two split samples collected by King County (LDW-SS18-010 and LDW-SS20-010); the results will be provided separately.

[16] One of the samples analyzed by King County (LDW-SS18-010) also had a TOC content of less than 0.5% (0.122%)

5.1.7 Comparison of non-detect results to analytical concentration goals (ACGs)

Appendix C of the sediment QAPP (Windward 2005c) documented the derivation of analytical concentration goals (ACGs) for benthic invertebrates (based on SQS, or SL, where no SQS was available), sandpipers (based on consumption of benthic invertebrates and sediment), and human health (based on both direct exposure [e.g., dermal contact] and indirect exposure [e.g., seafood consumption]). The QAPP also included a comparison of ACGs to method detection limits (MDLs) and RLs. The laboratory reported non-detect results to the RL. The sample-specific RL is based on the lowest point of the calibration curve associated with each analytical batch of samples, whereas the MDL is statistically derived following EPA methods. Both the RL and MDL will be elevated in cases where the sample extract is diluted. Detected concentrations between the MDL and RL were reported by the laboratory and flagged with a J qualifier to indicate that the reported concentration was an estimate because it falls below the lowest known point on the calibration curve.

In this section, ACGs for human health-indirect exposure, human health-direct exposure, and benthic invertebrates are compared to both RLs and MDLs for non-detect results. For the sandpiper-based ACGs, there was only a single chemical, selenium, that had one or more RLs (range of RLs from 6 to 40 mg/kg dw) above the ACG (14.9 mg/kg dw). All selenium MDLs were less than the ACG, ranging from 3.5 to 6 mg/kg dw.

Thirty-two chemicals had at least one sample-specific RL above the applicable ACG for human health-indirect exposure (Table 5-13). Eighteen of these chemicals were never detected. One or more MDLs for 25 of the 32 chemicals also exceeded ACGs. The minimum MDL reported in Table 5-13 was generally lower than the target MDL specified in the QAPP (also listed in Table 5-13), indicating that many of the MDLs that were above the ACGs were for chemicals previously identified in the QAPP as those that would likely represent analytical challenges. Seven chemicals had RLs above the ACG that were not anticipated in the QAPP; however, all of these ACGs were met by the associated MDLs, with the exception of hexachlorobutadiene and total chlordane.

The chemicals for which there were unanticipated ACG exceedances had RL and MDL ranges that spanned a factor of 5 to 10 as a result of necessary analytical dilutions or the adjustment of extracted sample volume for some samples based on pre-screen results. When sample extracts were diluted because the concentrations for one or more target analytes exceeded the upper end of the calibration curve, RLs from the original undiluted extract were reported for compounds other than the target analytes that required dilution. The analytical laboratory performed the appropriate sample cleanups to achieve the lowest possible RLs.

Table 5-13. Detected and non-detected results, RLs, and MDLs for sediment samples compared to human health ACGs associated with indirect exposure

Chemical	Unit	Number of Detected Results	Range of Detected Results	Number of Non-detect Results	Range of RLs for Non-detects	Number of RLs > ACG	Range of MDLs for Nondetects	Number of MDLs > ACG	Target MDL	Human Health ACG
Metals and trace elements										
Arsenic	mg/kg dw	79	2.4 – 1,100	0	na	0	na	0	0.02	0.006
Cadmium	mg/kg dw	43	0.3 – 3.6	36	0.2 – 0.8	36	0.024 – 0.16	36	0.02	0.003
Chromium	mg/kg dw	79	11.2 – 455	0	na	0	na	0	0.09	100
Copper	mg/kg dw	79	16.9 – 1,420	0	na	0	na	0	0.04	1.3
Mercury	mg/kg dw	67	0.05 – 2.46	12	0.05 – 0.1	12	0.0033 – 0.006	0	0.003	0.016
Zinc	mg/kg dw	79	38 – 2,830	0	na	0	na	0	0.29	16
Organometals										
Tributyltin as ion	µg/kg dw	14	7.5 – 140	4	3.7 – 3.9	4	2.1 – 2.2	4	2.84	0.28
PAHs										
2-Methylnaphthalene	µg/kg dw	4	21 – 260	75	19 – 290	0	11 – 170	0	7.21	1,700
Acenaphthene	µg/kg dw	12	21 – 330	67	19 – 290	0	6.7 – 100	0	9.36	540,000
Anthracene	µg/kg dw	45	21 – 650	34	19 – 290	0	6.3 – 95	0	8.69	900,000
Benzo(a)anthracene	µg/kg dw	78	7.8 – 1,500	2	19 – 200	2	4.2 – 43	1	8.34	5.2
Benzo(a)pyrene	µg/kg dw	79	6.5 – 1,700	1	19 – 19	1	3.8 – 3.8	1	7.31	0.76
Benzo(b)fluoranthene	µg/kg dw	79	9.1 – 1,900	1	19 – 19	1	6.0 – 6.0	1	7.34	4.7
Benzo(k)fluoranthene	µg/kg dw	70	23 – 1,700	9	19 – 200	7	3.9 – 40	0	10.4	47
Chrysene	µg/kg dw	78	23 – 2,500	1	19 – 19	0	5.3 – 5.3	0	8.09	480
Dibenzofuran	µg/kg dw	3	100 – 140	76	19 – 290	0	12 – 180	0	7.95	560
Fluoranthene	µg/kg dw	78	33 – 5,200	1	19 – 19	0	4.6 – 4.6	0	8.49	2,100
Indeno(1,2,3-cd)pyrene	µg/kg dw	73	6.4 – 600	7	6.5 – 200	7	1.0 – 53	4	8.54	2.9
Naphthalene	µg/kg dw	4	34 – 360	75	19 – 290	0	5.4 – 81	0	7.53	4,500
Pyrene	µg/kg dw	78	28 – 3,400	1	19 – 19	0	8.2 – 8.2	0	8.72	8,900

Chemical	Unit	Number of Detected Results	Range of Detected Results	Number of Non-detect Results	Range of RLs for Non-detects	Number of RLs > ACG	Range of MDLs for Nondetects	Number of MDLs > ACG	Target MDL	Human Health ACG
Phthalates										
Bis(2-ethylhexyl)phthalate	µg/kg dw	65	20 – 4,200	14	19 – 200	1	5.1 – 52	0	10.8	120
Butyl benzyl phthalate	µg/kg dw	24	7.0 – 350	56	6.4 – 290	0	3.8 – 120	0	10.3	30,000
Dimethyl phthalate	µg/kg dw	8	7.3 – 120	73	6.4 – 290	0	1.6 – 99	0	12	1,400,000
Di-n-butyl phthalate	µg/kg dw	5	83 – 380	74	19 – 200	0	6.4 – 67	0	13.5	14,000
Di-n-octyl phthalate	µg/kg dw	2	36 – 1,000	77	19 – 290	0	3.8 – 57	0	11.3	3,000
Other SVOCs										
1,2-Dichlorobenzene	µg/kg dw	0	na	81	6.3 – 290	0	1.3 – 95	0	8.76	12,000
1,4-Dichlorobenzene	µg/kg dw	0	na	81	6.3 – 290	13	2.1 – 95	1	8.16	73
2,4,5-Trichlorophenol	µg/kg dw	0	na	79	96 – 1,400	0	3.4 – 51	0	8.34	37,000
2,4-Dichlorophenol	µg/kg dw	0	na	79	96 – 1,400	1	5.7 – 86	0	7.73	1,100
2-Chlorophenol	µg/kg dw	0	na	79	19 – 290	0	5.7 – 86	0	9.48	1,800
4-Methylphenol	µg/kg dw	3	23 – 88	76	19 – 290	0	4.7 – 71	0	13.5	1,800
Hexachlorobutadiene	µg/kg dw	0	na	81	0.96 – 200	10	0.354 – 60	9	8.28	23
Hexachloroethane	µg/kg dw	0	na	79	19 – 290	9	6.5 – 98	0	7.98	120
Phenol	µg/kg dw	8	22 – 370	71	19 – 290	0	6.4 – 98	0	9.47	210,000
Polychlorinated biphenyls										
Aroclor-1016	µg/kg dw	0	na	79	16 – 1,100	79	2.6 – 170	13	0.98	6.1
Aroclor-1221	µg/kg dw	0	na	79	16 – 1,100	79	2.6 – 170	79	0.98	0.21
Aroclor-1232	µg/kg dw	0	na	79	16 – 1,100	79	2.6 – 170	79	0.98	0.21
Aroclor-1242	µg/kg dw	12	21 – 2,700	67	19 – 2,100	67	3.0 – 170	67	0.98	0.21
Aroclor-1248	µg/kg dw	24	20 – 12,000	55	16 – 4,300	55	2.6 – 170	55	0.98	0.21
Aroclor-1254	µg/kg dw	70	18 – 110,000	9	19 – 20	9	3.0 – 3.1	9	0.98	0.21
Aroclor-1260	µg/kg dw	57	27 – 4,300	22	19 – 8,100	22	3.0 – 120	22	0.98	0.21
Total PCB Aroclors	µg/kg dw	71	18 – 110,000	8	19 – 20	8	3.0 – 3.1	8	0.98	0.21

Chemical	Unit	Number of Detected Results	Range of Detected Results	Number of Non-detect Results	Range of RLs for Non-detects	Number of RLs > ACG	Range of MDLs for Nondetects	Number of MDLs > ACG	Target MDL	Human Health ACG
Pesticides										
4,4'-DDD	µg/kg dw	0	na	33	1.9 – 540	1	0.308 – 5.47	0	0.32	8.3
4,4'-DDE	µg/kg dw	0	na	33	1.9 – 800	8	0.16 – 2.84	1	0.166	2.6
4,4'-DDT	µg/kg dw	0	na	33	1.9 – 34	33	0.271 – 4.82	1	0.284	0.92
Total DDT	µg/kg dw	0	na	33	1.9 – 800	33	0.271 – 4.82	1	0.32	0.92
Aldrin	µg/kg dw	0	na	33	0.96 – 17	33	0.052 – 0.924	4	0.054	0.063
Total Chlordane	µg/kg dw	0	na	33	1.9 - 330	33	0.927 – 5.75	3	0.964	1.7
Dieldrin	µg/kg dw	0	na	33	1.9 – 34	33	0.047 – 0.838	33	0.049	0.033
beta-BHC	µg/kg dw	0	na	33	0.96 – 17	33	0.043 – 0.77	1	0.045	0.63
gamma-BHC	µg/kg dw	0	na	33	0.96 – 17	33	0.136 – 2.41	1	0.141	0.83
Endrin	µg/kg dw	0	na	33	1.9 – 34	1	0.048 – 0.855	0	0.24	27
Heptachlor	µg/kg dw	0	na	33	0.96 – 70	33	0.026 – 0.462	1	0.027	0.25
Methoxychlor	µg/kg dw	0	na	33	9.6 – 170	0	0.39 – 6.95	0	0.402	440

na – not applicable

The purpose of developing ACGs for analyses of sediment samples on the basis of human seafood consumption (i.e., through the use of assumptions of chemical transfer from sediment to seafood tissue) was to provide an additional method to evaluate the possibility that these chemicals could accumulate in tissue at concentrations of concern. The fish, crab, and clam tissue data collected for this project provide the most relevant data for this evaluation (Windward 2005a, b). Other than three SVOCs[17] all the chemicals listed in Table 5-13 with at least one RL above applicable ACGs were either detected in fish, crab, and clam tissue samples or the chemical contributes to a group sum (i.e., total PCBs as Aroclors) that is detected in fish, crab, and clam tissue samples. For the three SVOCs listed above, very few of the RLs and MDLs were above applicable ACGs. Based on the comparisons presented above, there appears to be a very low likelihood that the non-detect results for the chemicals listed in Table 5-13 would be associated with unacceptable uncertainty that is not already accounted for in the existing fish, crab, and clam tissue data collected in 2004.

Table 5-14 shows that RLs for seventeen chemicals exceeded applicable ACGs developed for the protection of human health through direct exposure. All MDLs were below the ACGs with the exception of a few sample-specific MDLs for N-nitrosodi-n-propylamine, and most MDLs for N-nitrosodimethylamine. These chemicals are known to be difficult to quantify in sediment.

[17] 1,4-dichlorobenzene; hexachlorobutadiene, and hexachloroethane

Table 5-14. Detected and non-detected results, RLs, and MDLs for sediment samples compared to human health ACGs associated with direct exposure

Chemical	Unit	Number of Detected Results	Range of Detected Results	Number of Non-detect Results	Range of RLs for Non-detects	Number of RLs > ACG	Range of MDLs for Nondetects	Number of MDLs > ACG	Target MDL	Human Health ACG
Metals and trace elements										
Antimony	mg/kg dw	7	0.4 – 6.8	72	0.2 – 0.6	0	0.0058 – 0.033	0	0.005	3.1
Arsenic	mg/kg dw	79	2.4 – 1,100	0	na	0	na	0	0.02	0.39
Cadmium	mg/kg dw	43	0.3 – 3.6	36	0.2 – 0.8	0	0.024 – 0.16	0	0.02	3.7
Chromium	mg/kg dw	79	11.2 – 455	0	na	0	na	0	0.09	210
Cobalt	mg/kg dw	79	4.4 – 50	0	na	0	na	0	0.03	900
Copper	mg/kg dw	79	16.9 – 1,420	0	na	0	na	0	0.04	310
Lead	mg/kg dw	79	4 – 870	0	na	0	na	0	0.12	40
Mercury	mg/kg dw	67	0.05 – 2.46	12	0.05 – 0.1	0	0.0033 – 0.006	0	0.003	2.3
Molybdenum	mg/kg dw	79	0.7 – 75	0	na	0	na	0	0.06	39
Nickel	mg/kg dw	79	8 – 387	0	na	0	na	0	0.38	160
Selenium	mg/kg dw	0	na	79	6 – 40	1	0.35 – 6	0	0.3	39
Silver	mg/kg dw	32	0.5 – 3.9	47	0.4 – 2	0	0.035 – 0.23	0	0.03	39
Thallium	mg/kg dw	1	0.4 – 0.4	78	0.2 – 0.6	1	0.0035 – 0.018	0	0.003	0.52
Vanadium	mg/kg dw	79	37.1 – 89.6	0	na	0	na	0	0.03	55
Zinc	mg/kg dw	79	38 – 2,830	0	na	0	na	0	0.29	2,300
Organometals										
Tributyltin as ion	µg/kg dw	14	7.5 – 140	4	3.7 – 3.9	0	2.1 – 2.2	0	2.84	1,800
PAHs										
2-Chloronaphthalene	µg/kg dw	0	na	79	19 – 290	0	6.9 – 100	0	8.32	490,000
Acenaphthene	µg/kg dw	12	21 – 330	67	19 – 290	0	6.7 – 100	0	9.36	370,000
Anthracene	µg/kg dw	45	21 – 650	34	19 – 290	0	6.3 – 95	0	8.69	2,200,000
Benzo(a)anthracene	µg/kg dw	78	7.8 – 1,500	2	19 – 200	0	4.2 – 43	0	8.34	620
Benzo(a)pyrene	µg/kg dw	79	6.5 – 1,700	1	19 – 19	0	3.8 – 3.8	0	7.31	62
Benzo(b)fluoranthene	µg/kg dw	79	9.1 – 1900	1	19 – 19	0	6.0 – 6.0	0	7.34	620
Benzo(k)fluoranthene	µg/kg dw	70	23 – 1700	9	19 – 200	0	3.9 – 40	0	10.4	6,200

Chemical	Unit	Number of Detected Results	Range of Detected Results	Number of Non-detect Results	Range of RLs for Non-detects	Number of RLs > ACG	Range of MDLs for Nondetects	Number of MDLs > ACG	Target MDL	Human Health ACG
Chrysene	µg/kg dw	78	23 – 2500	1	19 – 19	0	5.3 – 5.3	0	8.09	62,000
Dibenzo(a,h)anthracene	µg/kg dw	7	22 – 240	72	19 – 290	40	3.8 – 57	0	8.35	62
Dibenzofuran	µg/kg dw	3	100 – 140	76	19 – 290	0	12 – 180	0	7.95	29,000
Fluoranthene	µg/kg dw	78	33 – 5200	1	19 – 19	0	4.6 – 4.6	0	8.49	230,000
Fluorene	µg/kg dw	14	21 – 640	65	19 – 290	0	6.1 – 93	0	9.17	270,000
Indeno(1,2,3-cd)pyrene	µg/kg dw	73	6.4 – 600	7	6.5 – 200	0	1.0 – 53	0	8.54	620
Naphthalene	µg/kg dw	4	34 – 360	75	19 – 290	0	5.4 – 81	0	7.53	5,600
Pyrene	µg/kg dw	78	28 – 3400	1	19 – 19	0	8.2 – 8.2	0	8.72	230,000
Phthalates										
Bis(2-ethylhexyl)phthalate	µg/kg dw	65	20 – 4200	14	19 – 200	0	5.1 – 52	0	10.8	35,000
Butyl benzyl phthalate	µg/kg dw	24	7.0 – 350	56	6.4 – 290	0	3.8 – 120	0	10.3	1,200,000
Diethyl phthalate	µg/kg dw	9	6.6 – 110	72	6.3 – 290	0	4.2 – 110	0	135	4,900,000
Dimethyl phthalate	µg/kg dw	8	7.3 – 120	73	6.4 – 290	0	1.6 – 99	0	12	100,000,000
Di-n-butyl phthalate	µg/kg dw	5	83 – 380	74	19 – 200	0	6.4 – 67	0	13.5	610,000
Di-n-octyl phthalate	µg/kg dw	2	36 – 1000	77	19 – 290	0	3.8 – 57	0	11.3	240,000
Other SVOCs										
1,2,4-Trichlorobenzene	µg/kg dw	0	na	81	3.3 – 290	0	1.6 – 91	0	5.88	65,000
1,2-Dichlorobenzene	µg/kg dw	0	na	81	6.3 – 290	0	1.3 – 95	0	8.76	370,000
1,3-Dichlorobenzene	µg/kg dw	0	na	79	19 – 290	0	6.8 – 100	0	7.55	1,600
1,4-Dichlorobenzene	µg/kg dw	0	na	81	6.3 – 290	0	2.1 – 95	0	8.16	3,400
2,4,5-Trichlorophenol	µg/kg dw	0	na	79	96 – 1,400	0	3.4 – 51	0	8.34	610,000
2,4,6-Trichlorophenol	µg/kg dw	0	na	79	96 – 1,400	9	4.0 – 61	0	10	610
2,4-Dichlorophenol	µg/kg dw	0	na	79	96 – 1,400	0	5.7 – 86	0	7.73	18,000
2,4-Dimethylphenol	µg/kg dw	0	na	81	6.3 – 290	0	3.7 – 110	0	10.52	120,000
2,4-Dinitrophenol	µg/kg dw	0	na	79	190 – 2,900	0	65 – 980	0	104.2	12,000
2,4-Dinitrotoluene	µg/kg dw	0	na	79	96 – 1,400	0	3.7 – 56	0	8.97	12,000
2,6-Dinitrotoluene	µg/kg dw	0	na	79	96 – 1,400	0	6.4 – 96	0	10.73	6,100
2-Chlorophenol	µg/kg dw	0	na	79	19 – 290	0	5.7 – 86	0	9.48	6,300
2-Methylphenol	µg/kg dw	1	21 – 21	80	6.3 – 290	0	3.2 – 87	0	13.8	310,000

