Lower Duwamish Waterway Group

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

Lower Duwamish Waterway Remedial Investigation

DATA REPORT:
ROUND 3 SURFACE SEDIMENT SAMPLING FOR CHEMICAL ANALYSES
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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Appendices D through G, which consist of detailed validation reports and scanned versions of original field and laboratory documents, may be viewed at http://www.ldwg.org/rifs_docs4.htm. These materials will also be provided on a compact disk at the back of the data report.

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Acronyms

ACRONYM	Definition
2LAET	second lowest apparent effects threshold
%D	percent difference
%RSD	percent relative standard deviation
ACG	analytical concentration goal
AET	apparent effects threshold

ACRONYM	Definition
ARI	Analytical Resources, Inc.
Axys	Axys Analytical Services, Ltd.
CCV	continuing calibration verification
CSL	cleanup screening level
CVAA	cold vapor atomic absorption
DMMP	Dredged Material Management Program
dw	dry weight
Ecology	Washington State Department of Ecology
EPA	US Environmental Protection Agency
GC/ECD	gas chromatography-electron capture detection
GC/MS	gas chromatography-mass spectrometry
HPAH	high-molecular-weight polycylic aromatic hydrocarbon
HpCDD	heptachlorodibenzo-*p*-dioxin
HpCDF	heptachlorodibenzofuran
HRGD/HRMS	high-resolution gas chromatography/high-resolution mass spectrometry
HxCDD	hexachlorodibenzo-*p*-dioxin
HxCDF	hexachlorodibenzofuran
ICP-AES	inductively coupled plasma-atomic emission spectrometry
ICP-MS	inductively coupled plasma mass spectrometry
ICS	interference check sample
ICV	initial calibration verification
ID	identification
LAET	lowest apparent effects threshold
LCS	laboratory control sample
LDC	Laboratory Data Consultants, Inc.
LDW	Lower Duwamish Waterway
LDWG	Lower Duwamish Waterway Group
LPAH	low-molecular-weight polycyclic aromatic hydrocarbon
MDL	method detection limit
ML	maximum level
MLLW	mean lower low water
MS	matrix spike
MSD	matrix spike duplicate
NAD83	North American Datum of 1983

ACRONYM	Definition
OC	organic carbon
OCDD	octachlorodibenzo-*p*-dioxin
OCDF	octachlorodibenzofuran
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PDT	Pacific Daylight Time
PeCDD	pentachlorodibenzo-*p*-dioxin
PeCDF	pentachlorodibenzofuran
PQL	practical quantitation limit
PSEP	Puget Sound Estuary Program
QAPP	quality assurance project plan
QC	quality control
RB	rinsate blank
RI	remedial investigation
RL	reporting limit
RPD	relative percent difference
SDG	sample delivery group
SIM	selected ion monitoring
SL	screening level
SMS	Washington State Sediment Management Standards
SQS	sediment quality standard
SRM	standard reference material
SVOC	semivolatile organic compound
TCDD	tetrachlorodibenzo-*p*-dioxin
TCDF	tetrachlorodibenzofuran
TEF	toxic equivalency factor
TEQ	toxic equivalent
TOC	total organic carbon
Windward	Windward Environmental LLC

1.0 Introduction

This data report presents the results of chemical analyses conducted on surface sediment samples collected in Round 3 as part of the Phase 2 Remedial Investigation (RI) for the Lower Duwamish Waterway (LDW). The surface sediment quality assurance project plan (QAPP) addendum (Windward 2006b) presented the design for the collection and analysis of Round 3 samples, including details on project organization, field sample collection, laboratory analyses, and data management. The data collected during Round 3 surface sediment sampling will be presented and discussed in the Phase 2 RI in conjunction with other datasets (i.e., Phase 2, Rounds 1 and 2, and Phase 1) to support the feasibility study. The Round 3 data will not be incorporated into the baseline risk assessments. Instead, potential implications of the Round 3 data on risk conclusions will be discussed in an appendix to the RI.

Surface sediment samples (0 to 10 cm) were collected at 44 locations in the LDW during the Round 3 surface sediment sampling event in October 2006. All samples were analyzed for the chemicals listed in the Washington State Sediment Management Standards (SMS). In addition, a subset of these samples was analyzed for dioxins/furans, and a separate subset was analyzed for butyltins.

The remainder of this report is organized as follows:

- Section 2 – Surface sediment collection methods
- Section 3 – Laboratory methods
- Section 4 – Results
- Section 5 – References

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

- Appendix A – Data tables for Round 3
- Appendix B – Summary data tables for Rounds 1, 2, and 3 combined
- Appendix C – Data management
- Appendix D – Data validation reports
- Appendix E – Raw laboratory data
- Appendix F – Collection forms and field notes
- Appendix G – Chain-of-custody forms

Appendices D through G, which consist of detailed validation reports and scanned versions of original field and laboratory documents may be viewed at http://www.ldwg.org/rifs_docs.htm. These materials will also be provided on a compact disk at the back of the data report.

2.0 Surface Sediment Collection Methods

This section describes the methods used to collect the Round 3 surface sediment samples and includes a discussion of the sample identification (ID) scheme, sample locations, collection methods, and field deviations from the original QAPP and QAPP addendum (Windward 2005, 2006b). Additional details regarding the surface sediment collection methods are presented in the original QAPP (Windward 2005).

Copies of field notes, surface sediment collection forms, and protocol modification forms are presented in Appendix F. Copies of completed chain-of-custody forms used to track sample custody are presented in Appendix G.

2.1 SAMPLE IDENTIFICATION SCHEME

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

The sample IDs are similar to the location IDs but include a suffix of "010" to indicate that sediment from the 0-to-10-cm depth range was included in the sample. For example, the sediment sample collected at location LDW-SS301 was identified as LDW-SS301-010. Three field duplicate samples were identified using sampling location numbers LDW-SS401 through LDW-SS403. Rinsate blanks (RBs) were identified by the location identifier followed by the suffix "RB" (e.g., LDW-SS301-RB).

2.2 SAMPLING LOCATIONS

Round 3 surface sediment samples were collected from 44 sampling locations on October 2 to 4, 2006 (Table 2-1 and Figure 2-1). The rationale for selecting these sediment sampling locations is presented in the QAPP addendum (Windward 2006b).

Table 2-1. Round 3 surface sediment sampling locations

Sampling Location	Date	Time (PDT)	Target Location[a]		Actual Location[a]		Distance from Target (m)	Depth Above (+) or Below (-) MLLW (ft)
			X	Y	X	Y		
LDW-SS301[b]	10/03/06	1205	1266210	211325	1266211	211325	0.4	-10.0
LDW-SS302	10/03/06	1218	1266437	211221	1266435	211223	0.8	-19.6
LDW-SS303	10/04/06	1153	1266910	211349	1266944	211347	10.4[c]	-16.8
LDW-SS304	10/04/06	1445	1267051	211325	1267012	211261	22.9[c]	-22.2
LDW-SS305	10/03/06	1344	1267097	211038	1267099	211040	0.5	-7.8
LDW-SS306	10/03/06	1412	1265950	210561	1265949	210564	0.9	+5.5
LDW-SS307	10/03/06	1356	1267019	210683	1267017	210683	0.5	-24.7
LDW-SS308	10/03/06	1432	1266431	209987	1266432	209989	0.6	-39.4
LDW-SS309	10/03/06	1446	1266471	209768	1266473	209769	0.7	-40.4

Sampling Location	Date	Time (PDT)	Target Location[a]		Actual Location[a]		Distance from Target (m)	Depth Above (+) or Below (-) MLLW (ft)
			X	Y	X	Y		
LDW-SS310	10/03/06	1457	1266483	209455	1266483	209453	0.7	-40.5
LDW-SS311	10/03/06	1523	1265971	208308	1265999	208295	9.4	+2.9
LDW-SS312	10/03/06	1537	1265952	208004	1265998	208009	14.0[c]	+4.3
LDW-SS313	10/04/06	0914	1266326	207619	1266327	207620	0.5	+8.4
LDW-SS314	10/04/06	0914	1266203	207452	1266205	207452	0.6	+4.4
LDW-SS315	10/04/06	1135	1267334	207247	1267324	207229	6.3	-32.6
LDW-SS316	10/04/06	1125	1267300	207014	1267299	207017	0.9	-20.0
LDW-SS317	10/04/06	1114	1267481	207060	1267481	207068	2.5	-34.4
LDW-SS318	10/04/06	1056	1267471	206835	1267464	206831	2.4	-35.2
LDW-SS319	10/04/06	1005	1267822	206718	1267816	206721	2.0	-24.1
LDW-SS320	10/04/06	0955	1267960	206670	1267963	206669	1.1	-22.4
LDW-SS321	10/04/06	1039	1267693	206344	1267698	206352	2.9	-30.9
LDW-SS322	10/04/06	0933	1267593	206143	1267595	206141	0.6	-28.0
LDW-SS323	10/04/06	0943	1267825	206206	1267827	206204	0.6	-27.7
LDW-SS324	10/04/06	1022	1267783	205991	1267777	205992	2.0	-32.5
LDW-SS325	10/04/06	1352	1268445	204741	1268444	204744	1.0	-8.9
LDW-SS326	10/04/06	1402	1268416	204485	1268415	204484	0.6	-24.7
LDW-SS327	10/02/06	1225	1269345	202959	1269344	202957	0.6	-16.7
LDW-SS328	10/02/06	1330	1269510	201597	1269511	201598	0.5	-29.9
LDW-SS329[d]	10/02/06	1406	1269671	201555	1269671	201553	0.8	-24.8
LDW-SS330	10/02/06	1100	1270484	201439	1270484	201439	0.1	-15.7
LDW-SS331	10/02/06	1433	1269568	200916	1269568	200916	0.1	+1.1
LDW-SS332	10/02/06	1510	1269603	200875	1269666	200890	19.6[c]	+3.9
LDW-SS333	10/02/06	1600	1271773	199401	1271774	199402	0.5	-7.6
LDW-SS334	10/02/06	1545	1271829	199194	1271828	199194	0.4	-37.4
LDW-SS335	10/04/06	0836	1271975	198625	1271973	198626	0.6	-2.9
LDW-SS336	10/03/06	1058	1272224	198560	1272223	198560	0.3	-10.4
LDW-SS337[e]	10/02/06	1625	1275788	195240	1275787	195238	0.6	-20.0
LDW-SS338	10/03/06	1022	1275934	194824	1275936	194822	0.8	-11.8
LDW-SS339	10/03/06	1007	1277656	190148	1277655	190149	0.6	+6.6
LDW-SS340	10/03/06	1009	1277524	189892	1277522	189891	0.8	+4.7
LDW-SS341	10/03/06	0945	1278543	190194	1278541	190193	0.6	+4.8
LDW-SS342	10/03/06	0924	1278515	190156	1278516	190157	0.5	-6.8
LDW-SS343	10/03/06	0935	1278589	190169	1278590	190168	0.4	+3.5
LDW-SS344	10/03/06	0855	1278627	190079	1278626	190082	1.1	-1.7

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

[b] Field duplicate sample LDW-SS403-010 was also collected at this location.

[c] These four locations could not be sampled within 10 m of the targeted location, as specified in the QAPP addendum (Windward 2006b), for reasons presented in Section 2.4.

[d] Field duplicate sample LDW-SS401-010 was also collected at this location.

[e] Field duplicate sample LDW-SS402-010 was also collected at this location.

na – not available

NAD83 – North American Datum of 1983

MLLW – mean lower low water

PDT – Pacific Daylight Time

2.3 SAMPLE COLLECTION METHODS

Round 3 surface sediment samples were collected using standardized procedures from the Puget Sound Estuary Program (PSEP; 1997). Surface sediment samples were collected at 38 of the 44 locations using a 0.1-m^2 single van Veen grab sampler. Exposed sediment was collected during low tide using a pre-cleaned stainless steel spoon at the remaining six locations, all of which were intertidal (LDW-SS313, LDW-SS314, LDW-SS339, LDW-SS340, LDW-SS341, and LDW-SS343).

Each successful grab sample was evaluated for acceptability in accordance with the QAPP and QAPP addendum (Windward 2005, 2006b). At each grab location, sediment was obtained from one acceptable grab sample. At all locations, sediment was taken from the 0-to-10-cm interval and homogenized in a clean, stainless steel bowl using a stainless steel spoon until texture and color were homogenous. Homogenized sediment was then split into the appropriate sampling containers for chemical analyses. Field duplicate samples were obtained by filling additional separate containers with the same homogenized sample.

Appendix F contains copies of field logbooks and field collection forms. Table F-1 in Appendix F presents the sediment characteristics and penetration depth for each Round 3 surface sediment sample.

2.4 FIELD DEVIATIONS FROM THE QAPP

Field deviations from the QAPP and QAPP addendum (Windward 2005, 2006b) included modifications to collection methods and sampling 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:

- Four samples could not be collected at a distance ≤ 10 m from the target location. Table 2-2 identifies these four sampling locations and presents the rationale for the new locations. Representatives from EPA and Ecology were consulted regarding each location change.
- The minimum penetration depth of 11 cm for samples collected with the van Veen grab sampler (as defined in the QAPP and QAPP addendum [Windward 2005; 2006b]) was not achieved at two sampling locations (LDW-SS303 and LDW-SS334) because of hard-packed native sediment or obstructions, such as rocks or wood debris. The maximum penetration depth of sediment at these locations was 10.5 cm despite several efforts. At these locations, sediment was taken from the 0-to-10-cm interval and homogenized for sampling.

Table 2-2. Round 3 locations where actual sampling locations were >10 m from target sampling locations

Location ID	Distance from Target Location (m)	Rationale
LDW-SS303	10.4	Target location was located on rocky riprap slope inside marina; sample was collected approximately 30 m from outfall closest to target location where the van Veen grab sampler would close and collect an acceptable sample.
LDW-SS304	22.9	Target location was located on rocky riprap slope inside marina; sample was collected approximately 23 m southwest of the target location, between the outfall adjacent to the target location and north of the Round 2 location (LDW-SS6) where there was a CSL exceedance.
LDW-SS312	14.0	Location was moved to correspond to a location selected during site reconnaissance with EPA and Ecology.
LDW-SS332	19.6	Location was moved to correspond to a location selected during site reconnaissance with EPA and Ecology.

CSL – cleanup screening level

EPA – US Environmental Protection Agency

Ecology – Washington State Department of Ecology

3.0 Laboratory Methods

The methods used to chemically analyze sediment samples are described briefly in this section and in detail in the surface sediment QAPP and QAPP addendum (Windward 2005, 2006b). This section also summarizes any laboratory deviations from the QAPP.

3.1 Methods for Chemical Analyses

Table 3-1 summarizes the numbers of sediment samples analyzed for various chemicals in the Round 3 sampling event. Table 3-2 identifies the chemicals (by type) analyzed at each location.

Table 3-1. Summary of chemical analyses conducted for Round 3 surface sediment samples

Chemicals Analyzed	No. of Samples	No. of Field Duplicate Samples	Total No. of Samples
SMS chemicals (SVOCs, selected SVOCs by SIM, metals including mercury, PCBs as Aroclors), total solids, TOC, grain size	44	3	47
Butyltins	3	1	4
Dioxins/furans	5	0	5

LDW – Lower Duwamish Waterway

PCB – polychlorinated biphenyl

SIM – selected ion monitoring

SMS – Sediment Management Standards

SVOC – semivolatile organic compound

TOC – total organic carbon

Table 3-2. Round 3 chemicals analyzed by surface sediment sampling location

Sampling Location	SMS Chemicals	Butyltins	Dioxins/Furans
LDW-SS301[a]	X	X	
LDW-SS302	X	X	
LDW-SS303	X		
LDW-SS304	X		
LDW-SS305	X		
LDW-SS306	X		
LDW-SS307	X		
LDW-SS308	X		
LDW-SS309	X		
LDW-SS310	X	X	
LDW-SS311	X		
LDW-SS312	X		
LDW-SS313	X		
LDW-SS314	X		
LDW-SS315	X		
LDW-SS316	X		
LDW-SS317	X		
LDW-SS318	X		X
LDW-SS319	X		
LDW-SS320	X		
LDW-SS321	X		X
LDW-SS322	X		X
LDW-SS323	X		X
LDW-SS324	X		X
LDW-SS325	X		
LDW-SS326	X		
LDW-SS327	X		
LDW-SS328	X		
LDW-SS329[b]	X		
LDW-SS330	X		
LDW-SS331	X		
LDW-SS332	X		
LDW-SS333	X		
LDW-SS334	X		
LDW-SS335	X		
LDW-SS336	X		
LDW-SS337[c]	X		
LDW-SS338	X		

Sampling Location	SMS Chemicals	Butyltins	Dioxins/Furans
LDW-SS339	X		
LDW-SS340	X		
LDW-SS341	X		
LDW-SS342	X		
LDW-SS343	X		
LDW-SS344	X		
Total number of locations analyzed	44	3	5

[a] Field duplicate sample LDW-SS403-010 was also collected at this location.

[b] Field duplicate sample LDW-SS401-010 was also collected at this location.

[c] Field duplicate sample LDW-SS402-010 was also collected at this location.

All analyses of the sediment samples were conducted at Analytical Resources, Inc. (ARI), except for the dioxin/furan analyses, which were conducted at Axys Analytical Services, Ltd. (Axys). Analytical methods are presented in Table 3-3.

Table 3-3. Chemical analysis methods for surface sediment samples

Parameter	Laboratory	Method	Reference
Dioxins and furans	Axys	HRGC/HRMS	EPA 1613B
PCBs as Aroclors[a]	ARI	GC/ECD	EPA 8082
SVOCs (including PAHs)[b, c]	ARI	GC/MS	EPA 8270D
Selected SVOCs[b, d]	ARI	GC/MS	EPA 8270D-SIM
Mercury	ARI	CVAA	EPA 7471A
Other metals[e]	ARI	ICP-MS	EPA 200.8
Tributyltin, dibutyltin, and monobutyltin (as ions)[f]	ARI	GC/MS-SIM	Krone et al. (1989)
Grain size	ARI	sieve/pipette	PSEP (1986)
TOC	ARI	combustion	Plumb (1981)
Total solids	ARI	oven-dried	PSEP (1986)

[a] A sulfur cleanup procedure (EPA Method 3660B) and a sulfuric acid cleanup procedure (EPA Method 3665A) were applied to extracts.