Chemical	Unit	Number of Detected Results	Range of Detected Results	Number of Non-detect Results	Range of RLs for Non-detects	Number of RLs > ACG	Range of MDLs for Nondetects	Number of MDLs > ACG	Target MDL	Human Health ACG
3,3'-Dichlorobenzidine	µg/kg dw	0	na	79	96 – 1,400	1	23 – 340	0	61.7	1,100
4-Chloroaniline	µg/kg dw	0	na	79	96 – 1,400	0	27 – 410	0	25.7	24,000
4-Methylphenol	µg/kg dw	3	23 – 88	76	19 – 290	0	4.7 – 71	0	13.5	31,000
Aniline	µg/kg dw	0	na	79	19 – 290	0	4.8 – 72	0	9.12	85,000
Benzoic acid	µg/kg dw	10	54 – 250	71	63 – 2,900	0	50 – 880	0	105	100,000,000
Benzyl alcohol	µg/kg dw	0	na	80	19 – 290	0	15 – 250	0	41	1,800,000
bis(2-chloroethyl)ether	µg/kg dw	0	na	79	19 – 290	1	5.7 – 87	0	9.93	210
bis(2-chloroisopropyl)ether	µg/kg dw	0	na	79	19 – 290	0	9.3 – 140	0	9.96	2,900
Hexachlorobenzene	µg/kg dw	0	na	80	0.96 – 200	0	0.033 – 61	0	9.28	300
Hexachlorobutadiene	µg/kg dw	0	na	81	0.96 – 200	0	0.354 – 60	0	8.28	6,200
Hexachloroethane	µg/kg dw	0	na	79	19 – 290	0	6.5 – 98	0	7.98	35,000
Isophorone	µg/kg dw	1	26 – 26	78	19 – 290	0	8.1 – 120	0	7.38	510,000
Nitrobenzene	µg/kg dw	0	na	79	19 – 290	0	15 – 230	0	15.9	2,000
N-Nitrosodimethylamine	µg/kg dw	0	na	81	32 – 1,000	81	8.8 – 110	71	9.12	9.5
N-Nitroso-di-n-propylamine	µg/kg dw	0	na	80	32 – 1,400	27	2.6 – 120	6	10.2	69
N-Nitrosodiphenylamine	µg/kg dw	4	6.5 – 7.2	77	6.3 – 290	0	2.9 – 86	0	10.7	99,000
Pentachlorophenol	µg/kg dw	0	na	81	32 – 1,400	0	13 – 280	0	37.1	3,000
Phenol	µg/kg dw	8	22 – 370	71	19 – 290	0	6.4 – 98	0	9.47	3,700,000
Polychlorinated biphenyls										
Aroclor-1016	µg/kg dw	0	na	79	16 – 1100	3	2.6 – 170	0	0.98	390
Aroclor-1221	µg/kg dw	0	na	79	16 – 1100	5	2.6 – 170	0	0.98	220
Aroclor-1232	µg/kg dw	0	na	79	16 – 1100	5	2.6 – 170	0	0.98	220
Aroclor-1242	µg/kg dw	12	21 – 2,700	67	19 – 2100	5	3.0 – 170	0	0.98	220
Aroclor-1248	µg/kg dw	24	20 – 12,000	55	16 – 4300	4	2.6 – 170	0	0.98	220
Aroclor-1254	µg/kg dw	70	18 – 110,000	9	19 – 20	0	3.0 – 3.1	0	0.98	220
Aroclor-1260	µg/kg dw	57	27 – 4,300	22	19 – 8100	1	3.0 – 120	0	0.98	220
Total PCB Aroclors	µg/kg dw	71	18 – 110,000	8	19 – 20	0	3.0 – 3.1	0	0.98	220
Pesticides										
4,4'-DDD	µg/kg dw	0	na	33	1.9 – 540	0	0.308 – 5.47	0	0.32	2,400

Chemical	Unit	Number of Detected Results	Range of Detected Results	Number of Non-detect Results	Range of RLs for Non-detects	Number of RLs > ACG	Range of MDLs for Nondetects	Number of MDLs > ACG	Target MDL	Human Health ACG
4,4'-DDE	µg/kg dw	0	na	33	1.9 – 800	0	0.16 – 2.84	0	0.166	1,700
4,4'-DDT	µg/kg dw	0	na	33	1.9 – 34	0	0.271 – 4.82	0	0.284	1,700
Total DDT	µg/kg dw	0	na	33	1.9 – 800	0	1.07 – 19.0	0	0.32	1,700
Aldrin	µg/kg dw	0	na	33	0.96 – 17	0	0.052 – 0.924	0	0.054	29
Dieldrin	µg/kg dw	0	na	33	1.9 – 34	1	0.047 – 0.838	0	0.049	30
alpha-BHC	µg/kg dw	0	na	33	0.96 – 17	0	0.206 – 3.66	0	0.214	90
beta-BHC	µg/kg dw	0	na	33	0.96 – 17	0	0.043 – 0.77	0	0.045	320
gamma-BHC	µg/kg dw	0	na	33	0.96 – 17	0	0.136 – 2.41	0	0.141	440
Endrin	µg/kg dw	0	na	33	1.9 – 34	0	0.048 – 0.855	0	0.24	1,800
Total Chlordane	µg/kg dw	0	na	33	1.9 – 330	0	0.927 – 5.75	0	0.964	1,600
Heptachlor	µg/kg dw	0	na	33	0.96 – 70	0	0.026 – 0.462	0	0.027	110
Heptachlor epoxide	µg/kg dw	0	na	33	0.96 – 510	1	0.117 – 2.09	0	0.122	53
Methoxychlor	µg/kg dw	0	na	33	9.6 – 170	0	0.39 – 6.95	0	0.402	31,000
Mirex	µg/kg dw	0	na	33	1.9 – 34	0	0.381 – 6.78	0	1.22	270
Toxaphene	µg/kg dw	0	na	33	96 – 1,700	1	2.85 – 50.6	0	29.7	440

na – not applicable

Table 5-15 lists 27 chemicals with RLs above applicable ACGs for benthic invertebrates. Fourteen of these chemicals had MDLs above their respective ACGs. Twenty-one chemicals had RLs above the ACG that were not anticipated in the QAPP; however, these ACGs were met by the associated MDLs for all but nine chemicals. For chemicals with SQS expressed on an organic-carbon- normalized basis, a lower-than-average OC content of 0.5% was assumed in the ACG derivation to convert the SQS to its dry weight equivalent. This decision to use a low TOC content for the calculation was made to ensure that RLs would be sufficiently low for samples with such low TOC content. In actuality, only two samples had a TOC concentration below 0.5%, and the mean TOC concentration from the Round 1 sediment samples was 1.8%. The more relevant comparison for non-detect results is to normalize (if appropriate for that chemical) to the actual TOC content for that sample and compare to the SQS. A summary of these comparisons is presented in Table 5-6 for SVOCs. As noted in Table 5-6, all samples with RLs > SQS were either tested for toxicity or will be evaluated in the Phase 2 ERA based on chemical concentrations.

Table 5-15. Detected and non-detected results (in µg/kg dw, except where noted), RLs, and MDLs for sediment samples compared to benthic invertebrate ACGs

Chemical	Unit	Number of Detected Results	Range of Detected Results	Number of Non-detect Results	Range of RLs for Non-detects	Number of RLs > ACG	Range of MDLs for Nondetects	Number of MDLs > ACG	Target MDL	Benthic Invertebrate ACG
Metals and trace elements										
Antimony	mg/kg dw	7	0.4-6.8	72	0.2-0.6	0	0.0058-0.033	0	0.005	150
Arsenic	mg/kg dw	79	2.4-1100	0	na	0	na	0	0.02	57
Cadmium	mg/kg dw	43	0.3-3.6	36	0.2-0.8	0	0.024-0.16	0	0.02	5.1
Chromium	mg/kg dw	79	11.2-455	0	na	0	na	0	0.09	260
Copper	mg/kg dw	79	16.9-1,420	0	na	0	na	0	0.04	390
Lead	mg/kg dw	79	4-870	0	na	0	na	0	0.12	450
Mercury	mg/kg dw	67	0.05-2.46	12	0.05-0.1	0	0.0033-0.006	0	0.003	0.41
Nickel	mg/kg dw	79	8-387	0	na	0	na	0	0.38	140
Silver	mg/kg dw	32	0.5-3.9	47	0.4-2	0	0.035-0.23	0	0.03	6.1
Zinc	mg/kg dw	79	38-2,830	0	na	0	na	0	0.29	410
Organometals										
Tributyltin as ion	µg/kg dw	14	7.5-140	4	3.7-3.9	0	2.1-2.2	0	2.84	8.5
PAHs										
2-Methylnaphthalene	µg/kg dw	4	21-260	75	19-290	4	11-170	0	7.21	190
Acenaphthene	µg/kg dw	12	21-330	67	19-290	30	6.7-100	1	9.36	80
Acenaphthylene	µg/kg dw	3	54-88	76	19-290	0	6.8-100	0	9.09	330
Anthracene	µg/kg dw	45	21-650	34	19-290	0	6.3-95	0	8.69	1,100
Benzo(a)anthracene	µg/kg dw	79	7.8-1,500	2	6.6-200	0	0.95-43	0	8.34	550
Benzo(a)pyrene	µg/kg dw	80	6.5-1,700	1	6.6-19	0	1.1-3.8	0	7.31	500
Benzo(g,h,i)perylene	µg/kg dw	49	16-490	30	19-200	2	4.7-48	0	8.04	160
Chrysene	µg/kg dw	78	23-2,500	1	19-19	0	5.3-5.3	0	8.09	500
Dibenzo(a,h)anthracene	µg/kg dw	7	22-240	72	19-290	41	3.8-57	0	8.35	60
Dibenzofuran	µg/kg dw	3	100-140	76	19-290	35	12-180	10	7.95	75
Fluoranthene	µg/kg dw	78	33-5,200	1	19-19	0	4.6-4.6	0	8.49	800

Chemical	Unit	Number of Detected Results	Range of Detected Results	Number of Non-detect Results	Range of RLs for Non-detects	Number of RLs > ACG	Range of MDLs for Nondetects	Number of MDLs > ACG	Target MDL	Benthic Invertebrate ACG
Fluorene	µg/kg dw	14	21-640	65	19-290	6	6.1-93	0	9.17	120
Indeno(1,2,3-cd)pyrene	µg/kg dw	74	6.4-600	7	6.5-200	2	1.0-53	0	8.54	170
Naphthalene	µg/kg dw	4	34-360	75	19-290	0	5.4-81	0	7.53	500
Phenanthrene	µg/kg dw	76	22-3,200	3	19-200	0	5.8-60	0	8.63	500
Pyrene	µg/kg dw	78	28-3,400	1	19-19	0	8.2-8.2	0	8.72	5,000
Total LPAH	µg/kg dw	76	22-5,200	3	19-200	0	6.8-110	0	9.36	1,900
Total HPAH	µg/kg dw	78	160-19,000	1	19-19	0	11-11	0	10.4	4,800
Total Benzofluoranthenes	µg/kg dw	78	20-3,600	1	19-19	0	6.0-6.0	0	10.4	1,200
Phthalates										
Bis(2-ethylhexyl)phthalate	µg/kg dw	65	20-4,200	14	19-200	0	5.1-52	0	10.8	240
Butyl benzyl phthalate	µg/kg dw	25	7-350	56	6.4-290	10	3.8-120	10	10.3	25
Diethyl phthalate	µg/kg dw	9	6.6-110	72	6.3-290	0	4.2-110	0	135	310
Dimethyl phthalate	µg/kg dw	8	7.3-120	73	6.4-290	1	1.6-99	0	12	270
Di-n-butyl phthalate	µg/kg dw	5	49-380	74	19-200	0	6.4-67	0	13.5	1,100
Di-n-octyl phthalate	µg/kg dw	2	36-1,000	77	19-290	0	3.8-57	0	11.3	290
Other SVOCs										
1,2,4-Trichlorobenzene	µg/kg dw	0	na	81	3.3-290	77	1.6-91	25	5.88	4.1
1,2-Dichlorobenzene	µg/kg dw	0	na	81	6.3-290	28	1.3-95	13	8.76	12
1,3-Dichlorobenzene	µg/kg dw	0	na	79	19-290	6	6.8-100	0	7.55	170
1,4-Dichlorobenzene	µg/kg dw	0	na	81	6.3-290	24	2.1-95	13	8.16	16
2,4-Dimethylphenol	µg/kg dw	0	na	80	6.3-290	13	3.7-110	13	10.52	29
2-Methylphenol	µg/kg dw	1	21-21	80	6.3-290	13	3.2-87	1	13.8	63
4-Methylphenol	µg/kg dw	3	23-88	76	19-290	0	4.7-71	0	13.5	670
Benzoic acid	µg/kg dw	10	54-250	71	63-2,900	13	50-880	1	105	650
Benzyl alcohol	µg/kg dw	0	na	81	19-290	14	15-250	15	41	57
Hexachlorobenzene	µg/kg dw	0	na	81	0.96-200	46	0.033-61	24	9.28	1.9

Chemical	Unit	Number of Detected Results	Range of Detected Results	Number of Non-detect Results	Range of RLs for Non-detects	Number of RLs > ACG	Range of MDLs for Nondetects	Number of MDLs > ACG	Target MDL	Benthic Invertebrate ACG
Hexachlorobutadiene	µg/kg dw	0	na	81	0.96-200	11	0.354-60	9	8.28	20
Hexachloroethane	µg/kg dw	0	na	79	19-290	0	6.5-98	0	7.98	1,400
N-Nitrosodiphenylamine	µg/kg dw	4	6.5-7.2	77	6.3-290	13	2.9-86	5	10.7	55
Pentachlorophenol	µg/kg dw	0	na	81	32-1,400	13	13-280	0	37.1	360
Phenol	µg/kg dw	8	22-370	71	19-290	0	6.4-98	0	9.47	420
PCBs										
Total PCB Aroclor	µg/kg dw	71	18-110,000	8	19-20	0	3.0-3.1	0	0.98	60
Pesticides										
Aldrin	µg/kg dw	0	na	33	0.96-17	1	0.052-0.924	0	0.054	10
Dieldrin	µg/kg dw	0	na	33	1.9-34	1	0.047-0.838	0	0.049	10
gamma-BHC	µg/kg dw	0	na	33	0.96-17	1	0.136-2.41	0	0.141	10
alpha-Chlordane	µg/kg dw	0	na	33	0.96-17	1	0.138-2.46	0	0.144	10
Total DDT	µg/kg dw	0	na	33	1.9-800	6	1.07-19.0	1	0.32	6.9
Heptachlor	µg/kg dw	0	na	33	0.96-70	1	0.026-0.462	0	0.027	10

na – not applicable

5.2 UPSTREAM DUWAMISH RIVER SURFACE SEDIMENT RESULTS

Surface sediment samples were collected from eight locations situated upstream of the LDW in the Duwamish River. These samples were analyzed for total arsenic, grain size, and total solids. The results of these analyses are discussed below by sampling location and are summarized in Table 5-16.

Table 5-16. Summary of arsenic, grain size, and total solids results for upstream Duwamish River sediment samples

Analyte	Unit	Detection Frequency	Detected Concentration		
			Minimum	Maximum	Mean
Arsenic	mg/kg dw	8/8	4.6	10.9	7.5
Sediment grain size					
Rocks (total calc'd)	% dw	6/8	0.2	3.3	0.8
Sand (total calc'd)	% dw	8/8	43.4	72.2	50
Silt (total calc'd)	% dw	8/8	23.1	47.6	39
Clay (total calc'd)	% dw	8/8	4.6	9.5	7.3
Fines (percent silt+clay)	% dw	8/8	27.7	56.5	46
Total solids	% ww	8/8	43.30 J	69.80 J	52.98

5.2.1 Arsenic

Arsenic was detected at all eight upstream sediment sampling locations at concentrations ranging from 4.6 to 10.9 mg/kg dw. The highest concentration was detected in the sample collected at location DR-SS15 (Figure 2-2). The upstream arsenic concentrations in all eight samples were well below the SQS (57 mg/kg dw) and CSL (93 mg/kg dw).

5.2.2 Grain size and total solids

Sediments at all eight upstream Duwamish River locations had a medium grain size. The lowest percent fines of 27.7% dw was in the sample collected at location DR-SS14. Percent fines ranged from 39% to 56.5% dw in the other seven samples. Total solids ranged from 43.30% ww in the sample from location DR-SS10 to 69.80% ww in the sample from location DR-SS7.

5.3 REFERENCE SEDIMENT CHEMICAL RESULTS

Table 5-17 presents a summary of results for the three sediment samples collected from Carr Inlet reference locations (LDW-SSCR20, LDW-SSCR23, and LDW-SSMSMP43) for use in the laboratory toxicity tests. Most metals, except mercury, selenium, silver, and thallium, were detected in at least one of the three samples. Organic chemicals were undetected in all samples, except for phenol in one sample, which was detected at 38 µg/kg dw. Grain size ranged from low to high fines, consistent with the targeted approach of acquiring a broad range of grain sizes for use in the toxicity tests. All three samples had relatively low TOC concentrations (< 1%).

Table 5-17. Summary of reference sample results

Analyte	Unit	Detection Frequency	Detected Concentration			Reporting Limit[a]	
			Minimum	Maximum	Mean[b]	Minimum	Maximum
Metals and trace elements							
Antimony	mg/kg dw	1/3	0.3	0.3	0.3	0.3	0.3
Arsenic	mg/kg dw	3/3	1.8	3.6	2.9	na	na
Cadmium	mg/kg dw	1/3	0.3	0.3	0.3	0.3	0.3
Chromium	mg/kg dw	3/3	12.6	32.4	23.7	na	na
Cobalt	mg/kg dw	3/3	2.5	6.5	4.7	na	na
Copper	mg/kg dw	3/3	4.7	19.9	13	na	na
Lead	mg/kg dw	3/3	3	5	4	na	na
Mercury	mg/kg dw	0/3	nd	nd	nd	0.05	0.08
Molybdenum	mg/kg dw	2/3	1.3	1.3	1.3	0.7	0.7
Nickel	mg/kg dw	3/3	10	31	22	na	na
Selenium	mg/kg dw	0/3	nd	nd	nd	7	8
Silver	mg/kg dw	0/3	nd	nd	nd	0.4	0.5
Thallium	mg/kg dw	0/3	nd	nd	nd	0.3	0.3
Vanadium	mg/kg dw	3/3	17.2	51.5	35.8	na	na
Zinc	mg/kg dw	3/3	15.1	42	30	na	na
PAHs							
2-Chloronaphthalene	µg/kg dw	0/3	nd	nd	nd	19	20
2-Methylnaphthalene	µg/kg dw	0/3	nd	nd	nd	19	20
Acenaphthene	µg/kg dw	0/3	nd	nd	nd	19	20
Acenaphthylene	µg/kg dw	0/3	nd	nd	nd	19	20
Anthracene	µg/kg dw	0/3	nd	nd	nd	19	20
Benzo(a)anthracene	µg/kg dw	0/3	nd	nd	nd	19	20
Benzo(a)pyrene	µg/kg dw	0/3	nd	nd	nd	19	20
Benzo(b)fluoranthene	µg/kg dw	0/3	nd	nd	nd	19	20
Benzo(g,h,i)perylene	µg/kg dw	0/3	nd	nd	nd	19	20
Benzo(k)fluoranthene	µg/kg dw	0/3	nd	nd	nd	19	20
Total benzofluoranthenes (calc'd)	µg/kg dw	0/3	nd	nd	nd	na	na
Chrysene	µg/kg dw	0/3	nd	nd	nd	19	20
Dibenzo(a,h)anthracene	µg/kg dw	0/3	nd	nd	nd	19	20
Dibenzofuran	µg/kg dw	0/3	nd	nd	nd	19	20
Fluoranthene	µg/kg dw	0/3	nd	nd	nd	19	20
Fluorene	µg/kg dw	0/3	nd	nd	nd	19	20
Indeno(1,2,3-cd)pyrene	µg/kg dw	0/3	nd	nd	nd	19	20
Naphthalene	µg/kg dw	0/3	nd	nd	nd	19	20
Phenanthrene	µg/kg dw	0/3	nd	nd	nd	19	20

Analyte	Unit	Detection Frequency	Detected Concentration			Reporting Limit[a]	
			Minimum	Maximum	Mean[b]	Minimum	Maximum
Pyrene	µg/kg dw	0/3	nd	nd	nd	19	20
Total HPAH (calc'd)	µg/kg dw	0/3	nd	nd	nd	na	na
Total LPAH (calc'd)	µg/kg dw	0/3	nd	nd	nd	na	na
Total PAH (calc'd)	µg/kg dw	0/3	nd	nd	nd	na	na
Phthalates							
Bis(2-ethylhexyl)phthalate	µg/kg dw	0/3	nd	nd	nd	19	20
Butyl benzyl phthalate	µg/kg dw	0/3	nd	nd	nd	19	20
Diethyl phthalate	µg/kg dw	0/3	nd	nd	nd	19	20
Dimethyl phthalate	µg/kg dw	0/3	nd	nd	nd	19	20
Di-n-butyl phthalate	µg/kg dw	0/3	nd	nd	nd	19	20
Di-n-octyl phthalate	µg/kg dw	0/3	nd	nd	nd	19	20
Other SVOCs							
1,2,4-Trichlorobenzene	µg/kg dw	0/3	nd	nd	nd	19	20
1,2-Dichlorobenzene	µg/kg dw	0/3	nd	nd	nd	19	20
1,3-Dichlorobenzene	µg/kg dw	0/3	nd	nd	nd	19	20
1,4-Dichlorobenzene	µg/kg dw	0/3	nd	nd	nd	19	20
2,4,5-Trichlorophenol	µg/kg dw	0/3	nd	nd	nd	95	99
2,4,6-Trichlorophenol	µg/kg dw	0/3	nd	nd	nd	95	99
2,4-Dichlorophenol	µg/kg dw	0/3	nd	nd	nd	95	99
2,4-Dimethylphenol	µg/kg dw	0/3	nd	nd	nd	19	20
2,4-Dinitrophenol	µg/kg dw	0/3	nd	nd	nd	190	200
2,4-Dinitrotoluene	µg/kg dw	0/3	nd	nd	nd	95	99
2,6-Dinitrotoluene	µg/kg dw	0/3	nd	nd	nd	95	99
2-Chlorophenol	µg/kg dw	0/3	nd	nd	nd	19	20
2-Methylphenol	µg/kg dw	0/3	nd	nd	nd	19	20
2-Nitroaniline	µg/kg dw	0/3	nd	nd	nd	95	99
2-Nitrophenol	µg/kg dw	0/3	nd	nd	nd	95	99
3,3'-Dichlorobenzidine	µg/kg dw	0/3	nd	nd	nd	95	99
3-Nitroaniline	µg/kg dw	0/3	nd	nd	nd	95	99
4,6-Dinitro-o-cresol	µg/kg dw	0/3	nd	nd	nd	190	200
4-Bromophenyl phenyl ether	µg/kg dw	0/3	nd	nd	nd	19	20
4-Chloro-3-methylphenol	µg/kg dw	0/3	nd	nd	nd	95	99
4-Chloroaniline	µg/kg dw	0/3	nd	nd	nd	95	99
4-Chlorophenyl phenyl ether	µg/kg dw	0/3	nd	nd	nd	19	20
4-Methylphenol	µg/kg dw	0/3	nd	nd	nd	19	20
4-Nitroaniline	µg/kg dw	0/3	nd	nd	nd	95	99
4-Nitrophenol	µg/kg dw	0/3	nd	nd	nd	95	99
Aniline	µg/kg dw	0/3	nd	nd	nd	19	20
Benzoic acid	µg/kg dw	0/3	nd	nd	nd	190	200
Benzyl alcohol	µg/kg dw	0/3	nd	nd	nd	19	20

ANALYTE	UNIT	DETECTION FREQUENCY	DETECTED CONCENTRATION			REPORTING LIMIT[a]	
			MINIMUM	MAXIMUM	MEAN[b]	MINIMUM	MAXIMUM
bis(2-chloroethoxy)methane	µg/kg dw	0/3	nd	nd	nd	19	20
bis(2-chloroethyl)ether	µg/kg dw	0/3	nd	nd	nd	19	20
bis(2-chloroisopropyl)ether	µg/kg dw	0/3	nd	nd	nd	19	20
Carbazole	µg/kg dw	0/3	nd	nd	nd	19	20
Hexachlorobenzene	µg/kg dw	0/3	nd	nd	nd	19	20
Hexachlorobutadiene	µg/kg dw	0/3	nd	nd	nd	19	20
Hexachlorocyclopentadiene	µg/kg dw	0/3	nd	nd	nd	95	99
Hexachloroethane	µg/kg dw	0/3	nd	nd	nd	19	20
Isophorone	µg/kg dw	0/3	nd	nd	nd	19	20
Nitrobenzene	µg/kg dw	0/3	nd	nd	nd	19	20
N-Nitrosodimethylamine	µg/kg dw	0/3	nd	nd	nd	95	99
N-Nitroso-di-n-propylamine	µg/kg dw	0/3	nd	nd	nd	95	99
N-Nitrosodiphenylamine	µg/kg dw	0/3	nd	nd	nd	19	20
Pentachlorophenol	µg/kg dw	0/3	nd	nd	nd	95	99
Phenol	µg/kg dw	1/3	38	38	38	19	19
Polychlorinated biphenyls							
Aroclor-1016	µg/kg dw	0/3	nd	nd	nd	19	20
Aroclor-1221	µg/kg dw	0/3	nd	nd	nd	19	20
Aroclor-1232	µg/kg dw	0/3	nd	nd	nd	19	20
Aroclor-1242	µg/kg dw	0/3	nd	nd	nd	19	20
Aroclor-1248	µg/kg dw	0/3	nd	nd	nd	19	20
Aroclor-1254	µg/kg dw	0/3	nd	nd	nd	19	20
Aroclor-1260	µg/kg dw	0/3	nd	nd	nd	19	20
Total PCBs (calc'd)	µg/kg dw	0/3	nd	nd	nd	na	na
Sediment grain size							
Rocks (total calc'd)	% dw	0/3	nd	nd	nd	0.1	0.1
Sand (total calc'd)	% dw	3/3	22.3	93.0	60	na	na
Silt (total calc'd)	% dw	3/3	3.3	69.7	40	na	na
Clay (total calc'd)	% dw	3/3	3.6	8.0	6	na	na
Fines (percent silt+clay)	% dw	3/3	6.9	77.7	40	na	na
Conventional parameters							
Total Organic Carbon (TOC)	% dw	3/3	0.478	0.632	0.561	na	na
Total solids	% ww	3/3	61.85	75.20	67.42	na	na
Sulfides (total)	mg/kg dw	2/3	87	250	170	2.8	2.8
Ammonia (total as nitrogen)	mg-N/kg	3/3	8.83	12.1	10.7	na	na

[a] RL range for non-detect samples

[b] Reported mean concentration is the average of the detected concentrations only; RLs were not included in calculation of the mean concentration

dw – dry weight, ww – wet weight, nd – not detected, na – not applicable

Table 5-18 compares the results for the reference samples to applicable SQS/SL and CSL/ML values for both detected concentrations and RLs. None of the detected results exceeded SQS/SL, indicating that these samples adequately represented reference conditions without elevated chemical concentrations that could adversely affect benthic organisms. As a result of the low TOC concentrations in these samples, RLs for a few SVOCs exceeded either the SQS or CSL (for chemicals whose SQS and CSL are expressed on an organic carbon-normalized basis), but these results should not adversely impact the use of these data to represent reference conditions because this collection area has been widely used as a reference area with no evidence of chemical contamination.

Table 5-18. Numbers of reference samples in each SQS/SL or CSL/ML category for detected concentrations and reporting limits

Analyte	Detected Concentrations			Reporting Limits when Undetected		
	≤ SQS/SL	> SQS/SL ≤ CSL/ML	> CSL/ML	≤ SQS/SL	> SQS/SL ≤ CSL/ML	> CSL/ML
Metals and trace elements						
Antimony	1			2		
Arsenic	3					
Cadmium	1			2		
Chromium	3					
Copper	3					
Lead	3					
Mercury				3		
Nickel	3					
Silver				3		
Zinc	3					
PAHs						
2-Methylnaphthalene				3		
Acenaphthene				3		
Acenaphthylene				3		
Anthracene				3		
Benzo(a)anthracene				3		
Benzo(a)pyrene				3		
Benzo(g,h,i)perylene				3		
Total benzofluoranthenes (calc'd)				3		
Chrysene				3		
Dibenzo(a,h)anthracene				3		
Dibenzofuran				3		
Fluoranthene				3		
Fluorene				3		
Indeno(1,2,3-cd)pyrene				3		

Analyte	Detected Concentrations			Reporting Limits when Undetected		
	≤ SQS/SL	> SQS/SL ≤ CSL/ML	> CSL/ML	≤ SQS/SL	> SQS/SL ≤ CSL/ML	> CSL/ML
Naphthalene				3		
Phenanthrene				3		
Pyrene				3		
Total HPAH (calc'd)				3		
Total LPAH (calc'd)				3		
Phthalates						
Bis(2-ethylhexyl)phthalate				3		
Butyl benzyl phthalate				3		
Diethyl phthalate				3		
Dimethyl phthalate				3		
Di-n-butyl phthalate				3		
Di-n-octyl phthalate				3		
Other SVOCs						
1,2,4-Trichlorobenzene				1		2
1,2-Dichlorobenzene				1		2
1,3-Dichlorobenzene				3		
1,4-Dichlorobenzene				1	2	
2,4-Dimethylphenol				3		
2-Methylphenol				3		
4-Methylphenol				3		
Benzoic acid				3		
Benzyl alcohol				3		
Hexachlorobenzene				1		2
Hexachlorobutadiene				2	1	
Hexachloroethane				3		
N-Nitrosodiphenylamine				3		
Pentachlorophenol				3		
Phenol	1			2		
Polychlorinated biphenyls						
Total PCBs (calc'd)				3		

5.4 Chemical Data Validation Results

Independent data validation of all results was conducted by LDC. The complete data validation report is provided in Appendix C. The following sections summarize the results of the validation, but do not list every sample affected by a qualification in this summary. Detailed information regarding every qualified sample is available in Appendix C.

5.4.1 Overall data quality

The surface sediment samples were analyzed by ARI in 19 sample delivery groups (SDGs). LDC conducted a full validation on two SDGs (HP67 and HP70). All sample results that were not selected for full validation underwent a summary validation. The summary validation included a subsequent review of calibration, internal standard, and ICP interference check sample summary forms. The follow-up validation did not warrant the qualification of the associated data as unusable. Table 5-19 provides a summary of the numbers of samples in each SDG, the analyses performed, and the level of data validation.

The majority of the data were either not qualified or had "J" (estimate) qualifiers added. Low LCS recoveries of monobutyltin resulted in the rejection of 16 non-detected results for this compound and J qualification of two detected results. Method blank contamination resulted in the qualification of BEHP as non-detected (U) for 13 samples from SDGs HP67 and HP70. In addition, method blank contamination resulted in the qualification of diethylphthalate as non-detected for 17 samples in SDG HU13. The elevated RLs resulting from blank contamination were below the ACGs, so reanalysis was not performed.

Based on the information reviewed, the overall data quality was considered acceptable for use in the RI, as qualified. The results of the validation are summarized below by analyte group.

Table 5-19. Numbers of sediment samples and level of data validation performed for each SDG

SDG	Lab	Validation Level	SVOCs	SVOC-SIM	Pesticides	PCBs	Metals and Mercury	Butyltins	Conventionals [a]
HP67	ARI	full	11	4	1	9	9	3	9
HP70	ARI	full	17	7	3	10	10	5	10
HP90&HQ69[b]	ARI	summary	8	6	1	8	8	na	8
HQ17&HQ04[b]	ARI	summary	11	5	8	13	12	na	12
HQ48	ARI	summary	21	12	13	22	21	5	21
HQ27&HQ28[b]	ARI	summary	12	3	4	12	11	3	12
HR48	ARI	summary	na	1	na	na	na	1	na
HQ56 & HQ57[b]	ARI	summary	12	5	3	17	11	2	11
HQ93	ARI	summary	3	na	na	3	3	na	3
HT37	ARI	summary	na	4	na	na	na	na	na
HU13	ARI	summary	na	17	1	na	na	na	na
HV08	ARI	summary	na	na	2	na	na	na	na
HS56	ARI	summary	na	na	na	3	na	na	3[c]
HT56	ARI	summary	na	na	na	na	9[d]	na	4[e]
IL52	ARI	summary	1	1	na	na	na	na	na

[a] Includes ammonia, sulfides, total solids, TOC, and grain size

[b] These SDGs were batched together for analysis and quality control purposes

[c] Analyzed for total solids and TOC only

[d] Analyzed for arsenic only

[e] Analyzed for grain size and total solids only

na – not analyzed

5.4.2 Sample transport and holding times

All analyses of the sediment samples were conducted within the maximum holding times, with the following exceptions. Sulfides were analyzed in LDW-SS-111-010 outside of the 7-day holding time, resulting in J- qualification (estimated, biased low) of the detected result. Total solids results for 10 samples in HR49 and 9 samples in HT56 were also qualified J- (estimated, biased low) because of holding time exceedances. The chain-of-custody documents were reviewed for documentation of cooler temperatures. All cooler temperatures met validation criteria.

5.4.3 Field blank results

Rinsate blanks were submitted for each of the analyses. No analytes were detected in any of the rinsate blank samples except for zinc in one rinsate blank associated with SDG HQ48. The rinsate concentration was low (0.006 mg/L). No qualification of data resulted.

5.4.4 SVOCs (including PAHs)

Calibration

The initial calibration was conducted correctly. All response factors and system performance check compounds were adequate. Continuing calibration was conducted at the required frequencies. The only compounds with percent deviations higher than 25% in the continuing calibration relative to the initial calibration were hexachlorocyclopentadiene, benzyl alcohol, 2,4-dinitrophenol, 4,6-dinitro-2-methylphenol, dibenz(a,h)anthracene, and benzo(g,h,i)perylene. The results for hexachlorocyclopentadiene in SDGs HP67 and HP70 were qualified as estimated (J-qualified). The results for all the remaining compounds were J-qualified for samples in HP70.

Blanks

BEHP was detected in the method blank associated with SDGs HP67 and HP70; no other SVOCs were detected in the SVOC method blanks. Sample concentrations were compared to the concentration of BEHP detected in the method blank. Detected concentrations that were less than ten times the blank concentration were qualified as non-detected with elevated RLs as a result of blank contamination. Results for BEHP were qualified as non-detected (U) in five samples in HP67 and eight samples in HP70 because of blank contamination.

Surrogate recovery

Surrogates were added to all samples and blanks as required by the method. All surrogate recoveries were within quality control (QC) limits except for the recovery of 1,2-dichlorobenzene-d4 in LDW-SS-118-010, which resulted in J qualification of the results for n-nitrosodimethylamine in that sample.

Matrix spike

Matrix spike/matrix spike duplicate (MS/MSD) results were reviewed, and all were found to be within QC limits, except for the calculated relative percent difference (RPD) for pyrene, which exceeded the QC limit of 50% for two SDGs (HQ17 and HQ56). As a result, the pyrene concentrations in the two samples associated with the MS/MSD samples (LDW-SS116-010 and LDW-SS92-010) were J-qualified.

Laboratory control samples and standard reference material

Laboratory control sample results were reviewed and percent recoveries (%R) and RPD results were within QC limits. SRMs were run at the required frequencies and all results were within QC limits.

Internal standards

All internal standard areas and retention times were within QC limits except for perylene-d12 in two samples in HP67 and five samples from HP70 where the internal standard was below the lower QC limit. As a result, results for six PAH compounds (benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, indeno(1,2,3-cd)pyrene, dibenz(a,h)anthracene, and benzo(g,h,i)perylene) were qualified as estimated (J) in the seven affected samples.

5.4.5 SVOC by selected ion monitoring (SIM)

Calibration

Initial and continuing calibrations were conducted as required by the methods. The initial calibration percent relative standard deviations (%RSDs) were less than or equal to 30% for all compounds, with one exception. Benzoic acid results for HP67 and HP70 were J-qualified based on a %RSD of 39.2%. All of the continuing calibration percent differences were less than 25% except for benzoic acid results associated with HP67 and HP70.

Blanks

Two method blanks associated with SDGs HR48 and HU13 contained diethylphthalate. Sample concentrations were compared to the concentrations detected in the method blanks. Detected concentrations that were less than ten times the blank concentration were qualified as non-detected with elevated RLs as a result of blank contamination. Detected diethylphthalate concentrations in 17 samples in SDG HU13 were qualified as non-detected (U) because of blank contamination.

Surrogate recovery

All surrogate recoveries were within QC limits except for five surrogates with %R (32.4-39.2%) below the limit of 40% associated with LDW-SS-99-010. As a result, all SIM analyte results for this sample were J-qualified.

Matrix spike

All MS/MSD results were reviewed and %R and RPD were within QC limits. MS/MSD analyses were not performed for SDG HQ56 and HQ57. These SDGs were run with HQ48 and the QAPP requirement for MS/MSD frequency was met. This was not apparent in the documentation reviewed by the validator. No data qualification resulted.

Laboratory control samples and standard reference materials

Laboratory control sample results were reviewed and %R and RPD results were within QC limits, except for the results for pentachlorophenol in the laboratory control sample (LCS) associated with SDG HU13. The recovery of pentachlorophenol was 28.8%, which is below the QC limit of 40%. As a result, the pentachlorophenol results for the 17 samples in HU13 were J-qualified. SRMs were run at the required frequencies, and all results were within QC limits.

5.4.6 PCBs as Aroclors and pesticides

Calibration

Initial and continuing calibrations were conducted as required by the methods. The %RSDs were less than or equal to 20% for all compounds, and retention times of all compounds were within QC limits. The percent differences (%D) calculated for the continuing calibrations were within QC limits.

Blanks

PCBs as Aroclors and pesticides were not detected in any of the method blanks.

Surrogate recovery

Surrogates were added to all samples and blanks as required by the method. All surrogate recoveries were within QC limits except for three samples. Two samples (LDW-SS4-010 and LDW-SS56-010) had recoveries of decachlorobiphenyl that exceeded the upper QC limit of 150%. One sample (UB-SS8-010) had a reported recovery of tetrachloro-m-xylene below the lower QC limit of 50%. For these three samples, all the detected PCB Aroclor results were J-qualified. The undetected results were J-qualified for UB-SS8-010 only.