[b] Extracts were subjected to a gel permeation chromatography cleanup procedure (EPA Method 3640A).

[c] Target PAHs included anthracene, pyrene, dibenzofuran, benzo(g,h,i)perylene, indeno(1,2,3-cd)pyrene, benzo(b)fluoranthene, fluoranthene, benzo(k)fluoranthene, acenaphthylene, chrysene, benzo(a)pyrene, dibenz(a,h)anthracene, benz(a)anthracene, acenaphthene, phenanthrene, fluorene, 1-methylnaphthalene, naphthalene, and 2-methylnaphthalene.

[d] Selected SVOCs for SIM included 1,2,4-trichlorobenzene, 1,2-dichlorobenzene, 1,4-dichlorobenzene, 2,4-dimethylphenol, 2-methylphenol, benzyl alcohol, butyl benzyl phthalate, dibenzo(a,h)anthracene, dimethyl phthalate, hexachlorobenzene, hexachlorobutadiene, n-nitrosodimethylamine, n-nitrosodiphenylamine, n-nitrosodi-n-propylamine, and pentachlorophenol. Chemicals analyzed using SIM were not included in the EPA Method 8270D analyte list.

[e] Other metals included antimony, arsenic, cadmium, chromium, cobalt, copper, lead, molybdenum, nickel, selenium, silver, thallium, vanadium, and zinc.

[f] Extracts were subjected to an alumina cleanup procedure (EPA Method 3610B).

ARI – Analytical Resources, Inc.

Axys – Axys Analytical Services, Ltd.
CVAA – cold vapor atomic absorption
EPA – US Environmental Protection Agency
GC/ECD – gas chromatography-electron capture detection
GC/MS – gas chromatography-mass spectrometry
HRGC/HRMS – high-resolution gas chromatography/high-resolution mass spectrometry
ICP-MS – inductively coupled plasma mass spectrometry
PAH – polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
PSEP – Puget Sound Estuary Program
SIM – selected ion monitoring
SVOC – semivolatile organic compound
TOC – total organic carbon

3.2 LABORATORY DEVIATIONS FROM THE QAPP

ARI and Axys followed the methods and procedures described in the QAPP and QAPP addendum (Windward 2005, 2006b), with one laboratory deviation. Instead of using EPA Method 6010B as specified in the QAPP addendum, metals (not including mercury) were analyzed using EPA Method 200.8. This method uses inductively coupled plasma mass spectrometry (ICP-MS), which has a greater analytical sensitivity than the inductively coupled plasma-atomic emission spectrometry (ICP-AES) used with EPA Method 6010B. Both methods are comparable, and there is no effect on the overall quality of the data. The alternative test method was used because the laboratory's ICP-AES was not operable at the time of analysis. This decision was made in consultation with EPA.

4.0 Results

This section presents the results of chemical analyses conducted on Round 3 surface sediment samples, including the results of the data validation, which was conducted by Laboratory Data Consultants, Inc. (LDC). Appendix A contains the complete dataset for all Round 3 surface sediment samples. Data tables that summarize sediment sampling results from Rounds 1, 2, and 3 combined are presented in Appendix B. Appendix C discusses data management procedures, including the approach used to average laboratory replicates and methods used to calculate concentrations of total polychlorinated biphenyls (PCBs) and total polycyclic aromatic hydrocarbons (PAHs). The data validation report prepared by LDC is presented in Appendix D and the raw laboratory data forms are presented in Appendix E.

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 C. There was no additional manipulation of significant figures.

4.1 SURFACE SEDIMENT CHEMISTRY RESULTS

Surface sediment samples collected from the 44 Round 3 locations were analyzed by ARI for metals (including mercury), semivolatile organic compounds (SVOCs) (including PAHs), selected SVOCs using selected ion monitoring (SIM), PCBs as Aroclors, grain size, total organic carbon (TOC), and percent solids. Samples from 3 of the 44 locations were also analyzed by ARI for butyltins. Samples from 5 of the 44 locations were analyzed by Axys for dioxins and furans. Field duplicate sample results are averaged with the original sample results for each of the three locations where field duplicate samples were collected. Figure 4-1 shows Round 3 locations, as well as all other baseline locations, where there were exceedances of SMS criteria by any chemical. Figure 4-2 shows Round 3 locations, as well as all other baseline locations, where there were exceedances of Dredged Material Management Program (DMMP) guidelines by chemicals that do not have SMS criteria. In this section, the results of the analyses are discussed in subsections by analyte group.

Tables in this section include summaries of sediment concentrations for approximately 110 chemicals or groups of chemicals. The concentrations of 47 chemicals are compared to the sediment quality standards (SQS) and cleanup screening levels (CSLs) of the SMS. The concentrations of four other chemicals that do not have SMS criteria are compared to the DMMP screening level (SL) and maximum level (ML) guidelines.

Where SMS criteria are expressed on an organic carbon (OC)-normalized basis, the chemical results are also shown as OC-normalized. In three of the Round 3 surface sediment samples, TOC is either less than 0.5% or greater than 4.0%. In these cases, the results are not OC-normalized; instead, the dry weight (dw) chemical concentrations are compared to the lowest apparent effects threshold (LAET) and second lowest apparent effects threshold (2LAET) (PTI 1988), which are analogous to the SQS and CSL, respectively. Appendix A tables present the results for each location in comparison to SMS, DMMP, or apparent effects threshold (AET) values. Appendix B contains tables that summarize surface sediment chemistry results for Rounds 1, 2, and 3 combined and present the number of samples within each SMS/SL or CSL/ML category for each analyte.

4.1.1 Metals

Table 4-1 summarizes the results for the Round 3 surface sediment samples that were analyzed for metals, including the number of detections, the range and mean of detected concentrations, and the range of reporting limits (RLs) for metals reported as non-detects. Table 4-1 also presents SQS/SL and CSL/ML values for comparison purposes. Figure 4-3 shows exceedances of the SQS and CSL for Round 3 arsenic results by location in conjunction with exceedances of the SQS and CSL in baseline samples; this figure is included because arsenic is a risk driver in the human health risk assessment (Windward 2006a).

Table 4-1. Round 3 surface sediment sampling results for metals

Analyte	Unit	Detection Frequency[b]	Detected Concentration			Reporting Limit[a]		SQS/ SL	CSL/ ML
			Minimum	Maximum	Mean[c]	Minimum	Maximum		
Antimony	mg/kg dw	2/44	0.4 J	1.1 J	0.8	0.3	0.6	150 [d]	200 [d]
Arsenic	mg/kg dw	44/44	4.0	123	13	na	na	57	93
Cadmium	mg/kg dw	22/44	0.4	1.1	0.5	0.3	0.5	5.1	6.7
Chromium	mg/kg dw	44/44	11.0	40	30	na	na	260	270
Cobalt	mg/kg dw	44/44	3.6	12	7.6	na	na	nv	nv
Copper	mg/kg dw	44/44	14.5	137	60	na	na	390	390
Lead	mg/kg dw	44/44	7	292	50	na	na	450	530
Mercury	mg/kg dw	37/44	0.060	1.8	0.3	0.050	0.080	0.41	0.59
Molybdenum	mg/kg dw	43/44	0.3	8.8	1	0.3	0.3	nv	nv
Nickel	mg/kg dw	44/44	9.2	35	20	na	na	140[d]	370[d]
Selenium	mg/kg dw	0/44	nd	nd	nd	0.6	1	nv	nv
Silver	mg/kg dw	24/44	0.3	0.9 J	0.5	0.3	0.6	6.1	6.1
Thallium	mg/kg dw	0/44	nd	nd	nd	0.3	0.6	nv	nv
Vanadium	mg/kg dw	44/44	34.6	74	51	na	na	nv	nv
Zinc	mg/kg dw	44/44	39	346	120	na	na	410	960

[a] RL range for non-detect samples.

[b] Field duplicate samples were collected at three of the 44 Round 3 locations. Field duplicate sample results are averaged with the original sample results for each of the three locations where field duplicate samples were collected.

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

[d] DMMP SL and ML guidelines.

CSL – cleanup screening level
dw – dry weight
J – estimated concentration
ML – maximum level
na – not applicable
nd – not detected
nv – no value available for this chemical
SL – screening level
SQS – sediment quality standard

Eight metals (arsenic, chromium, cobalt, copper, lead, nickel, vanadium, and zinc) were detected in all of the Round 3 surface sediment samples. Selenium and thallium were not detected in any of the surface sediment samples. The sample collected at location LDW-SS305 had the highest concentrations of antimony (1.1 mg/kg dw), arsenic (123 mg/kg dw), cadmium (1.1 mg/kg dw), copper (137 mg/kg dw), lead (292 mg/kg dw), and zinc (346 mg/kg dw) of any of the Round 3 surface sediment samples. The sample collected at location LDW-SS335 had the highest concentrations of chromium (40 mg/kg dw) and nickel (35 mg/kg dw). The sample collected at location LDW-SS310 had the highest concentration of mercury (1.8 mg/kg dw). See Figure 2-1 for the locations of specific samples.