Internal standards

All internal standard areas and retention times were within QC limits except for the area associated with the internal standard, heptachlorobiphenyl, in 13 samples. The reported areas were less than the QC limits for eight samples from SDG HP67 and five samples from SDG HP70. For these samples, the detected and nondetected results for Aroclors 1016, 1221, 1232, 1242, and 1248 were J-qualified.

Matrix spike

The pesticide MS/MSD results were reviewed and all %R and RPD values were within QC limits. The %R and RPD values calculated from the PCB MS/MSD were also within QC limits, except for low recoveries reported for Aroclor 1260 in MS samples associated with SDGs HP90 and HQ17. Consequently, the results for Aroclors 1248, 1254, and 1260 were J-qualified in the two samples associated with the MS/MSD samples (LDW-SS60-010 and LDW-SS116-010).

Laboratory control samples and standard reference materials

The laboratory control sample/laboratory control sample duplicate (LCS/LCSD) results for the PCB analyses were within QC limits. For pesticides, the LCS/LCSD results were within QC limits for all analyses except for the %R. The %R was below the QC limits for gamma-BHC, endrin aldehyde, and hexachlorobutadiene associated with SDGs HP67 and HP70, and endrin aldehyde associated with SDGs HP90, HQ17, HQ48, HQ56, HV08, and HQ27. The results for these compounds were J-qualified in the affected SDGs. SRM samples were analyzed at the required frequencies, and all results were within QC limits.

Compound quantification

Analyst experience in pattern recognition of the individual Aroclors was used in interpreting the PCB results. When samples contained more than one Aroclor, a higher level of analyst expertise and review was necessary to ensure the correct identification and quantification. When comparing the results of the two analytical columns, the greater of the two values was reported. Eleven samples were identified in which the results for detected Aroclors from the two analytical columns exceeded the QC limit of 40%. The samples and the qualified Aroclors are identified in Table 5-20. All of these detected results for the specific Aroclors and samples were J-qualified.

Table 5-20. Aroclor results with RPD more than 40%

Sample	Aroclor	RPD
LDW-SS15-010	Aroclor 1260	41
LDW-SS116-010	Aroclor 1260	41
LDW-SS22-010	Aroclor 1242	46
LDW-SS40-010	Aroclor 1242	44
LDW-SS111-010	Aroclor 1260	80
LDW-SS119-010	Aroclor 1260	44
LDW-SS56-010	Aroclor 1260	44
LDW-SS121-010	Aroclor 1260	44
LDW-SS120-010	Aroclor 1260	63
LDW-SS117-010	Aroclor 1260	50
LDW-SS142-010	Aroclor 1260	42

5.4.7 Metals (including mercury)

Calibration

The initial calibration was performed and the frequency and analysis criteria of the initial calibration verification and continuing calibration verification were met.

Blanks

Method blanks were reviewed. Copper and zinc were each detected in one blank. No sample qualification resulted. Metals in the sediment samples were either not detected or their concentrations were more than five times the blank concentrations.

ICP interference check sample analysis

The frequency of analysis criterion was met for interference check sample analysis. The %R results were within QC limits except for the result for selenium in one of the interference check samples associated with SDGs HP67 and HP70. As a result, all nondetected selenium results in seven samples associated with the interference check sample were J-qualified.

Matrix spike

MS and MSD results were reviewed. Percent recoveries and RPDs were within QC limits except for the percent recovery reported for antimony in all the MS samples. The recoveries for antimony ranged from 1.6-4.3%. All antimony results were qualified as estimated (J/UJ). Although the results were not rejected because the post-digestion spike recoveries for antimony were greater than 75%, the systematic low recoveries may be indicative of an overall low bias of the results and quantitation limits. The LCS and SRM were within QC limits for antimony recovery, indicating a matrix interference was present in the environmental samples.

Laboratory control samples

LCS results were reviewed and all recoveries were within QC limits. An SRM was analyzed at the required frequencies, and all results were within QC limits.

Sample result verification

All sample result verifications met validation criteria.

5.4.8 Total solids, ammonia as nitrogen, sulfides, grain size and total organic carbon

Calibration

All criteria for the initial calibration of each method were met.

Blanks

Method blanks were reviewed for each matrix as applicable. No analyte concentrations were found in the method blanks.

Matrix spike

MS/MSD results were reviewed for each analysis. %Rs and RPDs were within QC limits for all analyses except the sulfide analyses. %Rs of sulfide were less than the lower QC limit of 75% in MS samples associated with five SDGs (HP70, HP90, HQ17, HQ27, and HQ28). The sulfide recoveries for those MS samples ranged from 54.8-71.1%. All of the detected results in the five SDGs were J-qualified to reflect a potential negative bias in the result. The nondetected results were also J-qualified.

Standard reference materials and laboratory control samples

LCS were reviewed for each analysis. Percent recoveries were within QC limits. SRMs were included for all analyses except sulfide. All results were within QC limits.

5.4.9 Butyltins

Calibration

Initial calibration was performed as required by the method. Calibration verification was performed and all aspects of the calibration were within QC limits.

Blanks

No butyltin compounds were detected in the method blanks.

Surrogate recovery

All surrogate recoveries were within QC limits.

Matrix spike

MS/MSD results were reviewed and were all within QC limits with the exception of the relative percent difference between the MS and MSD for monobutyltin associated with SDG HQ27. The monobutyltin result for the sample associated with the MS/MSD (LDW-SS67-010) was J-qualified.

Standard reference materials and laboratory control samples

All SRM results were within QC limits. The LCS results for dibutyltin and tributyltin were within QC limits. However, recoveries less than 10% were reported for all three LCS samples. Subsequently, all the non-detected monobutyltin results were rejected and the detected results were J-qualified.

Compound quantification

All compound quantitation and contract required quantitation limits were within validation criteria.

5.5 SEDIMENT TOXICITY TESTING RESULTS

This section presents the results of the sediment toxicity tests performed with amphipods (*Eohaustorius estuarius*), polychaetes (*Neanthes arenaceodentata*), and bivalve larvae (*Mytilus galloprovincialis*). The complete laboratory toxicity test reports are presented in Appendix D-2, and raw data summaries from the laboratories are presented in Appendix D-3.

5.5.1 Amphipod tests

Mean mortality results in the 10-day sediment toxicity tests with *Eohaustorius estuarius* are presented in Table 5-21. The mean mortality in the test sediment samples ranged from 1% in LDW-SS92-010 to 85% in LDW-SS114-010.

Table 5-21. Percent mean mortality in the amphipod sediment toxicity tests and exceedances of the SMS biological effects criteria

Sample ID	Reference Sediment Match	Percent Mean Mortality ± SD	SMS Exceedance[a]
Batch 1			
Negative control	na	2.0 ± 2.7	na
LDW-SSMSMP43-010 (ref)	na	1.0 ± 2.2	na
LDW-SSCR20-010 (ref)	na	7.0 ± 5.7	na
LDW-SSCR23-010 (ref)	na	5.0 ± 8.7	na
LDW-SS15-010	LDW-SSCR20-010	28.0 ± 8.4	SQS
LDW-SS17-010	LDW-SSCR23-010	35.0 ± 20.9	SQS
LDW-SS22-010	LDW-SSCR23-010	32.0 ± 10.4	SQS
LDW-SS26-010	LDW-SSCR20-010	23.0 ± 11.0	no exceedances
LDW-SS31-010	LDW-SSCR20-010	43.0 ± 5.7	CSL
LDW-SS32-010	LDW-SSCR20-010	34.0 ± 11.9	SQS
LDW-SS37-010	LDW-SSCR20-010	45.0 ± 14.6	CSL
LDW-SS40-010	LDW-SSCR23-010	36.0 ± 12.9	CSL
LDW-SS49-010	LDW-SSCR23-010	49.0 ± 19.5	CSL
LDW-SS50-010	LDW-SSCR20-010	39.0 ± 10.8	CSL
LDW-SS56-010	LDW-SSMSMP43-010	6.0 ± 4.2	no exceedances
LDW-SS57-010	LDW-SSCR20-010	13.0 ± 12.5	no exceedances
LDW-SS58-010	LDW-SSCR20-010	5.0 ± 5.0	no exceedances
Batch 2			
Negative control	na	2.0 ± 2.7	na
LDW-SSMSMP43-010 (ref)	na	2.0 ± 2.7	na
LDW-SSCR20-010 (ref)	na	7.0 ± 8.4	na
LDW-SSCR23-010 (ref)	na	0.0 ± 0.0	na
LDW-SS60-010	LDW-SSMSMP43-010	7.0 ± 5.7	no exceedances
LDW-SS70-010	LDW-SSMSMP43-010	15.0 ± 7.1	no exceedances
LDW-SS75-010	LDW-SSMSMP43-010	8.0 ± 7.6	no exceedances
LDW-SS88-010	LDW-SSCR23-010	48.0 ± 25.9	CSL
LDW-SS89-010	LDW-SSMSMP43-010	5.0 ± 3.5	no exceedances
LDW-SS92-010	LDW-SSMSMP43-010	1.0 ± 2.2	no exceedances
LDW-SS112-010	LDW-SSCR23-010	4.0 ± 4.2	no exceedances

SAMPLE ID	REFERENCE SEDIMENT MATCH	PERCENT MEAN MORTALITY ± SD	SMS EXCEEDANCE[a]
LDW-SS114-010	LDW-SSCR23-010	85.0 ± 7.1	CSL
LDW-SS115-010	LDW-SSMSMP43-010	9.0 ± 4.2	no exceedances
LDW-SS119-010	LDW-SSCR23-010	3.0 ± 2.7	no exceedances
LDW-SS120-010	LDW-SSCR23-010	3.0 ± 2.7	no exceedances
LDW-SS121-010	LDW-SSMSMP43-010	4.0 ± 4.2	no exceedances
LDW-SS143-010	LDW-SSCR23-010	6.0 ± 5.5	no exceedances
Batch 3			
Negative control	na	1.0 ± 2.2	na
LDW-SSMSMP43-010 (ref)	na	5.0 ± 5.0	na
LDW-SS63-010	LDW-SSMSMP43-010	5.0 ± 6.1	no exceedances

na - not applicable

SD - standard deviation

SQS - mean mortality >25% on an absolute basis and statistically different from the reference sediment ($p \leq 0.05$)

CSL - mean mortality greater than the value in the reference sediment plus 30%, and statistically different from the reference sediment ($p \leq 0.05$)

[a] Statistical analyses in SedQual Release 5 include Wilk-Shapiro test for normality and Levene's test for equality of variances, followed by the appropriate statistical test for significance (i.e., Student's t-test, approximate t-test, or Mann-Whitney).

The mean mortality in the negative control ranged from 1 to 2% in the three batches and the mean mortality in the three reference sediments ranged from 0 to 7%. The negative control and reference sediments met the performance standards of less than 10% and 25% mortality, respectively (Table 3-7).

The lethal concentration (50%) (LC50) values from the positive control tests were within the laboratory warning limits of two standard deviations of the control chart mean of previous LC50 values, indicating that the test organisms were similar in sensitivity to those previously tested at the laboratory.

Results were compared to SMS biological effects criteria for amphipod toxicity tests (Table 3-7); four test sediment samples were classified as SQS exceedances and seven test sediment samples were classified as CSL exceedances using the statistical package included in SEDQUAL Release 5 (Table 5-21).

Water quality results for the amphipod toxicity tests are summarized in Table 5-22. All water quality parameters in the three batches were within protocol-specified ranges, except the salinity measurements listed in Section 3.3.2. As discussed in that section, these salinity deviations did not affect the data quality. The water quality results are presented in detail in Appendices D-2 and D-3.

Table 5-22. Water quality measurements for the amphipod sediment toxicity tests

Parameter	Batch 1			Batch 2			Batch 3		
	Mean ± SD	Min	Max	Mean ± SD	Min	Max	Mean ± SD	Min	Max
Overlying water									
Temperature (°C)	15.3 ± 0.3	14.6	15.9	15.1 ± 0.4	14.4	15.9	15.0 ± 0.3	14.7	15.7
Dissolved oxygen (mg/L)	7.8 ± 0.2	7.2	8.2	7.9 ± 0.2	7.2	8.6	8.0 ± 0.2	7.6	8.3
Salinity (ppt)	28.6 ± 0.7	27.0	30.5	28.1 ± 1.1	26.0	31.5	28.8 ± 0.7	28.0	30.5
pH	8.1 ± 0.1	7.9	8.7	8.0 ± 0.2	6.8	8.6	8.2 ± 0.1	8.0	8.3
Interstitial water									
Salinity (ppt)	28.0 ± 1.6	22.5	30.0	26.6 ± 2.4	20.0	30.0	28.2 ± 0.8	27.0	29.0
pH	7.7 ± 0.2	7.4	8.3	7.3 ± 0.3	6.8	8.1	7.6 ± 0.1	7.4	7.7

SD - standard deviation

Sulfides and ammonia results for the amphipod tests are summarized in Table 5-23. Positive control tests for ammonia were conducted concurrently with the sediment toxicity tests. The LC50 values for the three batches were 101 mg/L, 151 mg/L, and 226 mg/L total ammonia-N. All ammonia concentrations in the water overlying the test sediment samples were well below the LC50 concentrations.

Table 5-23. Sulfides and ammonia measurements for the amphipod sediment toxicity tests

Parameter	Batch 1		Batch 2		Batch 3	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Overlying water						
Dissolved sulfides (mg/L)	<0.02	<0.02	<0.02	0.18	<0.02	<0.02
Total ammonia-N (mg/L)	<0.1	13.4	<0.1	4.2	<0.1	5.2
Un-ionized ammonia (mg/L)	<0.003	0.459	<0.002	0.324	<0.003	0.173
Interstitial water						
Dissolved sulfides (mg/L)	<0.1	15.4	<0.1	14.4	<0.1	<0.1
Total ammonia-N (mg/L)	<0.5	33.2	<0.5	27.5	<0.5	22.5
Un-ionized ammonia (mg/L)	<0.008	0.911	<0.005	0.705	<0.007	0.153

5.5.2 Polychaete tests

Mortality and growth rate results for the 20-day sediment toxicity test with the polychaete *Neanthes arenaceodentata* are presented in Table 5-24. A mortality rate of 4% was observed in six of 27 test sediments (LDW-SS22-010, LDW-SS31-010, LDW-SS60-010, LDW-SS70-010, LDW-SS75-010, and LDW-SS114-010). No mortality was observed in the other polychaete test samples. The mean individual growth rate in the test sediment samples ranged from 0.68 mg/day in LDW-SS63-010 and LDW-SS88-010 to 0.92 mg/day in LDW-SS17-010.

Table 5-24. Mean mortality and individual growth rate in the polychaete sediment toxicity tests and exceedances of the SMS biological effects criteria

Sample ID	Reference Sediment Match	Mean Mortality ± SD	Mean Individual Growth Rate (mg/day) ± SD	SMS Exceedance[a]
Batch 1				
Negative control	na	0.0 ± 0.0	1.12 ± 0.10	na
LDW-SSMSMP43-010 (ref)	na	0.0 ± 0.0	0.86 ± 0.18	na
LDW-SSCR20-010 (ref)	na	0.0 ± 0.0	0.98 ± 0.19	na
LDW-SSCR23-010 (ref)	na	0.0 ± 0.0	1.12 ± 0.17	na
LDW-SS15-010	LDW-SSCR20-010	0.0 ± 0.0	0.73 ± 0.10	no exceedances
LDW-SS17-010	LDW-SSCR23-010	0.0 ± 0.0	0.92 ± 0.22	no exceedances
LDW-SS22-010	LDW-SSCR23-010	4.0 ± 8.9	0.70 ± 0.13	SQS
LDW-SS26-010	LDW-SSCR20-010	0.0 ± 0.0	0.86 ± 0.17	no exceedances
LDW-SS31-010	LDW-SSCR20-010	4.0 ± 8.9	0.81 ± 0.10	no exceedances
LDW-SS32-010	LDW-SSCR20-010	0.0 ± 0.0	0.69 ± 0.10	no exceedances
LDW-SS37-010	LDW-SSCR20-010	0.0 ± 0.0	0.78 ± 0.05	no exceedances
LDW-SS40-010	LDW-SSCR23-010	0.0 ± 0.0	0.78 ± 0.14	no exceedances
LDW-SS49-010	LDW-SSCR23-010	0.0 ± 0.0	0.79 ± 0.22	no exceedances
LDW-SS50-010	LDW-SSCR20-010	0.0 ± 0.0	0.73 ± 0.11	no exceedances
LDW-SS56-010	LDW-SSMSMP43-010	0.0 ± 0.0	0.85 ± 0.14	no exceedances
LDW-SS57-010	LDW-SSCR20-010	0.0 ± 0.0	0.78 ± 0.13	no exceedances
LDW-SS58-010	LDW-SSCR20-010	0.0 ± 0.0	0.69 ± 0.07	SQS
Batch 2				
Negative control	na	4.0 ± 8.9	0.95 ± 0.27	na
LDW-SSMSMP43-010 (ref)	na	0.0 ± 0.0	0.97 ± 0.16	na
LDW-SSCR20-010 (ref)	na	0.0 ± 0.0	0.92 ± 0.12	na
LDW-SSCR23-010 (ref)	na	0.0 ± 0.0	0.93 ± 0.16	na
LDW-SS60-010	LDW-SSMSMP43-010	4.0 ± 8.9	0.77 ± 0.17	no exceedances
LDW-SS70-010	LDW-SSMSMP43-010	4.0 ± 8.9	0.78 ± 0.12	no exceedances
LDW-SS75-010	LDW-SSMSMP43-010	4.0 ± 8.9	0.69 ± 0.16	no exceedances
LDW-SS88-010	LDW-SSCR23-010	0.0 ± 0.0	0.68 ± 0.14	no exceedances
LDW-SS89-010	LDW-SSMSMP43-010	0.0 ± 0.0	0.84 ± 0.26	no exceedances
LDW-SS92-010	LDW-SSMSMP43-010	0.0 ± 0.0	0.79 ± 0.17	no exceedances
LDW-SS112-010	LDW-SSCR23-010	0.0 ± 0.0	0.82 ± 0.06	no exceedances
LDW-SS114-010	LDW-SSCR23-010	4.0 ± 8.9	0.77 ± 0.19	no exceedances
LDW-SS115-010	LDW-SSMSMP43-010	0.0 ± 0.0	0.76 ± 0.21	no exceedances
LDW-SS119-010	LDW-SSCR23-010	0.0 ± 0.0	0.79 ± 0.06	no exceedances
LDW-SS120-010	LDW-SSCR23-010	0.0 ± 0.0	0.71 ± 0.09	no exceedances
LDW-SS121-010	LDW-SSMSMP43-010	0.0 ± 0.0	0.90 ± 0.12	no exceedances
LDW-SS143-010	LDW-SSCR23-010	0.0 ± 0.0	0.75 ± 0.07	no exceedances

Sample ID	Reference Sediment Match	Mean Mortality ± SD	Mean Individual Growth Rate (mg/day) ± SD	SMS Exceedance[a]
Batch 3				
Negative control	na	0.0 ± 0.0	0.87 ± 0.13	na
LDW-SSMSMP43-010 (ref)	na	0.0 ± 0.0	0.81 ± 0.13	na
LDW-SS63-010	LDW-SSMSMP43-010	0.0 ± 0.0	0.68 ± 0.19	no exceedances

na - not applicable

SD - standard deviation

SQS - mean individual growth rate <70% of that of the reference sediment and statistically different ($p \leq 0.05$)

[a] Statistical analyses in SedQual Release 5 include Wilk-Shapiro test for normality and Levene's test for equality of variances, followed by the appropriate statistical test for significance (i.e., Student's t-test, approximate t-test, or Mann-Whitney)

The mean individual growth rate in the negative control ranged from 0.87 to 1.12 mg/day in the three batches, and the mean individual growth rate in the three reference sediments ranged from 0.81 to 1.12 mg/day. The negative controls met the performance criteria of less than 10% mortality (0, 4, and 0%) and a mean individual target growth rate of at least 0.72 mg/day (Table 3-7).