Table 4-2 presents the numbers of samples with detected concentrations or RLs (for non-detected results) greater than the SQS/SL or CSL/ML for the 10 metals with SMS criteria or DMMP guidelines. Mercury was detected at concentrations exceeding the

SQS but not the CSL in two samples and the CSL in four samples. One sample had a detected arsenic concentration that exceeded the CSL. None of the non-detected samples had RLs that exceeded the SQS/SL or CSL/ML for metals.

Table 4-2. Numbers of Round 3 surface sediment samples with detected metal concentrations or reporting limits within each SQS/SL or CSL/ML category by analyte

Metal	No. of Samples with Detected Concentrations			No. of Undetected Samples with Reporting Limits		
	≤ SQS/SL	> SQS/SL ≤ CSL/ML	> CSL/ML	≤ SQS/SL	> SQS/SL ≤ CSL/ML	> CSL/ML
Antimony[a]	2			42		
Arsenic	43		1			
Cadmium	22			22		
Chromium	44					
Copper	44					
Lead	44					
Mercury	31	2	4	7		
Nickel[a]	44					
Silver	24			20		
Zinc	44					

[a] Detected concentrations and reporting limits for these analytes compared to DMMP SL and ML guidelines.

CSL – cleanup screening level

ML – maximum level

SL – screening level

SQS – sediment quality standard

4.1.2 Butyltins

Table 4-3 summarizes the results for the three Round 3 surface sediment samples that were analyzed for butyltins. Tributyltin and dibutyltin were detected at all three locations, and monobutyltin was detected at two of the three locations. Figure 4-4 presents the Round 3 tributyltin results with the concentrations of tributyltin at other baseline locations. The highest tributyltin concentration (73 µg/kg dw) in Round 3 was detected in the sample collected from location LDW-SS310.

Table 4-3. Round 3 surface sediment sampling results for butyltins

Sampling Location	Concentration		
	Monobutyltin as Ion (µg/kg dw)	Dibutyltin as Ion (µg/kg dw)	Tributyltin as Ion (µg/kg dw)
LDW-SS301[a]	3.9 U	6.9	16
LDW-SS302	5.4	18	55
LDW-SS310	5.2	18	73

[a] Results for sampling location LDW-SS301 are averages of the original sampling result (LDW-SS301-010) and the field duplicate sample (LDW-SS403-010).

dw – dry weight

U – not detected at reported concentration

4.1.3 SVOCs

Table 4-4 summarizes the SVOC results from all Round 3 surface sediment samples in dry weight units, including the results from SIM analyses. Included in this table are the frequency of detections, the range and mean of detected concentrations, and the range of RLs for chemicals reported as non-detects.

Table 4-4. Round 3 surface sediment sampling results for SVOCs

Analyte	Detection Frequency[a]	Unit	Detected Concentration			Reporting Limit[c]	
			Minimum	Maximum	Mean[b]	Minimum	Maximum
PAHs							
1-Methylnaphthalene	3/44	µg/kg dw	62	110	84	60	110
2-Chloronaphthalene	0/44	µg/kg dw	nd	nd	nd	60	110
2-Methylnaphthalene	3/44	µg/kg dw	85	110	97	60	110
Acenaphthene	6/44	µg/kg dw	34 J	210	140	60	62
Acenaphthylene	9/44	µg/kg dw	32 J	500	110	60	62
Anthracene	29/44	µg/kg dw	33 J	1,200	180	60	62
Benzo(a)anthracene	38/44	µg/kg dw	49 J	2,200	360	60	62
Benzo(a)pyrene	38/44	µg/kg dw	50 J	3,200	400	60	62
Benzo(b)fluoranthene	39/44	µg/kg dw	36 J	3,000	570	60	62
Benzo(g,h,i)perylene	37/44	µg/kg dw	31 J	1,600	180	60	62
Benzo(k)fluoranthene	38/44	µg/kg dw	52 J	1,700	370	60	62
Benzofluoranthenes (total calc'd)	39/44	µg/kg dw	36 J	4,700	930	nc	nc
Chrysene	40/44	µg/kg dw	35 J	3,000	600	60	62
Dibenzo(a,h)anthracene	38/44	µg/kg dw	6.7	320	56	6.1	6.2
Dibenzofuran	5/44	µg/kg dw	96	170	130	60	62
Fluoranthene	43/44	µg/kg dw	32 J	7,500	1,100	61	61
Fluorene	14/44	µg/kg dw	36 J	320	110	60	62
Indeno(1,2,3-cd)pyrene	36/44	µg/kg dw	34 J	1,600	180	60	62
Naphthalene	7/44	µg/kg dw	37 J	180	80	60	110
Phenanthrene	40/44	µg/kg dw	41 J	3,400	390	61	62
Pyrene	42/44	µg/kg dw	39 J	4,800	770	61	62
Total HPAH (calc'd)	43/44	µg/kg dw	32 J	26,300	4,300	nc	nc
Total LPAH (calc'd)	40/44	µg/kg dw	44 J	5,200	620	nc	nc
Total PAH (calc'd)	43/44	µg/kg dw	32 J	31,500	4,800	nc	nc
Phthalates							

Analyte	Detection Frequency[a]	Unit	Detected Concentration			Reporting Limit[c]	
			Minimum	Maximum	Mean[b]	Minimum	Maximum
bis(2-Ethylhexyl) phthalate	42/44	µg/kg dw	36 J	2,600	330	61	62
Butyl benzyl phthalate	38/44	µg/kg dw	6.2	200	30	6.1	6.2
Diethyl phthalate	0/44	µg/kg dw	nd	nd	nd	60	110
Dimethyl phthalate	21/44	µg/kg dw	6.1	33	11	6.0	6.2
Di-n-butyl phthalate	10/44	µg/kg dw	32 J	59 J	42	60	62
Di-n-octyl phthalate	1/44	µg/kg dw	92 J	92 J	92	60	62
Other SVOCs							
1,2,4-Trichlorobenzene	0/44	µg/kg dw	nd	nd	nd	6.0	11
1,2-Dichlorobenzene	0/44	µg/kg dw	nd	nd	nd	6.0	11
1,3-Dichlorobenzene	0/44	µg/kg dw	nd	nd	nd	60	110
1,4-Dichlorobenzene	5/44	µg/kg dw	6.2	64	19	6.0	6.2
2,4,5-Trichlorophenol	0/44	µg/kg dw	nd	nd	nd	300	540
2,4,6-Trichlorophenol	0/44	µg/kg dw	nd	nd	nd	300	540
2,4-Dichlorophenol	0/44	µg/kg dw	nd	nd	nd	300	540
2,4-Dimethylphenol	4/44	µg/kg dw	6.1	20	12	6.0	11
2,4-Dinitrophenol	0/44	µg/kg dw	nd	nd	nd	600	1,100
2,4-Dinitrotoluene	0/44	µg/kg dw	nd	nd	nd	300	540
2,6-Dinitrotoluene	0/44	µg/kg dw	nd	nd	nd	300	540
2-Chlorophenol	0/44	µg/kg dw	nd	nd	nd	60	110
2-Methylphenol	4/44	µg/kg dw	8.6	14	10	6.0	11
2-Nitroaniline	0/44	µg/kg dw	nd	nd	nd	300	540
2-Nitrophenol	0/44	µg/kg dw	nd	nd	nd	300	540
3,3′-Dichlorobenzidine	0/44	µg/kg dw	nd	nd	nd	300	540
3-Nitroaniline	0/44	µg/kg dw	nd	nd	nd	300	540
4,6-Dinitro-o-cresol	0/44	µg/kg dw	nd	nd	nd	600	1,100
4-Bromophenyl phenyl ether	0/44	µg/kg dw	nd	nd	nd	60	110
4-Chloro-3-methylphenol	0/44	µg/kg dw	nd	nd	nd	300	540
4-Chloroaniline	0/44	µg/kg dw	nd	nd	nd	300	540
4-Chlorophenyl phenyl ether	0/44	µg/kg dw	nd	nd	nd	60	110
4-Methylphenol[d]	4/44	µg/kg dw	36 J	300	120	60	110
4-Nitroaniline	0/44	µg/kg dw	nd	nd	nd	300	540
4-Nitrophenol	0/44	µg/kg dw	nd	nd	nd	300	540
Aniline	0/44	µg/kg dw	nd	nd	nd	60	110
Benzoic acid	1/44	µg/kg dw	1,600	1,600	1,600	540	620
Benzyl alcohol	1/44	µg/kg dw	540 J	540 J	540	30	74
bis(2-Chloroethoxy)methane	0/44	µg/kg dw	nd	nd	nd	60	110
bis(2-Chloroethyl)ether	0/44	µg/kg dw	nd	nd	nd	60	110

Analyte	Detection Frequency[a]	Unit	Detected Concentration			Reporting Limit[c]	
			Minimum	Maximum	Mean[b]	Minimum	Maximum
bis(2-Chloroisopropyl)ether	0/44	µg/kg dw	nd	nd	nd	60	110
Hexachlorobenzene	0/44	µg/kg dw	nd	nd	nd	6.0	11
Hexachlorobutadiene	0/44	µg/kg dw	nd	nd	nd	6.0	11
Hexachlorocyclopentadiene	0/44	µg/kg dw	nd	nd	nd	300	540
Hexachloroethane	0/44	µg/kg dw	nd	nd	nd	60	110
Isophorone	0/44	µg/kg dw	nd	nd	nd	60	110
Nitrobenzene	0/44	µg/kg dw	nd	nd	nd	60	110
n-Nitrosodimethylamine	0/44	µg/kg dw	nd	nd	nd	30	54
n-Nitroso-di-n-propylamine	0/44	µg/kg dw	nd	nd	nd	30	54
n-Nitrosodiphenylamine	0/44	µg/kg dw	nd	nd	nd	6.0	32
Pentachlorophenol	0/44	µg/kg dw	nd	nd	nd	30	54
Phenol	7/44	µg/kg dw	40 J	140	82	60	250

[a] Field duplicate samples were collected at three of the 44 Round 3 locations. Field duplicate sample results are averaged with the original sample results for each of the three locations where field duplicate samples were collected.