The three reference sediments met the performance criterion of an individual growth rate of at least 80% of the negative control (Table 3-7), except for LDW-SSMSMP43-010 in Batch 1, which had a growth rate of 77% of the negative control. Only one test sediment sample (LDW-SS56-010) had been selected for comparison to reference sediment LDW-SSMSMP43-010 based on grain size. Sample LDW-SS56-010 (grain size of 21.3% fines) was compared instead to reference sediment LDW-SSCR23-010 (grain size of 48.6% fines) and also to the negative control. Both comparisons provide the same result, because the mean individual growth rate for the negative control and reference sediment LDW-SSCR23-010 was 1.12 mg/day.

The LC50 values from the positive control tests were within the laboratory warning limits of two standard deviations of the control chart mean of previous LC50 values, indicating that the test organisms were of similar sensitivity to those previously tested at the laboratory.

Based on a comparison to SMS biological effects criteria for polychaete toxicity tests, two test sediment samples were classified as SQS exceedances and no samples exceeded the CSL. There are no SMS standards for mortality in the polychaete toxicity test.

Water quality results for the 20-day polychaete toxicity test are summarized in Table 5-25. All water quality parameters in the three batches were within protocol-specified ranges, except the salinity measurements listed in Section 3.3.2. The water quality results are presented in detail in Appendices D-2 and D-3.

Table 5-25. Water quality measurements for the polychaete sediment toxicity tests

Parameter	Batch 1			Batch 2			Batch 3		
	Mean ± SD	Min	Max	Mean ± SD	Min	Max	Mean ± SD	Min	Max
Overlying water									
Temperature (°C)	20.2 ± 0.4	19.4	20.9	20.2 ± 0.5	19.0	20.9	19.9 ± 0.4	19.0	20.4
Dissolved oxygen (mg/L)	6.2 ± 0.5	4.6	7.2	6.4 ± 0.4	5.0	6.9	6.9 ± 0.2	6.5	7.2
Salinity (ppt)	28.6 ± 0.8	27.0	30.5	28.2 ± 1.3	25.0	30.5	28.8 ± 1.1	27.0	31.0
pH	8.1 ± 0.2	7.6	8.7	7.9 ± 0.2	7.5	8.6	8.1 ± 0.2	7.8	8.4
Interstitial water									
Salinity (ppt)	28.5 ± 1.6	25.0	30.0	27.5 ± 2.5	22.0	30.0	28.2 ± 0.5	27.5	29.0
pH	7.4 ± 0.4	6.6	8.1	7.3 ± 0.3	6.8	7.8	7.5 ± 0.2	7.1	7.8

SD - standard deviation

The sulfides and ammonia results for the polychaete tests are summarized in Table 5-26. Positive control tests for ammonia were conducted concurrently with the sediment toxicity tests. The LC50 values for the three batches were 183 mg/L, 344 mg/L, and 350 mg/L total ammonia-N. All ammonia concentrations in the water overlying the test sediment samples were well below the LC50 concentrations.

Table 5-26. Sulfides and ammonia measurements for the polychaete sediment toxicity tests

Parameter	Batch 1		Batch 2		Batch 3	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Overlying water						
Dissolved sulfides (mg/L)	<0.02	<0.02	<0.02	0.02	<0.02	<0.02
Total ammonia-N (mg/L)	<0.1	9.9	<0.1	10.3	<0.1	5.0
Un-ionized ammonia (mg/L)	<0.005	0.509	<0.002	0.349	<0.004	0.361
Interstitial water						
Dissolved sulfides (mg/L)	<0.1	6.7	<0.1	29.8	<0.1	<0.1
Total ammonia-N (mg/L)	0.6	26.8	0.6	26.2	<0.5	20.3
Un-ionized ammonia (mg/L)	0.003	0.923	0.006	0.495	<0.012	0.252

5.5.3 Bivalve larvae tests

Results for the 48-hr sediment toxicity test with *Mytilus galloprovincialis* are presented in Table 5-27. The mean normal survivorship in the test sediment samples ranged from 11.9% in LDW-SS88-010 to 86.9% in LDW-SS89-010.

Table 5-27. Percent mean normal survivorship in the bivalve larvae sediment toxicity tests and exceedances of the SMS biological effects criteria

Sample ID	Reference Sediment Match	Percent Mean Normal Survivorship ± SD[a]	Percent Mean Effective Mortality ± SD[b]	SMS Exceedance[c]
Batch 1				
Negative control	na	98.2 ± 2.1	1.8 ± 2.1	na
LDW-SSMSMP43-010 (ref)	na	79.8 ± 11.6	20.2 ± 11.6	na
LDW-SSCR20-010 (ref)	na	81.5 ± 11.4	18.5 ± 11.4	na
LDW-SSCR23-010 (ref)	na	73.6 ± 8.0	26.4 ± 8.0	na
LDW-SS15-010	LDW-SSCR20-010	75.4 ± 8.7	24.6 ± 8.7	no exceedances
LDW-SS17-010	LDW-SSCR23-010	62.9 ± 7.6	37.1 ± 7.6	no exceedances
LDW-SS22-010	LDW-SSCR23-010	51.9 ± 1.7[d]	48.1 ± 1.7[d]	SQS
LDW-SS26-010	LDW-SSCR20-010	76.7 ± 7.4	23.3 ± 7.4	no exceedances
LDW-SS31-010	LDW-SSCR20-010	62.9 ± 7.6	37.1 ± 7.6	SQS
LDW-SS32-010	LDW-SSCR20-010	78.9 ± 15.7[d]	21.1 ± 15.7[d]	no exceedances
LDW-SS37-010	LDW-SSCR20-010	65.8 ± 19.2[e]	34.2 ± 19.2[e]	SQS
LDW-SS40-010	LDW-SSCR23-010	79.7 ± 4.9	20.3 ± 4.9	no exceedances
LDW-SS49-010	LDW-SSCR23-010	55.1 ± 17.4	44.9 ± 17.4	SQS
LDW-SS50-010	LDW-SSCR20-010	70.2 ± 10.2	29.8 ± 10.2	no exceedances
LDW-SS56-010	LDW-SSMSMP43-010	67.6 ± 7.2	32.4 ± 7.2	SQS
LDW-SS57-010	LDW-SSCR20-010	55.3 ± 15.1	44.7 ± 15.1	CSL
LDW-SS58-010	LDW-SSCR20-010	61.0 ± 4.0	39.0 ± 4.0	SQS
LDW-SS60-010	LDW-SSMSMP43-010	84.7 ± 6.0	15.3 ± 6.0	no exceedances
LDW-SS70-010	LDW-SSMSMP43-010	60.7 ± 12.0	39.3 ± 12.0	SQS
LDW-SS75-010	LDW-SSMSMP43-010	76.5 ± 7.5	23.5 ± 7.5	no exceedances
LDW-SS88-010	LDW-SSCR23-010	11.9 ± 5.3	88.1 ± 5.3	CSL
LDW-SS89-010	LDW-SSMSMP43-010	86.9 ± 5.1[e]	13.1 ± 5.1[e]	no exceedances
LDW-SS92-010	LDW-SSMSMP43-010	78.3 ± 14.3	21.7 ± 14.3	no exceedances
LDW-SS112-010	LDW-SSCR23-010	65.4 ± 9.6	34.6 ± 9.6	no exceedances
Batch 2				
Negative control	na	85.4 ± 11.6	14.7 ± 11.6	na
LDW-SSMSMP43-010 (ref)	na	76.4 ± 12.2	23.6 ± 12.2	na
LDW-SSCR20-010 (ref)	na	81.9 ± 12.2	18.1 ± 12.2	na
LDW-SSCR23-010 (ref)	na	73.0 ± 6.3	27.0 ± 6.3	na
LDW-SS63-010	LDW-SSMSMP43-010	80.0 ± 1.6	20.0 ± 1.6	no exceedances
LDW-SS114-010	LDW-SSCR23-010	56.6 ± 8.5	43.4 ± 8.5	SQS
LDW-SS115-010	LDW-SSMSMP43-010	77.6 ± 11.0	22.4 ± 11.0	no exceedances
LDW-SS119-010	LDW-SSCR23-010	68.8 ± 7.6	31.2 ± 7.6	no exceedances
LDW-SS120-010	LDW-SSCR23-010	56.3 ± 11.2	43.7 ± 11.2	SQS
LDW-SS121-010	LDW-SSMSMP43-010	76.4 ± 8.0	23.6 ± 8.0	no exceedances
LDW-SS143-010	LDW-SSCR23-010	72.8 ± 3.2	27.2 ± 3.2	no exceedances

[a] Percent mean normal survivorship was calculated by the toxicity testing laboratory by dividing the number of normal survivors in each test sample by the initial stocking density according to PSEP (1995). However, percent normal survivorship can also be calculated by dividing the number of normal survivors in each test sample by the number of survivors in the negative (seawater) control, as is done, for example, for the purposes of dredged material evaluation and disposal (USACE et al. 2000). Calculating normal survivorship in this way would result in slightly higher percent survivorship values, but would not change any of the SMS exceedance results

[b] Effective mortality as reported by the laboratory is a combination of larval mortality and abnormality, and is the complement of normal survivorship (i.e., 100% - effective mortality% = normal survivorship%), which is the metric used in the SQS and CSL biological effects criteria of the SMS

[c] Statistical analyses in SedQual Release 5 include Wilk-Shapiro test for normality and Levene's test for equality of variances, followed by the appropriate statistical test for significance (i.e., Student's t-test, approximate t-test, or Mann-Whitney

[d] One of the five replicates from each of these tests was double-inoculated, so those replicates were not used in calculating mean normal survivorship and mean effective mortality for those test sediments

[e] One of the five replicates from each of these tests was not inoculated at test initiation, so those replicates were not used in calculating mean normal survivorship and mean effective mortality for those test sediments

na - not applicable

SD - standard deviation

SQS - mean normal survivorship < 85% of that of the reference sediment and statistically different ($p \leq 0.10$)

CSL - mean normal survivorship < 70% of that of the reference sediment and statistically different ($p \leq 0.10$)

The results for mean normal survivorship in the negative controls were 98.2 and 85.4% in Batch 1 and Batch 2, respectively, and results for the mean normal survivorship in the three reference sediments ranged from 73.0 to 81.9%. The negative control in the two batches met the performance standard of > 70% mean normal survivorship (Table 3-7). There is no SMS performance standard for reference sediments for use in the bivalve larvae test, although Ecology has guidance stating that normal development in the reference sample must be ≥ 65% of the normal development in the negative control (Gries 2005). Normal development in the reference sediments ranged from 100 to 105% of that of the negative control (see Appendix D-2).

The effect concentration (50%) (EC50) values from the positive control tests were within the laboratory warning limits of one standard deviation of the control chart mean of previous EC50 values, indicating that the test organisms were of similar sensitivity to those previously tested at the laboratory.

Based on a comparison to SMS biological effects criteria for bivalve larvae toxicity tests, nine test sediment samples were classified as SQS exceedances and two test sediment samples as CSL exceedances (Table 5-28).

Water quality results for the 48-hr bivalve larvae toxicity test are summarized in Table 5-26. All water quality parameters in the two batches were within protocol-specified ranges. The water quality results are presented in detail in Appendices D-2 and D-3.

Table 5-28. Water quality measurements for the bivalve larvae sediment toxicity tests

Parameter	Batch 1			Batch 2		
	Mean ± SD	Minimum	Maximum	Mean ±SD	Minimum	Maximum
Temperature (°C)	15.9 ± 0.3	15.4	16.4	14.9 ± 0.5	14.4	16.2
Dissolved oxygen (mg/L)	7.1 ± 0.9	5.7	8.9	8.5 ± 0.4	7.5	8.8
Salinity (ppt)	28.1 ± 0.3	27.0	29.0	27.7 ± 0.5	27.0	28.0
pH	7.7 ± 0.21	7.4	7.9	7.7 ± 0.1	7.5	7.9

SD - standard deviation

The sulfides and ammonia results for the 48-hr bivalve larvae toxicity test are summarized in Table 5-29. Positive control tests for ammonia were conducted concurrently with the sediment toxicity tests. The EC50 values for the two batches were 5.7 mg/L, and 6.7 mg/L total ammonia-N. All ammonia concentrations in the water overlying the test sediment samples were well below the EC50 concentrations.

Table 5-29. Sulfides and ammonia measurements for overlying water in the bivalve larvae sediment toxicity tests

Parameter	Batch 1		Batch 2	
	Minimum	Maximum	Minimum	Maximum
Dissolved sulfides (mg/L)	0.000	0.145	0.004	0.155
Total ammonia-N (mg/L)	<0.1	1.24	<0.1	0.54

5.6 Summary of Toxicity Test Results

Table 5-30 presents results from the comparison to SMS biological effects criteria for each of the three toxicity tests. Figures 5-4a through 5-4c (located in the map folio) present these results graphically. Nine test sediment samples exceeded the biological effects criterion for one toxicity test, six test sediment samples exceeded the criteria for two toxicity tests, and one test sediment sample exceeded the criteria for all three toxicity tests. An exceedance of the SQS in any two toxicity tests at one location is considered a CSL exceedance for that location. Overall, there were six sediment samples that exceeded the SQS and ten sediments that exceeded the CSL.

Table 5-30. Summary of SMS biological effects criteria exceedances for the three toxicity tests

Sample ID	Individual Test Exceedances			Overall Exceedance
	Amphipod Test	Polychaete Test	Bivalve Larvae Test	
LDW-SS15-010	SQS	-	-	SQS
LDW-SS17-010	SQS	-	-	SQS
LDW-SS22-010	SQS	SQS	SQS	CSL[a]
LDW-SS26-010	-	-	-	-
LDW-SS31-010	CSL	-	SQS	CSL
LDW-SS32-010	SQS	-	-	SQS

Sample ID	Individual Test Exceedances			Overall Exceedance
	Amphipod Test	Polychaete Test	Bivalve Larvae Test	
LDW-SS37-010	CSL	-	SQS	CSL
LDW-SS40-010	CSL	-	-	CSL
LDW-SS49-010	CSL	-	SQS	CSL
LDW-SS50-010	CSL	-	-	CSL
LDW-SS56-010	-	-	SQS	SQS
LDW-SS57-010	-	-	CSL	CSL
LDW-SS58-010	-	SQS	SQS	CSL[a]
LDW-SS60-010	-	-	-	-
LDW-SS63-010	-	-	-	-
LDW-SS70-010	-	-	SQS	SQS
LDW-SS75-010	-	-	-	-
LDW-SS88-010	CSL	-	CSL	CSL
LDW-SS89-010	-	-	-	-
LDW-SS92-010	-	-	-	-
LDW-SS112-010	-	-	-	-
LDW-SS114-010	CSL	-	SQS	CSL
LDW-SS115-010	-	-	-	-
LDW-SS119-010	-	-	-	-
LDW-SS120-010	-	-	SQS	SQS
LDW-SS121-010	-	-	-	-
LDW-SS143-010	-	-	-	-

[a] An exceedance of the SQS in any two toxicity tests at one location is considered a CSL exceedance for that location

5.7 Toxicity Test Data Validation Results

Independent data validation of all results was conducted by Dinnel Marine Resources (DMR). The data validation process was performed as described in the QAPP (Section 5.1.2) and the validation reports for the Round 1 sediment toxicity testing conducted by the two laboratories are presented in Appendix C-3.

The toxicity test data validation process included the following tasks:

- a pre-test review of the standard operating procedures (SOPs)
- on-site laboratory visit to evaluate testing facilities and procedures
- an initial evaluation of all data for completeness, correct data entries, and accurate transcription to electronic formats
- a validation report of overall data quality and usability

DMR found the SOPs from both laboratories to be in excellent condition, and only minor changes were needed to the bivalve SOP other than the additional project-specific provisions requested by Windward (see Appendix C-2).

An on-site visit to Weston's Tiburon toxicity test laboratory occurred before initiation of the bivalve larvae tests to evaluate equipment and personnel qualifications. No test-in-progress audits of the bivalve larvae tests were conducted because of the travel distance involved and the very short duration of the bivalve larvae tests (48 hours). Weston's toxicity test laboratory, equipment, and credentials of the testing personnel all appeared to be in order. No modifications to the laboratory or equipment were required. An unannounced test-in-progress audit was conducted at the NAS laboratory during the Round 1 testing. All three batches of both the amphipod and polychaete tests were either in progress or being initiated. Auditors concluded that all PSEP (1995) and project-specific protocol provisions were being followed without any apparent deviations, as discussed in the DMR validation report, presented in Appendix C-2. Completed test-in-progress audit checklists are included in Appendix C-2.

All raw data forms and electronic database files generated by both laboratories were reviewed for completeness and fidelity of transcription to electronic formats. A 100% check was made of all data entered into each laboratory's internal electronic database. All errors, omissions, clarifications, or changes needed to the draft reports were documented and communicated to the laboratories. All needed corrections to the data reports were made by the laboratories and subsequently verified by DMR. Minor deviations to the methods and procedures were found during this validation process (see Section 3.3.2); DMR concluded that these deviations had no effect on the data quality.

6.0 References

ASTM. 2004. Standard test method for measuring the toxicity of sediment-associated contaminants with estuarine and marine invertebrates. Method E1367-03. In: 2004 Annual book of ASTM standards, vol 11.05, Biological effects and environmental fate; biotechnology; pesticides. American Society for Testing and Materials, West Conshohocken, PA.

Ecology. 2003. Sediment sampling and analysis plan appendix: guidance on the development of sediment sampling and analysis plans meeting the requirements of the sediment management standards (chapter 173-204 WAC). Ecology Publication No. 03-09-043. PTI Environmental Services, Bellevue, WA.

Ecology. 2004. SEDQUAL sediment quality information system. Release 5. Sediment Management Unit, Washington Department of Ecology, Olympia, WA.

Gries TH. 2005. Personal communication (e-mail to Berit Bergquist, Windward Environmental, regarding WDOE bioassay performance criteria). Washington Department of Ecology, Lacey, WA. 9/22/05.

Krone CA, Brown DW, Burrows DG, Chan SL, Varanasi U. 1989. Butyltins in sediment from marinas and waterways in Puget Sound Washington State, USA. Mar Pollut Bull 20:528-531.

Plumb R, Jr. 1981. Procedures for handling and chemical analysis of sediment and water samples. Waterways Experiment Station, US Army Corps of Engineers, Vicksburg, MS.

PSEP. 1986. Recommended protocols for measuring conventional sediment variables in Puget Sound. Prepared for the Puget Sound Estuary Program. US Environmental Protection Agency, Region 10, Seattle, WA.

PSEP. 1995. Recommended guidelines for conducting laboratory bioassays on Puget Sound sediments. Final Report. Prepared for the Puget Sound Estuary Program, U.S. Environmental Protection Agency, Region 10, Office of Puget Sound, and U.S. Army Corps of Engineers, Seattle District, Seattle, WA. PTI Environmental Services, Inc., Seattle, WA.