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

[c] RL range for non-detect samples.

[d] Coelutes with 3-methylphenol.

dw – dry weight

HPAH – high-molecular-weight polycyclic aromatic hydrocarbon

J – estimated concentration

LPAH – low-molecular-weight polycyclic aromatic hydrocarbon

nc – not calculated

nd – not detected

PAH – polycyclic aromatic hydrocarbon

SVOC – semivolatile organic compound

All individual PAH compounds were detected in at least one sample, with the exception of 2-chloronaphthalene, which was never detected. The 12 individual PAHs that were most frequently detected (each detected in samples from at least 29 locations) were anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, fluoranthene, indeno(1,2,3-cd)pyrene, phenanthrene, and pyrene. The remaining 8 individual PAHs were each detected in 14 or fewer samples. The highest concentrations of total low-molecular-weight PAHs (LPAHs) (5,200 µg/kg dw) and total high-molecular-weight PAHs (HPAHs) (26,300 µg/kg dw) were detected in the sample collected at LDW-SS312.

All six phthalates were detected in at least one sample, with the exception of diethyl phthalate, which was never detected. Bis(2-ethylhexyl) phthalate, the most frequently detected phthalate compound, was detected in samples collected at 42 of the 44

locations, with a maximum concentration of 2,600 µg/kg dw detected in the sample collected at LDW-SS335.

Seven other SVOCs were infrequently detected in samples from the 44 sampling locations at the following frequencies: 1,4-dichlorobenzene (5/44), 2,4-dimethylphenol (4/44), 2-methylphenol (4/44), 4-methylphenol (4/44), benzoic acid (1/44), benzyl alcohol (1/44), and phenol (7/44). The remaining 35 SVOCs were not detected in any Round 3 surface sediment samples.

Table 4-5 summarizes the Round 3 surface sediment results for SVOCs in appropriate units for comparison to SQS/SL and CSL/ML criteria and guidelines. The majority of the criteria are expressed on an OC-normalized basis; however, some are expressed on a dry weight unit basis. In Table 4-5, the three samples with TOC contents less than 0.5% or greater than 4.0% are not presented for comparison to the SQS and CSL because they cannot be OC-normalized. Instead, the dry weight concentrations of chemicals with OC-normalized criteria for those samples were compared to the LAET and 2LAET values, as presented in Table A-3-5 of Appendix A. Table 4-6 presents the number of samples with detected concentrations or RLs (for non-detected results) greater than the SQS/SL or CSL/ML for each analyte.

Table 4-5. Round 3 surface sediment sampling results for SVOCs compared to SMS criteria and DMMP guidelines

Analyte	Detection Frequency[a, b]	Unit	Detected Concentration			Reporting Limit[c]		SQS/ SL	CSL/ ML
			Minimum	Maximum	Mean[d]	Minimum	Maximum		
PAHs									
2-Methylnaphthalene	2/41	mg/kg OC	2.8	5.2	4.0	2.2	8.1	38	64
Acenaphthene	5/41	mg/kg OC	1.3 J	7.3	5.1	2.2	8.1	16	57
Acenaphthylene	7/41	mg/kg OC	1.6 J	4.6	2.4	2.2	8.1	66	66
Anthracene	27/41	mg/kg OC	1.7 J	42	7.6	2.2	6.8	220	1,200
Benzo(a)anthracene	36/41	mg/kg OC	2.2 J	74	16	3.0	6.8	110	270
Benzo(a)pyrene	36/41	mg/kg OC	2.5 J	86	16	3.0	6.8	99	210
Benzo(g,h,i)perylene	35/41	mg/kg OC	1.8 J	32	7.0	3.0	6.8	31	78
Benzofluoranthenes (total calc'd)	37/41	mg/kg OC	4.0 J	220	42	nc	nc	230	450
Chrysene	38/41	mg/kg OC	2.0 J	120	28	3.0	4.3	110	460
Dibenzo(a,h)anthracene	36/41	mg/kg OC	0.29 J	11	2.5	0.30	0.68	12	33
Dibenzofuran	4/41	mg/kg OC	4.6	5.7	5.3	2.2	8.1	15	58
Fluoranthene	41/41	mg/kg OC	1.6 J	620	50	na	na	160	1,200
Fluorene	12/41	mg/kg OC	1.6 J	11	4.7	2.2	6.8	23	79
Indeno(1,2,3-cd)pyrene	34/41	mg/kg OC	1.7 J	35	7.1	3.0	6.8	34	88
Naphthalene	5/41	mg/kg OC	1.5 J	4.3	2.9	2.2	8.1	99	170
Phenanthrene	38/41	mg/kg OC	2.3 J	97	14	3.0	6.8	100	480
Pyrene	40/41	mg/kg OC	2.3 J	260	34	3.0	3.0	1,000	1,400

Analyte	Detection Frequency[a, b]	Unit	Detected Concentration			Reporting Limit[c]		SQS/ SL	CSL/ ML
			Minimum	Maximum	Mean[d]	Minimum	Maximum		
Total HPAH (calc'd)	41/41	mg/kg OC	1.6 J	1,100 J	190	nc	nc	960	5,300
Total LPAH (calc'd)	38/41	mg/kg OC	2.3 J	160 J	23	nc	nc	370	780
Phthalates									
bis(2-Ethylhexyl) phthalate	40/41	mg/kg OC	2.0 J	90	17	2.2	2.2	47	78
Butyl benzyl phthalate	36/41	mg/kg OC	0.22	6.9	1.6	0.29	0.68	4.9	64
Diethyl phthalate	0/41	mg/kg OC	nd	nd	nd	2.0	8.1	61	110
Dimethyl phthalate	20/41	mg/kg OC	0.29	1.7	0.58	0.20	0.68	53	53
Di-n-butyl phthalate	8/41	mg/kg OC	1.3 J	2.6 J	1.9	2.0	8.1	220	1,700
Di-n-octyl phthalate	1/41	mg/kg OC	3.2 J	3.2 J	3.2	2.0	8.1	58	4,500
Other SVOCs									
1,2,4-Trichlorobenzene	0/41	mg/kg OC	nd	nd	nd	0.20	0.81	0.81	1.8
1,2-Dichlorobenzene	0/41	mg/kg OC	nd	nd	nd	0.20	0.81	2.3	2.3
1,3-Dichlorobenzene	0/44	µg/kg dw	nd	nd	nd	60	110	170[e]	nv
1,4-Dichlorobenzene	5/41	mg/kg OC	0.27	2.2	0.83	0.20	0.68	3.1	9
2,4-Dimethylphenol	4/44	µg/kg dw	6.1	20	12	6.0	11	29	29
2-Methylphenol	4/44	µg/kg dw	8.6	14	10	6.0	11	63	63
4-Methylphenol	4/44	µg/kg dw	36 J	300	120	60	110	670	670
Benzoic acid	1/44	µg/kg dw	1,600	1,600	1,600	540	620	650	650
Benzyl alcohol	1/44	µg/kg dw	540 J	540 J	540	30	74	57	73
Hexachlorobenzene	0/41	mg/kg OC	nd	nd	nd	0.20	0.81	0.38	2.3
Hexachlorobutadiene	0/41	mg/kg OC	nd	nd	nd	0.20	0.81	3.9	6.2
Hexachloroethane	0/44	µg/kg dw	nd	nd	nd	60	110	1,400[e]	14,000[e]
n-Nitrosodiphenylamine	0/41	mg/kg OC	nd	nd	nd	0.20	1.1	11	11
Pentachlorophenol	0/44	µg/kg dw	nd	nd	nd	30	54	360	690
Phenol	7/44	µg/kg dw	40 J	140	82	60	250	420	1,200

[a] Field duplicate samples were collected at three of the 44 Round 3 locations. Field duplicate sample results are averaged with the original sample results for each of the three locations where field duplicate samples were collected.

[b] For chemicals with OC-normalized criteria, only the 41 samples with TOC contents ≥ 0.5 and ≤ 4.0% are presented as OC-normalized results. The remaining three samples with TOC contents < 0.5 and > 4.0% are compared to LAET and 2LAET values in Table A-3-5 in Appendix A.

[c] RL range for non-detect samples.

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

[e] DMMP SL and ML guidelines.