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.

Romberg P. 2003. Duwamish/Diagonal sediment remediation, dredging and capping operations, sediment monitoring, sampling and analysis plan. King County Department of Natural Resources, Seattle, WA.

USACE, EPA, WDNR, Ecology. 2000. Dredged material evaluation and disposal procedures. A user's manual for the Puget Sound Dredged Disposal Analysis (PSDDA) Program. US Army Corps of Engineers, Seattle District, Seattle, WA; US Environmental Protection Agency, Region 10, Seattle, WA; Washington Department of Natural Resources; and Washington Department of Ecology.

Windward. 2004. Lower Duwamish Waterway remedial investigation. Task 8: Phase 2 RI work plan. Prepared for Lower Duwamish Waterway Group. Windward Environmental LLC, Seattle, WA.

Windward. 2005a. Lower Duwamish Waterway remedial investigation. Data report: Chemical analyses of benthic invertebrate and clam tissue samples and co-located sediment samples. Prepared for Lower Duwamish Waterway Group. Windward Environmental LLC, Seattle, WA.

Windward. 2005b. Lower Duwamish Waterway remedial investigation. Data report: Fish and crab tissue collection and chemical analyses. Prepared for Lower Duwamish Waterway Group. Windward Environmental LLC, Seattle, WA.

Windward. 2005c. Lower Duwamish Waterway remedial investigation. Quality assurance project plan: surface sediment sampling and toxicity testing of the Lower Duwamish Waterway. Prepared for Lower Duwamish Waterway Group. Windward Environmental LLC, Seattle, WA.

Oversize Figures

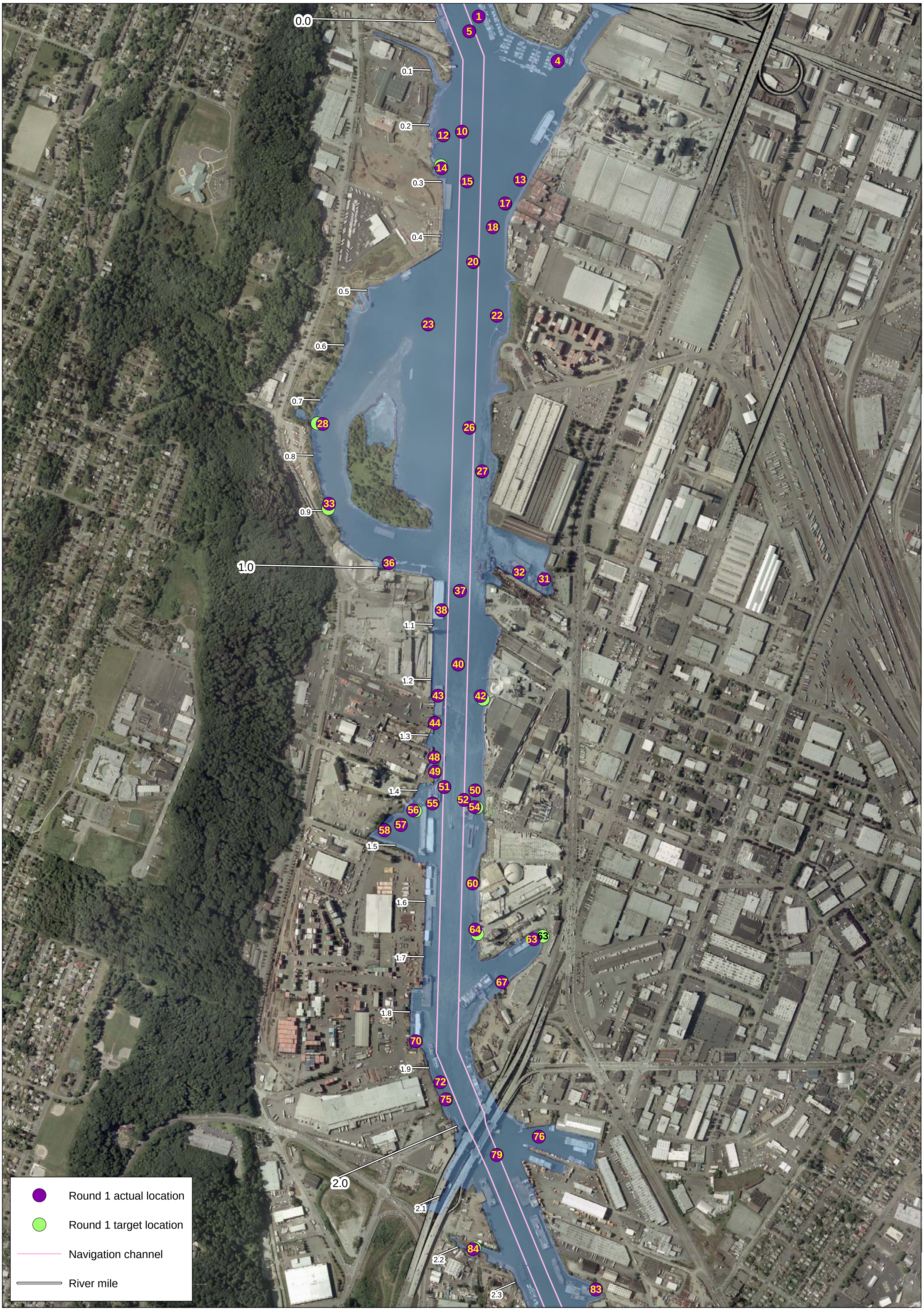

Figure 2-1a. Round 1 target and actual surface sediment locations (RM 0.0-2.3)

FINAL

0 0.2 Miles
0 0.2 Kilometers

N

Windward environmental LLC

Prepared by LSM 06/10/05, updated STS 07/01/05, 10/21/05 Map 1817

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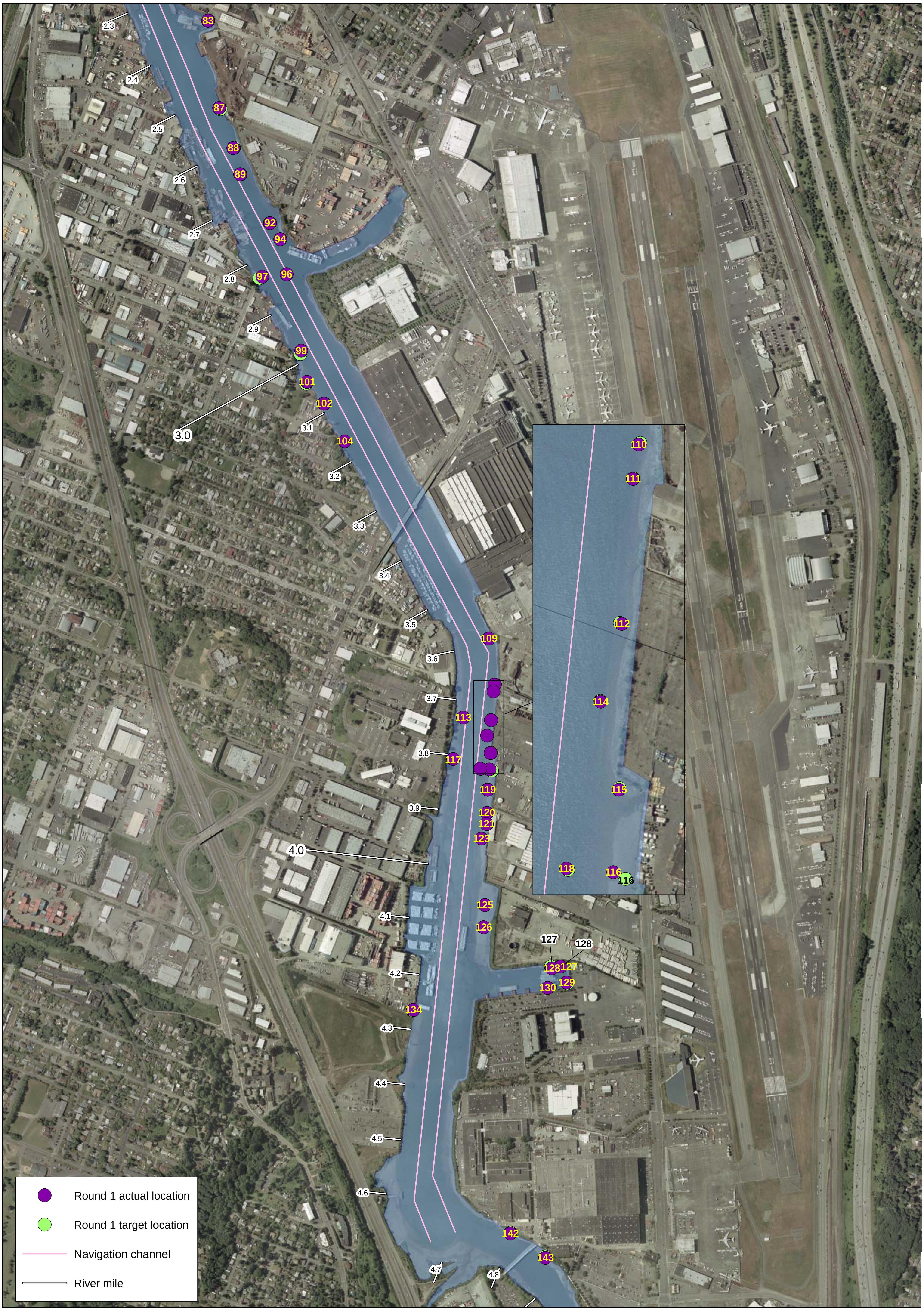

Figure 2-1b. Round 1 target and actual surface sediment locations (RM 2.3-4.8)

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Prepared by LSM 06/10/05, updated STS 07/01/05, 10/21/05 Map 1817

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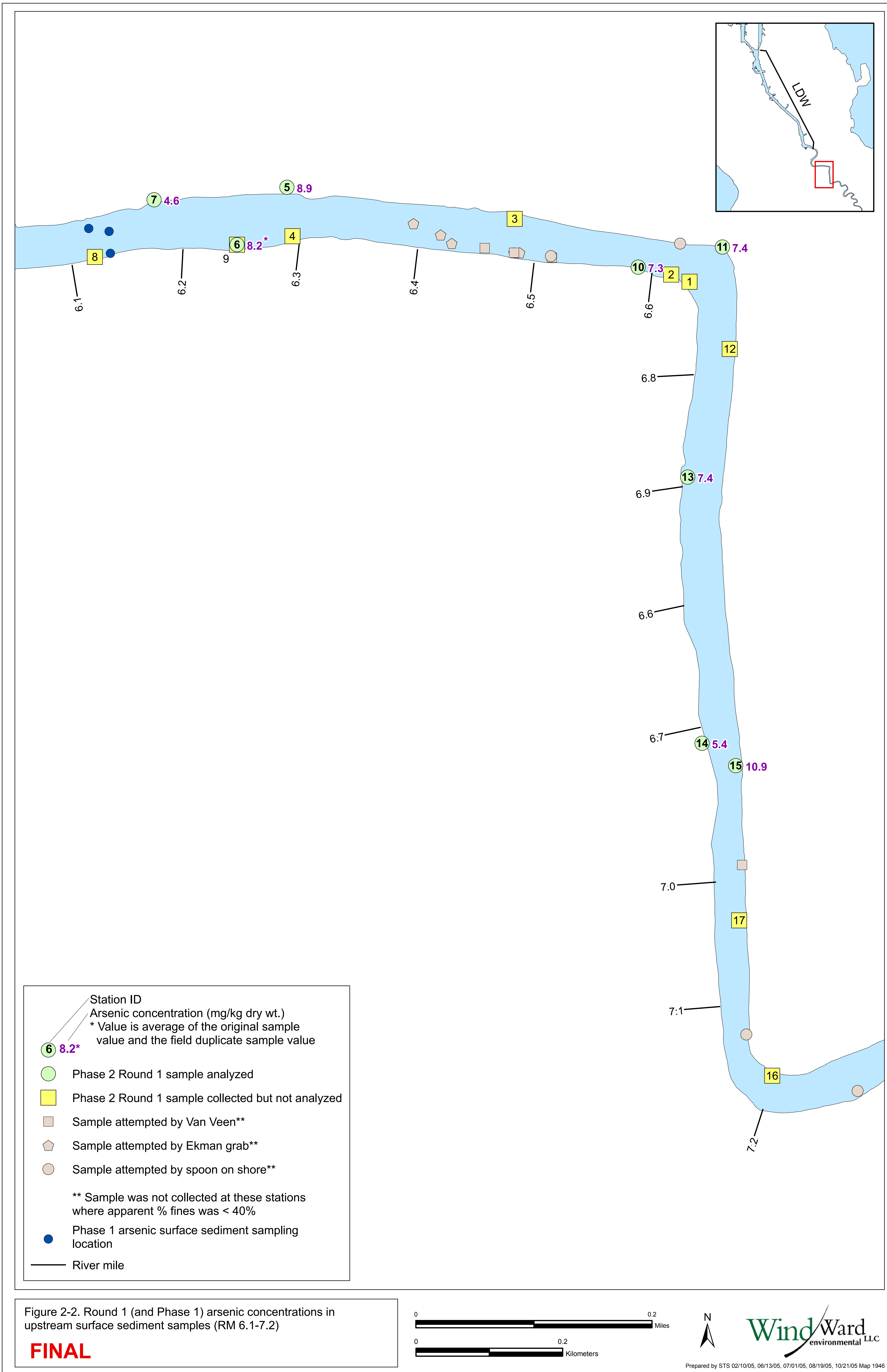

Figure 2-2. Round 1 (and Phase 1) arsenic concentrations in upstream surface sediment samples (RM 6.1-7.2)

FINAL

Windward environmental LLC

Prepared by STS 02/10/05, 06/13/05, 07/01/05, 08/19/05, 10/21/05 Map 1946

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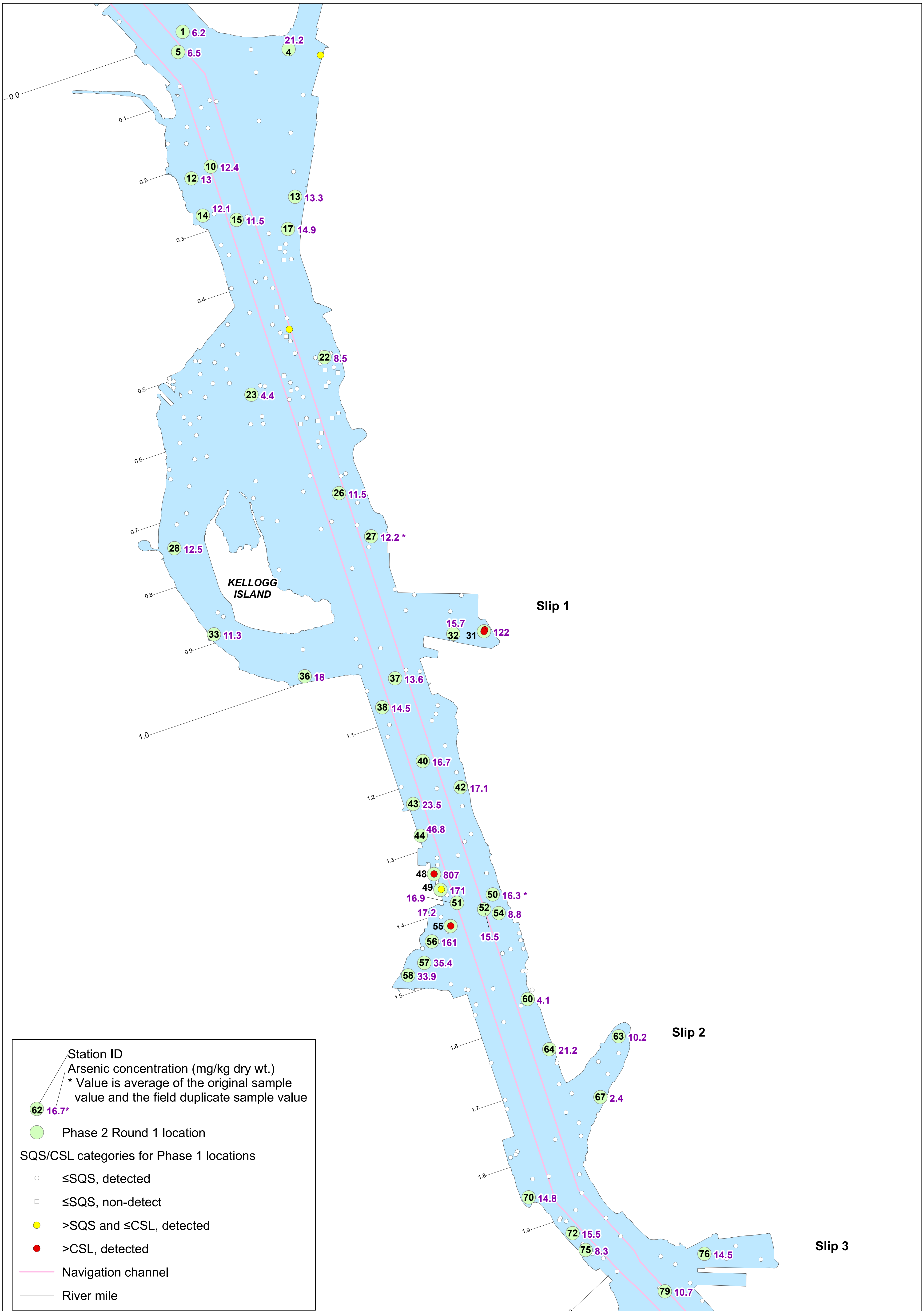

Figure 5-1a. Round 1 arsenic concentrations in surface sediment samples (RM 0.0-2.0)