CSL – cleanup screening level
DMMP – Dredged Material Management Program
dw – dry weight
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
J – estimated concentration
LPAH – low-molecular-weight polycyclic aromatic hydrocarbon
ML – maximum level
nc – not calculated
nd – not detected
nv – no value available for this chemical
OC – organic carbon
PAH – polycyclic aromatic hydrocarbon
SL – screening level
SMS – Sediment Management Standards
SQS – sediment quality standard
SVOC – semivolatile organic compound

Table 4-6. Numbers of Round 3 surface sediment samples with detected SVOC concentrations or RLs within each SQS/SL or CSL/ML category by analyte

Analyte	No. of Samples with Detected Concentrations			No. of Undetected Samples with Reporting Limits		
	≤ SQS/SL	> SQS/SL ≤ CSL/ML	> CSL/ML	≤ SQS/SL	> SQS/SL ≤ CSL/ML	> CSL/ML
PAHs						
2-Methylnaphthalene	3			41		
Acenaphthene	6			38		
Acenaphthylene	9			35		
Anthracene	29			15		
Benzo(a)anthracene	37		1	6		
Benzo(a)pyrene	37		1	6		
Benzo(g,h,i)perylene	35	1	1	7		
Total benzofluoranthenes (calc'd)	38		1	5		
Chrysene	37	2	1	4		
Dibenzo(a,h)anthracene	37	1		6		
Dibenzofuran	5			39		
Fluoranthene	39	2	2	1		
Fluorene	14			30		
Indeno(1,2,3-cd)pyrene	34	1	1	8		
Naphthalene	7			37		
Phenanthrene	39	1		4		
Pyrene	40	1	1	2		
Total HPAH (calc'd)	40	2	1	1[a]		
Total LPAH (calc'd)	40			4[b]		
Phthalates						
bis(2-Ethylhexyl) phthalate	40	1	1	2		
Butyl benzyl phthalate	36	2		6		
Diethyl phthalate				44		
Dimethyl phthalate	21			23		
Di-n-butyl phthalate	10			34		
Di-n-octyl phthalate	1			43		
Other SVOCs						
1,2,4-Trichlorobenzene				44		
1,2-Dichlorobenzene				44		
1,3-Dichlorobenzene[c]				44		
1,4-Dichlorobenzene	5			39		
2,4-Dimethylphenol	4			40		
2-Methylphenol	4			40		
4-Methylphenol	4			40		

Analyte	No. of Samples with Detected Concentrations			No. of Undetected Samples with Reporting Limits		
	≤ SQS/SL	> SQS/SL ≤ CSL/ML	> CSL/ML	≤ SQS/SL	> SQS/SL ≤ CSL/ML	> CSL/ML
Benzoic acid			1	43		
Benzyl alcohol			1	42		1
Hexachlorobenzene				39	5	
Hexachlorobutadiene				44		
Hexachloroethane[c]				44		
n-Nitrosodiphenylamine				44		
Pentachlorophenol				44		
Phenol	7			37		

[a] The RL for total HPAH was assigned a concentration equal to the highest RL of the individual HPAH compounds for a given sample.

[b] The RL for total LPAH was assigned a concentration equal to the highest RL of the individual LPAH compounds for a given sample.

[c] Reporting limits for this analyte are compared to DMMP SL and ML guidelines.

CSL – cleanup screening level

HPAH – high-molecular-weight polycyclic aromatic hydrocarbon

LPAH – low-molecular-weight polycyclic aromatic hydrocarbon

ML – maximum level

OC – organic carbon

PAH – polycyclic aromatic hydrocarbon

SL – screening level

SQS – sediment quality standard

SVOC – semivolatile organic compound

Seven individual PAHs had a total of nine detected concentrations that exceeded their respective SQS but not their CSL. Eight individual PAHs had a total of nine detected concentrations that exceeded their respective CSLs. Concentrations of total HPAHs exceeded the SQS but not the CSL at two locations (LDW-SS311 and LDW-SS316) and the CSL at one location (LDW-SS312). Concentrations of total LPAHs did not exceed either the SQS or CSL at any location.

Detected concentrations of butyl benzyl phthalate exceeded the SQS but not the CSL at two locations (LDW-SS322 and LDW-SS335). Detected concentrations of bis(2-ethylhexyl) phthalate exceeded the SQS but not the CSL at location LDW-SS322 and exceeded the CSL at location LDW-SS335.

Two other SVOCs, benzoic acid and benzyl alcohol, were detected at sampling location LDW-SS336 at concentrations exceeding their respective CSL values. One other SVOC, hexachlorobenzene, had RLs exceeding the SQS, and benzyl alcohol had a single RL exceeding its CSL value.

Seven additional samples were originally reported with RLs that exceeded SMS criteria for two SVOC chemicals (six samples for hexachlorobenzene and one sample for benzoic acid). For these non-detected results, the laboratory was able to determine with reasonable certainty that the RL was less than the SQS based on a visual

evaluation of the chromatogram and the spectrum of each analysis. The RLs for these seven results were lowered to values below the low calibration standard and flagged as estimated with a UJ qualifier. None of the qualified RLs are below the MDL.

4.1.4 PCB Aroclors

Table 4-7 summarizes results for PCBs in Round 3 surface sediment samples. Results are presented for both individual Aroclors and total PCBs. Table 4-7 also presents OC-normalized results for total PCBs for the 41 samples with TOC contents greater than or equal to 0.5% and less than or equal to 4.0% for comparison to the SQS and CSL. Figure 4-5 presents the total PCB results by location.

Table 4-7. Round 3 surface sediment sampling results for PCB Aroclors and total PCBs

Analyte	Unit	Detection Frequency[a]	Detected Concentration			Reporting Limit[c]		SMS	
			Minimum	Maximum	Mean[b]	Minimum	Maximum	SQS	CSL
Aroclor 1016	µg/kg dw	0/44	nd	nd	nd	3.8	120	na	na
Aroclor 1221	µg/kg dw	0/44	nd	nd	nd	3.8	120	na	na
Aroclor 1232	µg/kg dw	0/44	nd	nd	nd	3.8	120	na	na
Aroclor 1242	µg/kg dw	5/44	26	110	57	3.8	120	na	na
Aroclor 1248	µg/kg dw	26/44	6.3	240	59	3.9	120	na	na
Aroclor 1254	µg/kg dw	43/44	3.4 J	530	94	3.9	3.9	na	na
Aroclor 1260	µg/kg dw	43/44	4.0 J	240 J	87	3.9	3.9	na	na
Total PCBs (calc'd, dw)	µg/kg dw	43/44	8.4 J	1,010	220	nc	nc	na	na
Total PCBs (calc'd OC-normalized)	mg/kg OC	40/41[d]	0.65 J	46	12	nc	nc	12	65

[a] Field duplicate samples were collected at three of the 44 Round 3 locations. Field duplicate sample results are averaged with the original sample results for each of the three locations where field duplicate samples were collected.

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

[c] RL range for non-detect samples.

[d] Only those samples with TOC contents ≥ 0.5 and ≤ 4.0% are included. Three of the 44 samples analyzed had TOC contents < 0.5 or > 4.0%; therefore, OC-normalization and comparison with the SQS and CSL are not appropriate for those three samples.

CSL – cleanup screening level

dw – dry weight

na – not available

nc – not calculated

nd – not detected

J – estimated concentration

PCB – polychlorinated biphenyl

SMS – Sediment Management Standards

SQS – sediment quality standard

Four of the seven PCB Aroclors were detected in at least one sediment sample. The most frequently detected Aroclors were 1254 and 1260 (each detected in samples from 43 of 44 locations). The maximum total PCB concentration (1,010 µg/kg dw) was detected at location LDW-SS312. The TOC of this sample is greater than 4.0% and so it

was not appropriate to OC-normalize this result. The maximum OC-normalized total PCB concentration (46 mg/kg OC) was detected at location LDW-SS324. At one location, LDW-SS314, no PCB Aroclors were detected.

Table 4-8 presents the number of samples with total PCB detected concentrations or RLs (for non-detected results) greater than the SQS or CSL. Total PCBs exceeded the SQS in samples collected at 17 locations. The CSL for total PCBs was exceeded at a single location, LDW-SS312. None of the RLs for non-detected total PCB concentrations exceeded the SQS.

Table 4-8. Number of Round 3 surface sediment samples with total PCB concentrations within each SQS or CSL category

Analyte	No. of Samples with Detected Concentration			No. of Undetected Samples with Reporting Limits[a]		
	≤ SQS	> SQS ≤ CSL	> CSL	≤ SQS	> SQS ≤ CSL	> CSL
Total PCBs (calc'd)	26	16	1	1		

[a] The RL for total PCBs was assigned a concentration equal to the highest RL of the seven individual Aroclors for a given sample.

CSL – cleanup screening level

PCB – polychlorinated biphenyl

SQS – sediment quality standard

4.1.5 Dioxins and furans

Table 4-9 summarizes the results for the five Round 3 surface sediment samples that were analyzed for dioxins and furans.

Table 4-9. Round 3 surface sediment sampling results for dioxins and furans

Analyte	Detection Frequency	Unit	Detected Concentration			Reporting Limit[b]	
			Minimum	Maximum	Mean[a]	Minimum	Maximum
Dioxins							
2,3,7,8-TCDD	5/5	ng/kg dw	0.495 J	0.823 J	0.680	na	na
1,2,3,7,8-PeCDD	5/5	ng/kg dw	1.31 J	2.06 J	1.59	na	na
1,2,3,4,7,8-HxCDD	5/5	ng/kg dw	1.98 J	3.75 J	2.46	na	na
1,2,3,6,7,8-HxCDD	5/5	ng/kg dw	11.0 J	17.9 J	14.2	na	na
1,2,3,7,8,9-HxCDD	5/5	ng/kg dw	6.48 J	11.5 J	8.29	na	na
1,2,3,4,6,7,8-HpCDD	5/5	ng/kg dw	296	668	437	na	na
OCDD	5/5	ng/kg dw	2,830	4,900	3,710	na	na
Furans							
2,3,7,8-TCDF	5/5	ng/kg dw	0.992 J	2.04 J	1.52	na	na
1,2,3,7,8-PeCDF	5/5	ng/kg dw	0.905 J	1.52 J	1.19	na	na
2,3,4,7,8-PeCDF	5/5	ng/kg dw	2.05 J	4.49 J	3.11	na	na
1,2,3,4,7,8-HxCDF	5/5	ng/kg dw	6.81 J	14.2	9.78	na	na

Analyte	Detection Frequency	Unit	Detected Concentration			Reporting Limit[b]	
			Minimum	Maximum	Mean[a]	Minimum	Maximum
1,2,3,6,7,8-HxCDF	5/5	ng/kg dw	2.00 J	3.85 J	2.89	na	na
1,2,3,7,8,9-HxCDF	4/5	ng/kg dw	0.214 J	0.331 J	0.275	0.253	0.253
2,3,4,6,7,8-HxCDF	5/5	ng/kg dw	1.59 J	2.63 J	1.93	na	na
1,2,3,4,6,7,8-HpCDF	5/5	ng/kg dw	56.3	92.1	70.9	na	na
1,2,3,4,7,8,9-HpCDF	5/5	ng/kg dw	4.20 J	8.31 J	5.99	na	na
OCDF	5/5	ng/kg dw	203	353	270	na	na

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

[b] RL range for non-detect samples only.

dw – dry weight
J – estimated concentration
HpCDD – heptachlorodibenzo-*p*-dioxin
HpCDF – heptachlorodibenzofuran
HxCDD – hexachlorodibenzo-*p*-dioxin
HxCDF – hexachlorodibenzofuran
na – not applicable
OCDD – octachlorodibenzo-*p*-dioxin
OCDF – octachlorodibenzofuran
PeCDD – pentachlorodibenzo-*p*-dioxin
PeCDF – pentachlorodibenzofuran
TCDD – tetrachlorodibenzo-*p*-dioxin
TCDF – tetrachlorodibenzofuran

All of the dioxin congeners were detected in the five surface sediment samples analyzed for dioxins and furans. Of the dioxin congeners, the highest concentrations of 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD), 1,2,3,6,7,8-hexachlorodibenzo-*p*-dioxin (HxCDD), 1,2,3,4,6,7,8-heptachlorodibenzo-*p*-dioxin (HpCDD), and octachlorodibenzo-*p*-dioxin (OCDD) were detected in the sample from location LDW-SS321; the highest concentrations of the remaining dioxin congeners were detected in the sample from location LDW-SS322.

All of the furan congeners were detected in the five surface sediment samples, except for 1,2,3,7,8,9-hexachlorodibenzofuran (HxCDF), which was not detected in the sample from location LDW-SS321. Of the furan congeners, the highest concentrations of 2,3,7,8-tetrachlorodibenzofuran (TCDF), 1,2,3,7,8-pentachlorodibenzofuran (PeCDF), 2,3,4,6,7,8-HxCDF, 1,2,3,4,6,7,8-heptachlorodibenzofuran (HpCDF), and octachlorodibenzofuran (OCDF) were detected in the sample from location LDW-SS322; and the highest concentrations of the remaining furan congeners were detected in the sample from location LDW-SS324.

Toxic equivalents (TEQs) for 2,3,7,8-TCDD were calculated using mammalian toxic equivalency factors (TEFs) for dioxin and furan congeners from Van den Berg et al. (2006). These TEQs were calculated using one-half the RL for undetected congeners. Results for each location are presented in Table 4-10 and shown in Figure 4-6. The calculated TEQs in the five samples ranged from 10.2 to 16.9 ng/kg dw, with the highest TEQ detected in the sample collected from location LDW-SS321.

Table 4-10. Round 3 surface sediment sampling results for dioxin and furan calculated TEQs

Sampling Location	TEQ (ng/kg dw)[a]
LDW-SS318	10.2 J
LDW-SS321	16.9 J
LDW-SS322	16.4 J
LDW-SS323	10.6 J
LDW-SS324	14.4 J

[a] TEQs were calculated using the mammalian dioxin and furan TEFs from Van den Berg et al. (2006) and one-half the RL for undetected congeners.

dw – dry weight

J – estimated concentration

TEQ – toxic equivalent

4.1.6 Grain size, total organic carbon, and total solids

Table 4-11 summarizes the grain size, TOC, and total solids results for the 44 Round 3 surface sediment samples. Total solids are reported in wet weight, while the other parameters are in dry weight.

Table 4-11. Round 3 surface sediment sampling results for grain size, TOC, and total solids

Parameter	Unit	Minimum	Maximum	Mean
Grain Size				
Gravel	% dw	0.1	26.7	4
Sand	% dw	9.1	96.1	47
Silt	% dw	0.7	66.7	40
Clay	% dw	0.9	42.6	10
Fines (sum of silt and clay fractions)	% dw	1.6	89.7	49
Conventionals				
TOC	% dw	0.284	4.36	1.93
Total solids	% ww	34.20	78.50	56.65

dw – dry weight

LDW – Lower Duwamish Waterway

TOC – total organic carbon

ww – wet weight

Percent fines in surface sediment samples ranged from 1.6 to 89.7% dw, with a mean of 49% dw. TOC ranged from 0.284 to 4.36% dw, with a mean of 1.93% dw. One sample (from location LDW-SS306) had a TOC content less than 0.5% dw, and two samples (from locations LDW-SS311 and LDW-SS312) had TOC contents greater than 4.0% dw. Total solids ranged from 34.20 to 78.50% wet weight (ww).

4.1.7 Comparison of non-detected concentrations to analytical concentration goals

This section compares RLs and method detection limits (MDLs) for non-detected concentrations to site-specific analytical concentration goals (ACGs) (Windward 2005) and practical quantitation limits (PQLs) recommended for sediment analyses by Ecology (2003). The comparisons in this section were conducted using results from the 47 Round 3 surface sediment samples (44 samples plus 3 field duplicate samples). Appendix C of the surface sediment QAPP (Windward 2005) documented the initial derivation of ACGs for evaluating risks to human health (based on both indirect exposure [e.g., seafood consumption] and direct exposure [e.g., dermal contact]) [1], benthic invertebrates (based on SQS, or SL if an SQS was not available for a given chemical), and sandpiper (based on the consumption of benthic invertebrates and sediment). The target detection limits for the Round 3 surface sediment analyses, which were updated by the laboratories in 2005 and 2006, were identified in Appendix A of the surface sediment QAPP addendum (Windward 2006b) and are presented in the tables in this section.

Actual MDLs and RLs may differ from the target detection limits as a result of necessary analytical dilutions or the adjustment of extracted sample volumes for some samples based on a preliminary screen of the sample prior to analysis. 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 chemicals other than the target analytes that required dilution. The sample-specific RL is based on the lowest point of the calibration curve associated with each analysis, whereas the MDL is statistically derived following EPA methods (40 CFR 136). Both the RL and MDL will be elevated in cases where the sample extract required dilution. Detected concentrations between the MDL and RL were reported by the laboratories and flagged with a J-qualifier to indicate that the reported concentration was an estimate because it fell below the lowest point on the calibration curve. The analytical laboratory performed the appropriate sample cleanups to achieve the lowest possible detection limits.

Fifteen chemicals had at least one sample-specific RL above the applicable ACG for human health – indirect exposure (Table 4-12). One or more MDLs for 12 of these 15 chemicals also exceeded ACGs. The minimum MDLs reported in Table 4-12 were generally lower than the target MDLs; many of the MDLs that were above the ACGs were for chemicals previously identified in the surface sediment QAPP (Windward 2005) as those that would likely represent analytical challenges. One additional chemical, benzo(k)fluoranthene, that were not identified in the surface sediment QAPP had RLs above the ACGs . All MDLs were lower than the ACG for this chemical.

[1] The ACGs for human health that were presented in Table C-1 of the surface sediment QAPP (Windward 2005) have been updated, as presented later in this section.