FINAL

0 0.2 Miles

0 0.2 Kilometers

N

WindWard environmental LLC

Prepared by CEJ 09/07/05, 10/21/05, Map 1972

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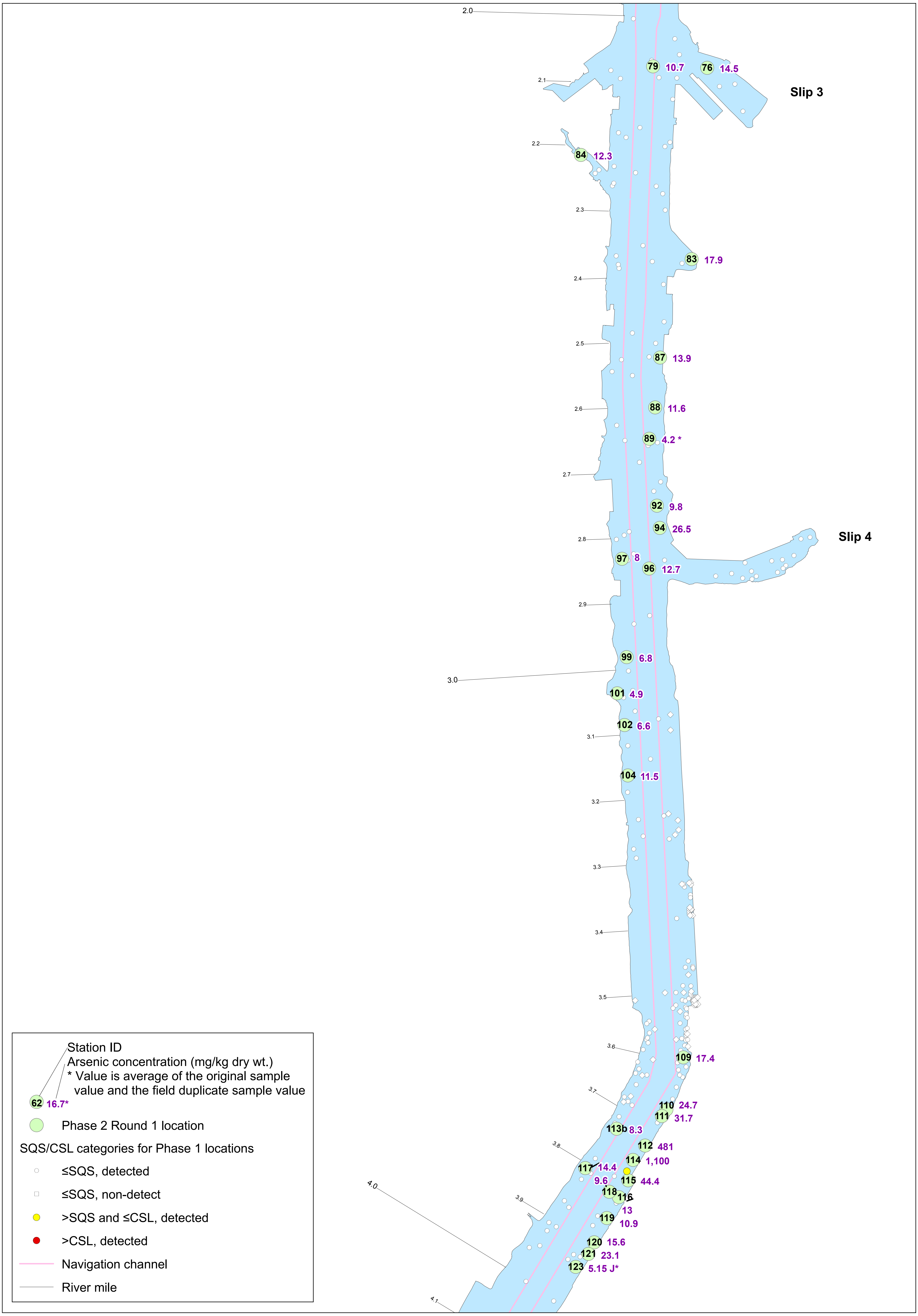

Figure 5-1b. Round 1 arsenic concentrations in surface sediment samples (RM 2.0-4.0)

FINAL

0 0.2 Miles

0 0.2 Kilometers

N

Wind Ward environmental LLC

Prepared by CEJ 09/07/05, 10/21/05 Map 1972

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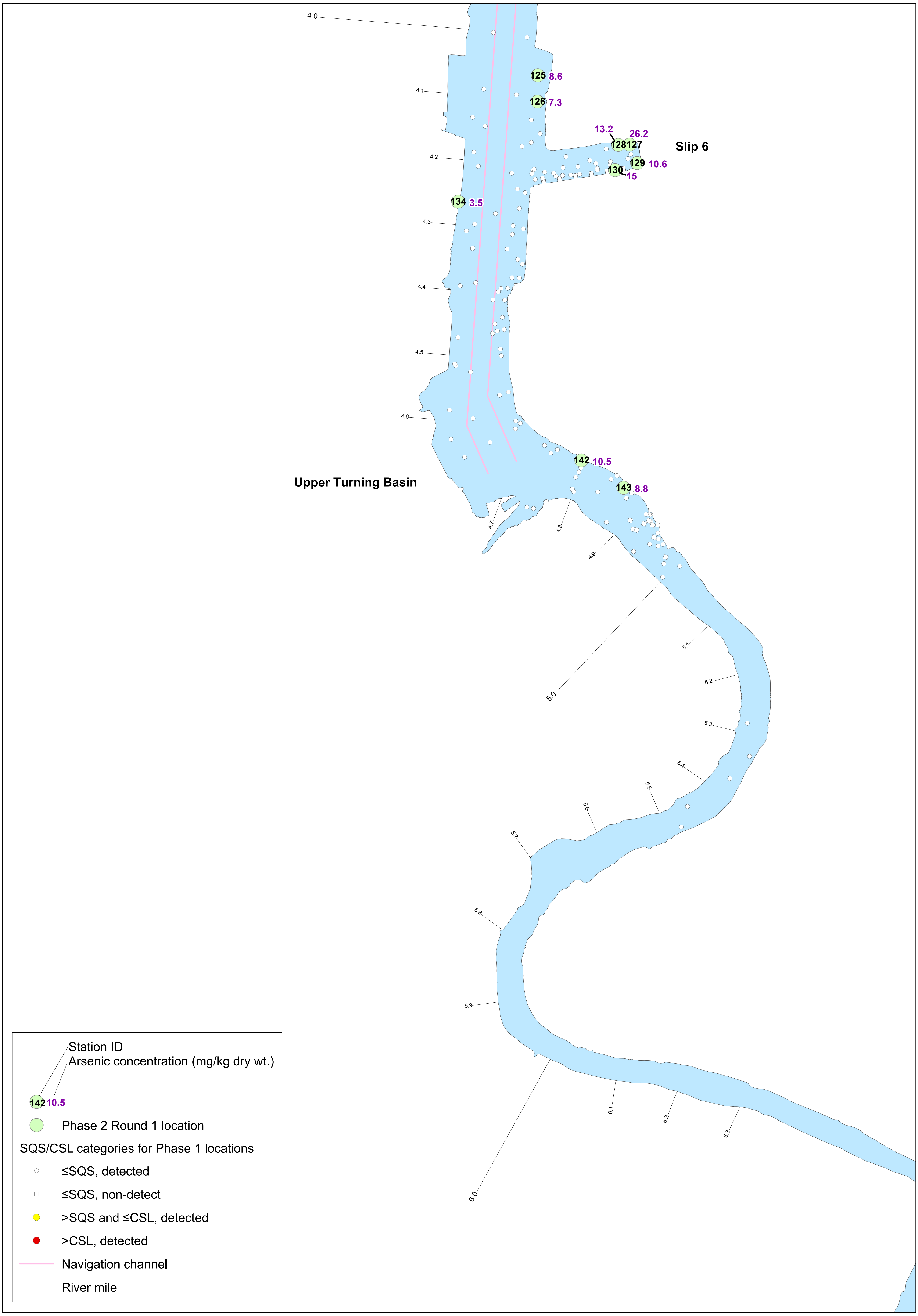

Figure 5-1c. Round 1 arsenic concentrations in surface sediment samples (RM 4.0-6.0)

FINAL

0 0.2 Miles

0 0.2 Kilometers

N

Windward environmental LLC

Prepared by CEJ 09/07/05, 10/21/05 Map 1972

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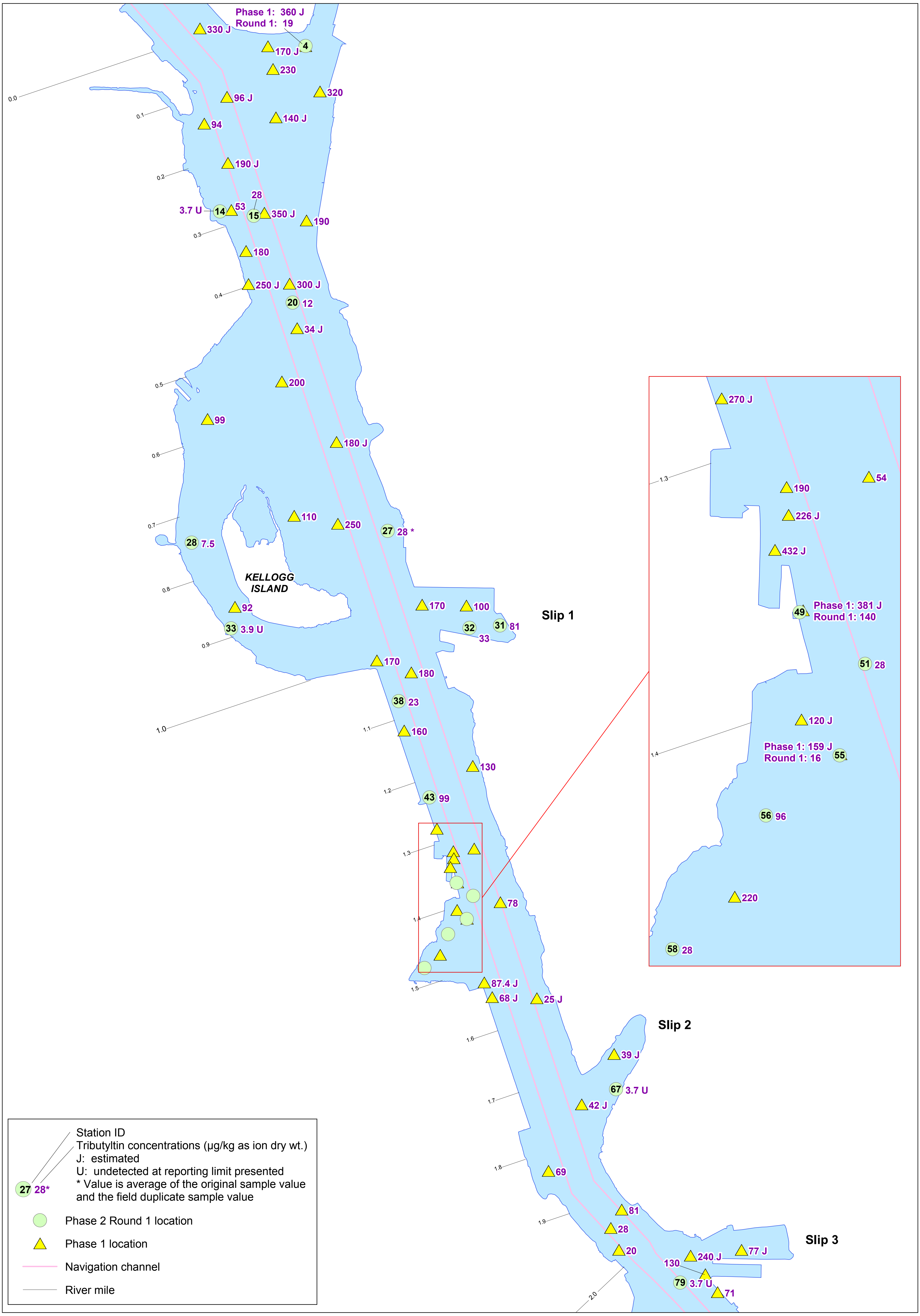

Figure 5-2a. Round 1 (and Phase 1) TBT concentrations in surface sediment samples (RM 0.0-2.0)

FINAL

0 0.2 Miles

0 0.2 Kilometers

N

Windward environmental LLC

Prepared by STS 07/22/05, 09/07/05, 10/21/05, Map 1857

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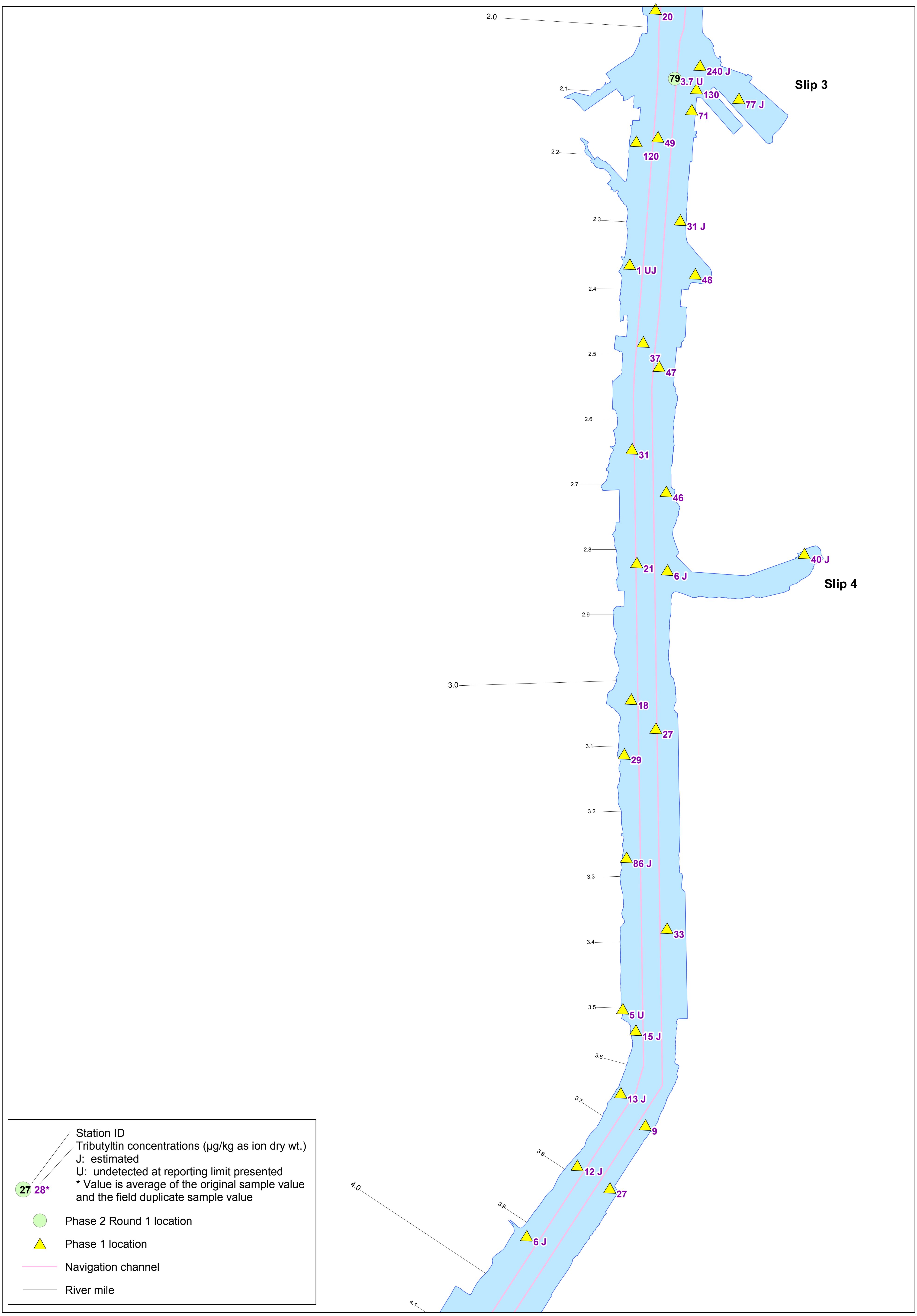

Figure 5-2b. Round 1 (and Phase 1) TBT concentrations in surface sediment samples (RM 2.0-4.0)

FINAL

Windward environmental LLC

Prepared by STS 07/22/05, 09/07/05, 10/21/05 Map 1857

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Figure 5-2c. Round 1 (and Phase 1) TBT concentrations in surface sediment samples (RM 4.0-6.0)

FINAL

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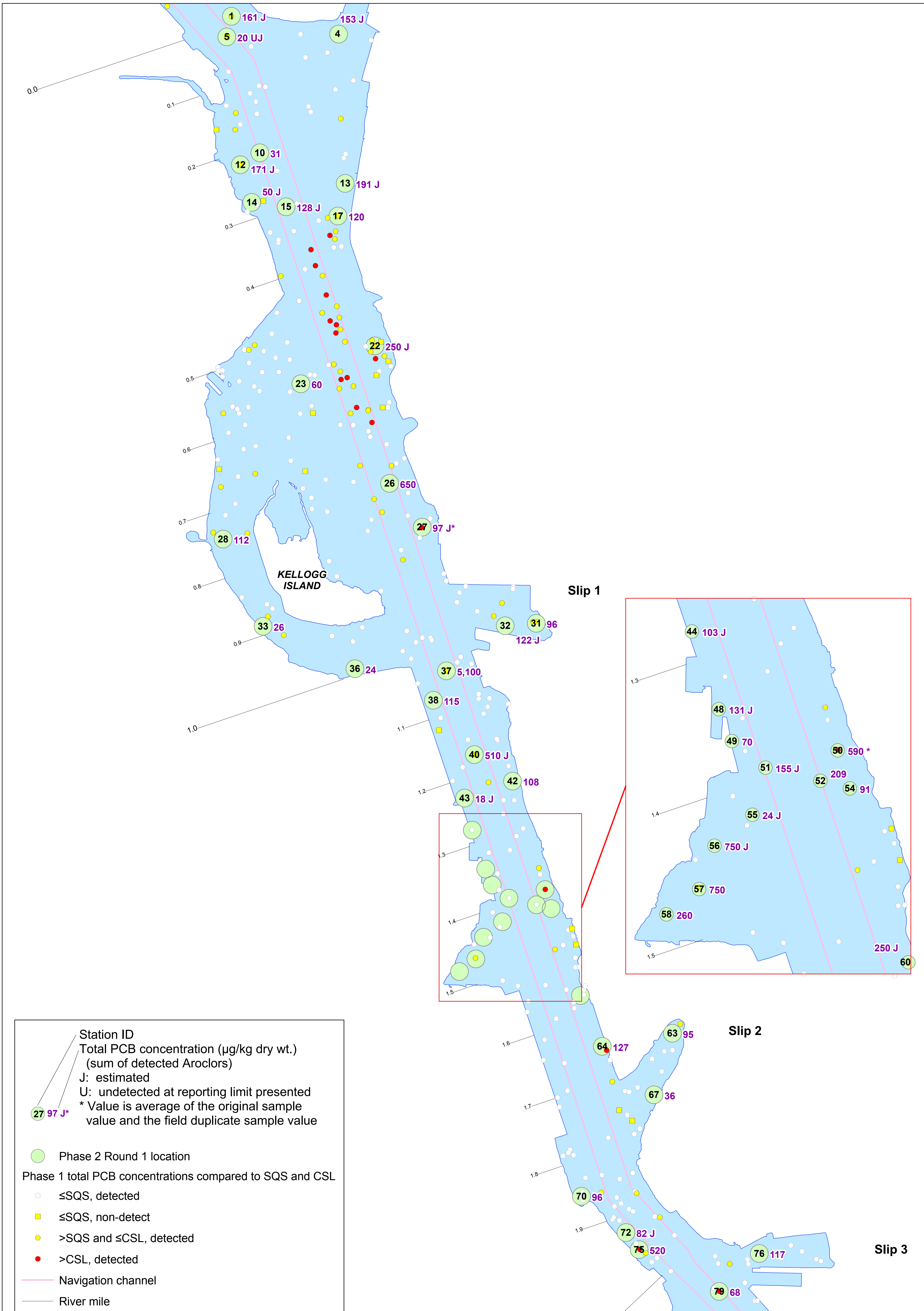

Figure 5-3a. Round 1 total PCB concentrations in surface sediment samples (RM 0.0-2.0)

FINAL

0 0.2 Miles

0 0.2 Kilometers

N

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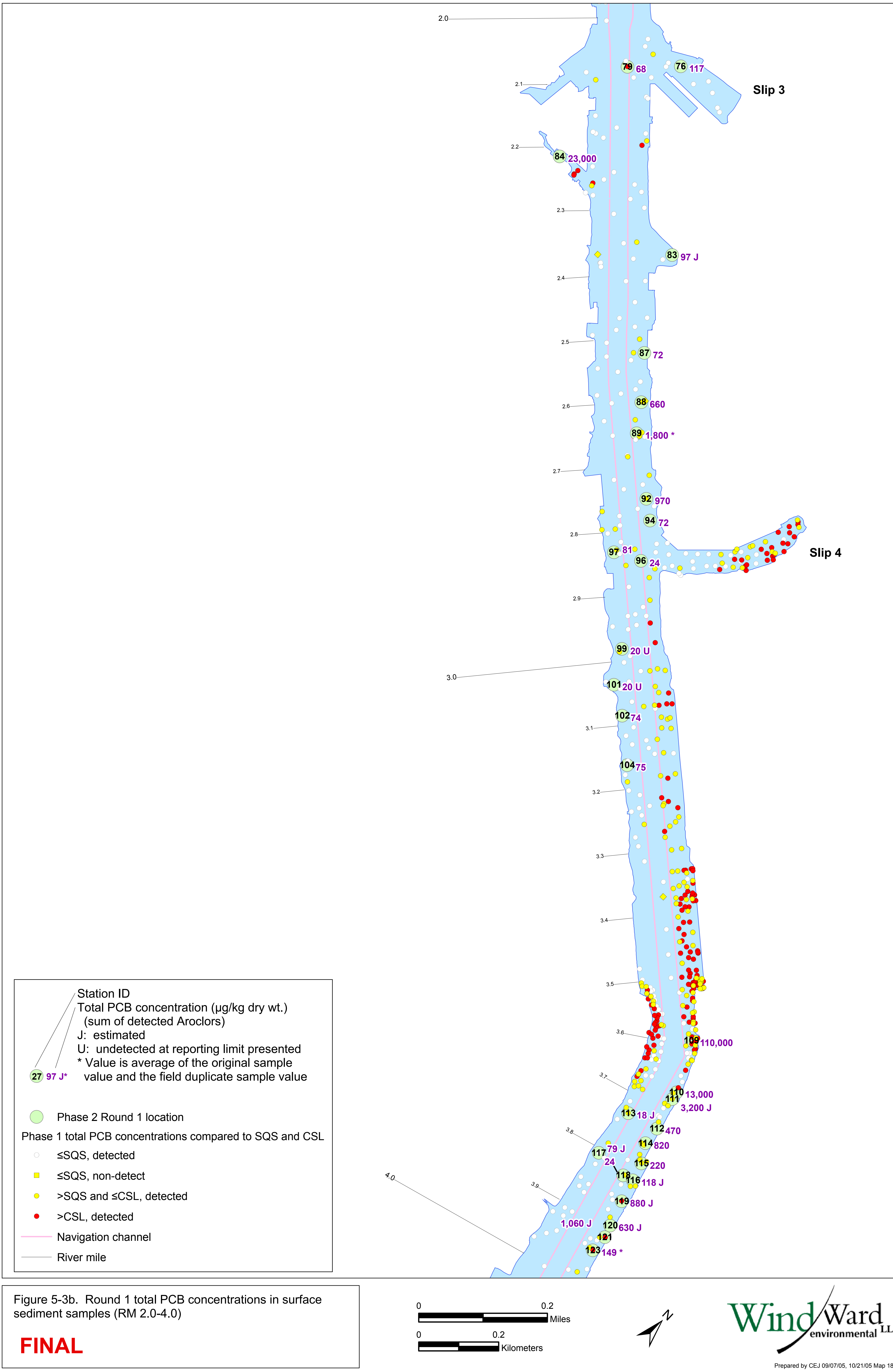

Figure 5-3b. Round 1 total PCB concentrations in surface sediment samples (RM 2.0-4.0)

FINAL

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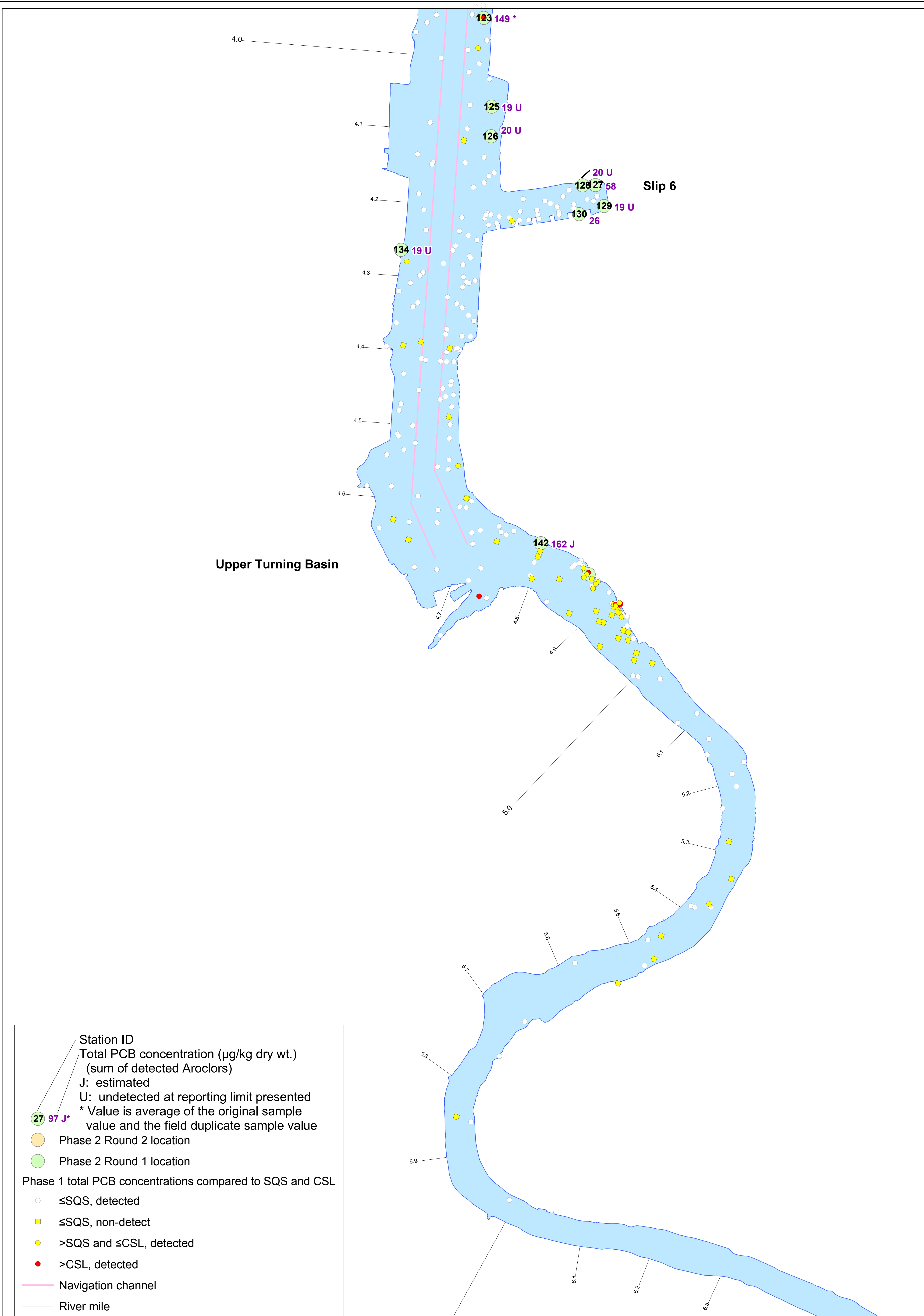

Figure 5-3c. Round 1 total PCB concentrations in surface sediment samples (RM 4.0-6.0)

FINAL

0 0.2 Miles

0 0.2 Kilometers

N

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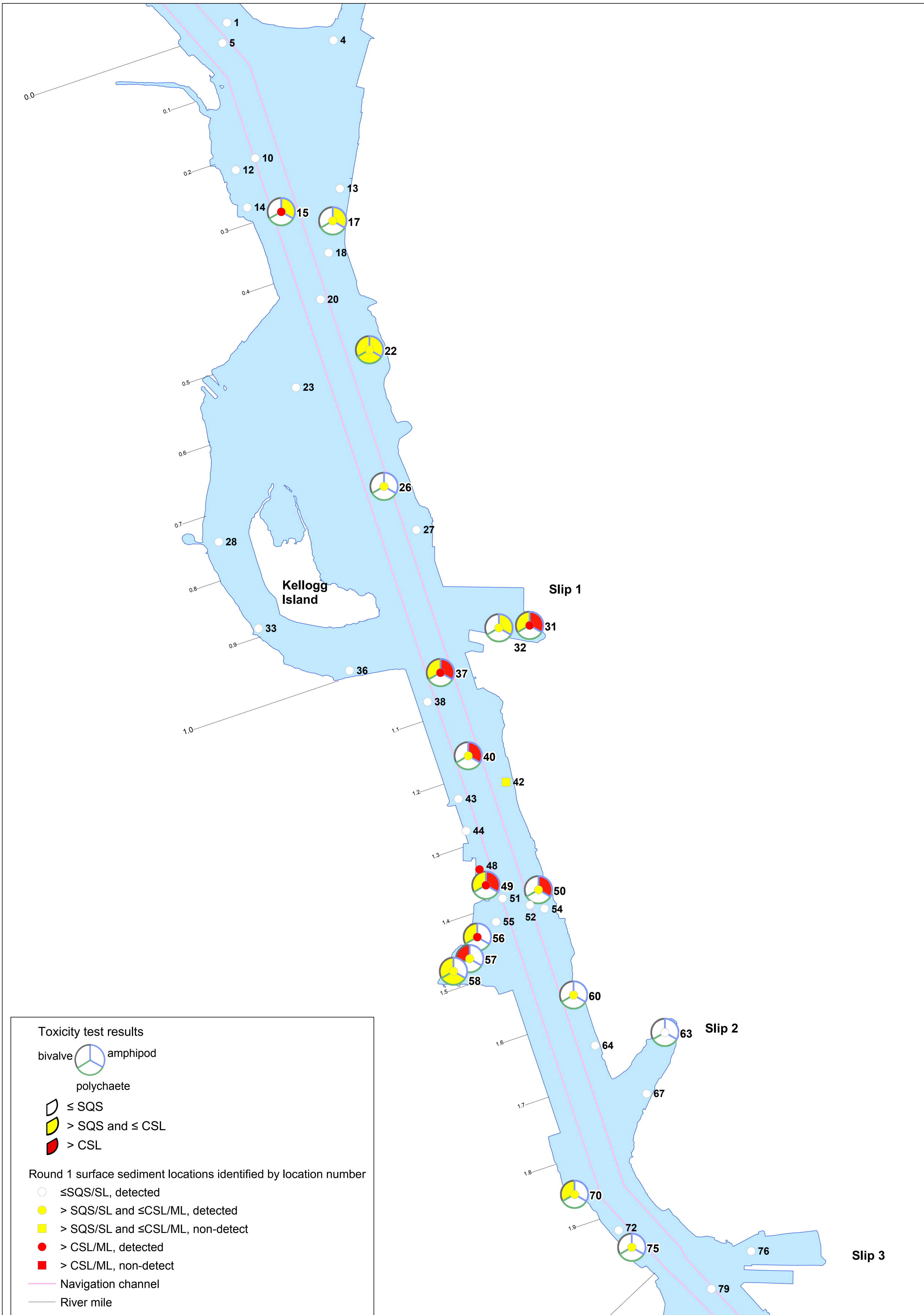

Figure 5-4a. Round 1 surface sediment chemistry and toxicity test results compared to the SQS and CSL of the SMS (RM 0.0 -2.0)

FINAL

0 0.2 Miles

0 0.2 Kilometers

N

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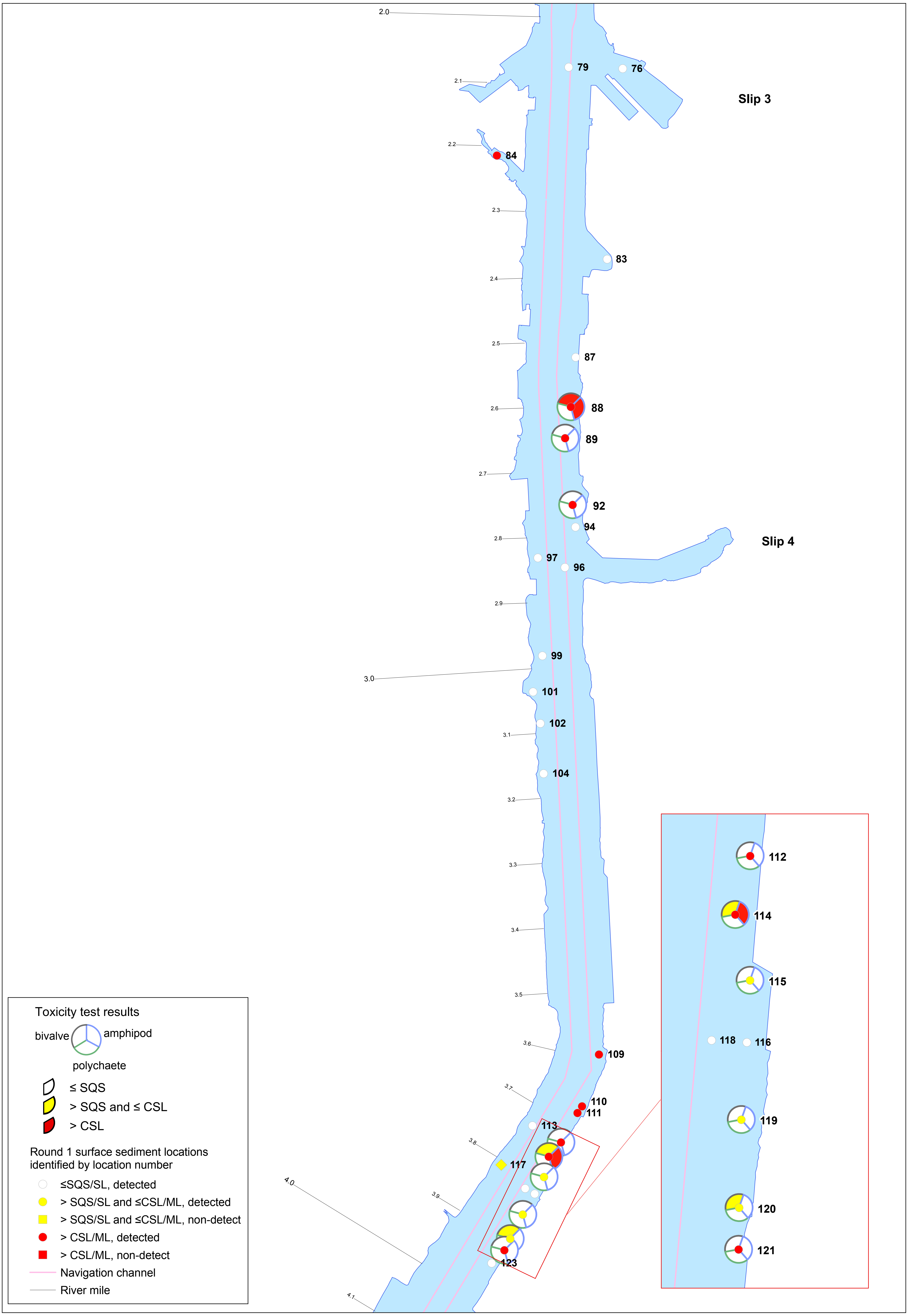

Figure 5-4b. Round 1 surface sediment chemistry and toxicity test results compared to the SQS and CSL of the SMS (RM 2.0-4.0)

FINAL

0 0.2 Miles

0 0.2 Kilometers

N

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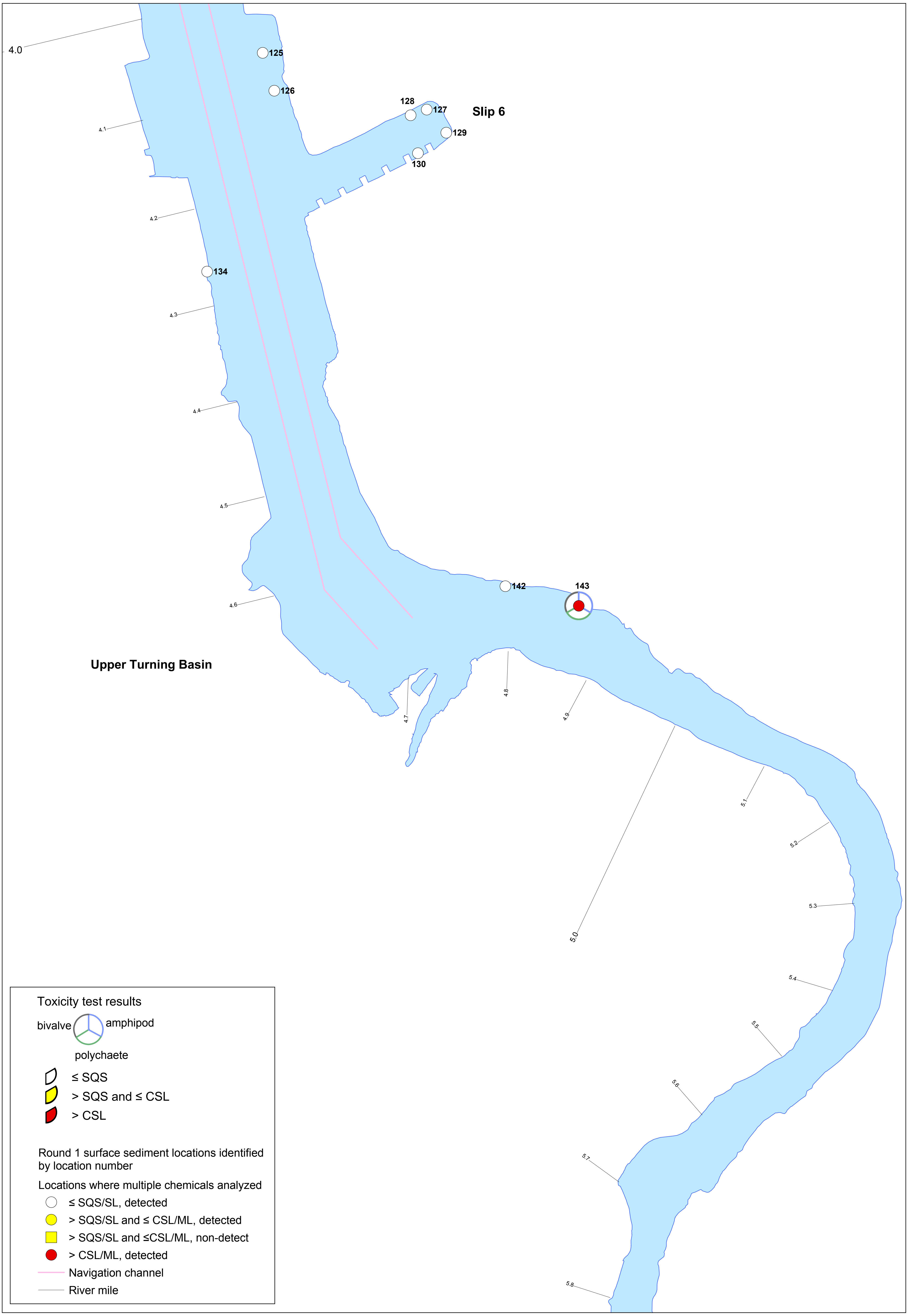

Figure 5-4c. Round 1 surface sediment chemistry and toxicity test results compared to the SQS and CSL of the SMS (RM 4.0-6.0)

FINAL

0 0.2 Miles

0 0.2 Kilometers

N

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