Table 4-12. RLs and MDLs for surface sediment analytes relative to human health ACGs associated with indirect exposure

Analyte	Unit	No. of Detected Results	Range of Detected Results	No. of Non-Detected Results	Range of RLs for Non-Detected Results	No. of RLs > ACG	Range of MDLs for Non-Detected Results	No. of MDLs > ACG	Target MDL	Human Health – Indirect Exposure ACG
Metals and trace elements										
Arsenic	mg/kg dw	47	4.0 – 123	0	na	0	na	0	0.83	0.006
Cadmium	mg/kg dw	22	0.4 – 1.1	25	0.3 – 0.5	25	0.00025 – 0.0005	0	0.013	0.003
Chromium	mg/kg dw	47	11.0 – 40	0	na	0	na	0	0.09	100
Copper	mg/kg dw	47	14.5 – 137	0	na	0	na	0	0.021	1.3
Mercury	mg/kg dw	40	0.060 – 1.8	7	0.05 – 0.08	7	0.0026 – 0.0042	0	0.0025	0.016
Zinc	mg/kg dw	47	39 – 346	0	na	0	na	0	1.06	16
Organometals										
Tributyltin as ion	µg/kg dw	4	14 – 73	0	na	0	na	0	2.08	0.28
PAHs										
2-Methylnaphthalene	µg/kg dw	3	85 – 110	44	60 – 110	0	55 – 98	0	18.3	1,700
Acenaphthene	µg/kg dw	6	34 – 210	41	60 – 62	0	31 – 32	0	10.4	5.4×10^5
Anthracene	µg/kg dw	30	33 – 1,200	17	60 – 62	0	24 – 25	0	7.95	9.0×10^5
Benzo(a)anthracene	µg/kg dw	41	46 – 2,200	6	60 – 62	6	26 – 27	6	8.67	5.2
Benzo(a)pyrene	µg/kg dw	41	49 – 3,200	6	60 – 62	6	24 – 25	6	8.05	0.76
Benzo(b)fluoranthene	µg/kg dw	42	36 – 4,600	5	60 – 62	5	26 – 27	5	8.63	4.7
Benzo(k)fluoranthene	µg/kg dw	41	52 – 2,200	6	60 – 62	6	24 – 25	0	7.98	47
Chrysene	µg/kg dw	43	35 – 3,600	4	60 – 62	0	29 – 30	0	9.65	480
Dibenzofuran	µg/kg dw	5	96 – 170	42	60 – 62	0	52 – 53	0	17.1	560
Fluoranthene	µg/kg dw	46	32 – 7,500	1	61 – 61	0	26 – 26	0	8.57	2,100
Indeno(1,2,3-cd)pyrene	µg/kg dw	39	34 – 1,600	8	60 – 62	8	19 – 19	8	6.18	2.9
Naphthalene	µg/kg dw	7	37 – 180	40	60 – 110	0	35 – 63	0	11.7	4,500
Pyrene	µg/kg dw	45	39 – 4,800	2	61 – 62	0	29 – 29	0	9.38	8,900

Table 4-12, cont.

Analyte	Unit	No. of Detected Results	Range of Detected Results	No. of Non-Detected Results	Range of RLs for Non-Detected Results	No. of RLs > ACG	Range of MDLs for Non-Detected Results	No. of MDLs > ACG	Target MDL	Human Health – Indirect Exposure ACG
Phthalates										
bis(2-Ethylhexyl) phthalate	µg/kg dw	45	36 – 2,600	2	61 – 62	0	34 – 34	0	11	120
Butyl benzyl phthalate	µg/kg dw	41	6.2 – 200	6	6.1 – 6.2	0	3.6 – 3.7	0	4	3.0×10^4
Dimethyl phthalate	µg/kg dw	21	6.1 – 33	26	6.0 – 6.2	0	1.6 – 1.6	0	1.7	1.4×10^6
Di-n-butyl phthalate	µg/kg dw	10	32 – 59	37	60 – 62	0	20 – 21	0	6.64	1.4×10^4
Di-n-octyl phthalate	µg/kg dw	1	92 – 92	46	60 – 62	0	31 – 32	0	10.2	3,000
Other SVOCs										
1,2-Dichlorobenzene	µg/kg dw	0	nd	47	6.0 – 11	0	1.2 – 2.2	0	1.347	1.2×10^4
1,4-Dichlorobenzene	µg/kg dw	5	6.2 – 64	42	6.0 – 6.2	0	2.0 – 2.1	0	2.205	73
2,4,5-Trichlorophenol	µg/kg dw	0	nd	47	300 – 540	0	18 – 19	0	5.95	3.7×10^4
2,4-Dichlorophenol	µg/kg dw	0	nd	47	300 – 540	0	25 – 26	0	8.3	1,100
2-Chlorophenol	µg/kg dw	0	nd	47	60 – 110	0	27 – 28	0	9.02	1,800
4-Methylphenol	µg/kg dw	4	36 – 300	43	60 – 110	0	22 – 23	0	7.3	1,800
Hexachlorobutadiene	µg/kg dw	0	nd	47	6.0 – 11	0	2.6 – 4.6	0	2.878	23
Hexachloroethane	µg/kg dw	0	nd	47	60 – 110	0	29 – 30	0	9.68	120
Phenol	µg/kg dw	7	40 – 140	40	60 – 250	0	37 – 29	0	12.2	2.1×10^5
PCBs										
Aroclor 1016	µg/kg dw	0	nd	47	3.8 – 120	32	1.3 – 42	21	1.33	6.1
Aroclor 1221	µg/kg dw	0	nd	47	3.8 – 120	47	1.3 – 42	47	1.33	0.21
Aroclor 1232	µg/kg dw	0	nd	47	3.8 – 120	47	1.3 – 42	47	1.33	0.21
Aroclor 1242	µg/kg dw	5	26 – 110	42	3.8 – 120	42	1.3 – 42	42	1.33	0.21
Aroclor 1248	µg/kg dw	27	6.3 – 240	20	3.9 – 120	20	1.3 – 42	20	1.33	0.21
Aroclor 1254	µg/kg dw	46	3.4 – 530	1	3.9 – 3.9	1	1.3 – 1.3	1	1.33	0.21
Aroclor 1260	µg/kg dw	46	4.0 – 240	1	3.9 – 3.9	1	1.3 – 1.3	1	1.33	0.21
Total PCBs (calc'd)	µg/kg dw	46	8.4 – 1,010	1	12 – 12	1	1.3 – 1.3	1	1.33	0.21

Table 4-12, cont.

Analyte	Unit	No. of Detected Results	Range of Detected Results	No. of Non-Detected Results	Range of RLs for Non-Detected Results	No. of RLs > ACG	Range of MDLs for Non-Detected Results	No. of MDLs > ACG	Target MDL	Human Health – Indirect Exposure ACG
Dioxin/furan										
2,3,7,8-TCDD	ng/kg dw	5	0.495 – 0.823	0	na	0	na	0	0.036	0.35
1,2,3,7,8-PeCDD	ng/kg dw	5	1.31 – 2.06	0	na	0	na	0	0.069	0.35
1,2,3,4,7,8-HxCDD	ng/kg dw	5	1.98 – 3.75	0	na	0	na	0	0.095	0.7
1,2,3,6,7,8-HxCDD	ng/kg dw	5	11.0 – 17.9	0	na	0	na	0	0.114	3.5
1,2,3,7,8,9-HxCDD	ng/kg dw	5	6.48 – 11.5	0	na	0	na	0	0.081	3.5
1,2,3,4,6,7,8-HpCDD	ng/kg dw	5	296 – 668	0	na	0	na	0	0.246	3.5
OCDD	ng/kg dw	5	2,830 – 4,900	0	na	0	na	0	2.39	3.5
2,3,7,8-TCDF	ng/kg dw	5	0.992 – 2.04	0	na	0	na	0	0.025	3.5
1,2,3,7,8-PeCDF	ng/kg dw	5	0.905 – 1.52	0	na	0	na	0	0.085	3.5
2,3,4,7,8-PeCDF	ng/kg dw	5	2.05 – 4.49	0	na	0	na	0	0.101	3.5
1,2,3,4,7,8-HxCDF	ng/kg dw	5	6.81 – 14.2	0	na	0	na	0	0.101	3.5
1,2,3,6,7,8-HxCDF	ng/kg dw	5	2.00 – 3.85	0	na	0	na	0	0.078	7
1,2,3,7,8,9-HxCDF	ng/kg dw	4	0.214 – 0.331	1	0.253 – 0.253	0	0.212 – 0.212	0	0.076	35
2,3,4,6,7,8-HxCDF	ng/kg dw	5	1.59 – 2.63	0	na	0	na	0	0.056	35
1,2,3,4,6,7,8-HpCDF	ng/kg dw	5	56.3 – 92.1	0	na	0	na	0	0.129	35
1,2,3,4,7,8,9-HpCDF	ng/kg dw	5	4.20 – 8.31	0	na	0	na	0	0.134	3,500
OCDF	ng/kg dw	5	203 – 353	0	na	0	na	0	0.15	3,500

ACG – analytical concentration goal
dw – dry weight
HpCDD – heptachlorodibenzo-*p*-dioxin
HpCDF – heptachlorodibenzofuran
HxCDD – hexachlorodibenzo-*p*-dioxin
HxCDF – hexachlorodibenzofuran
MDL – method detection limit
na – not applicable
nd – not detected
OCDD – octachlorodibenzo-*p*-dioxin
OCDF – octachlorodibenzofuran
PAH – polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
PeCDD – pentachlorodibenzo-*p*-dioxin
PeCDF – pentachlorodibenzofuran
RL – reporting limit
SVOC – semivolatile organic compound
TCDD – tetrachlorodibenzo-*p*-dioxin
TCDF – tetrachlorodibenzofuran

For human health – direct exposure, two chemicals had one or more RLs that exceeded the applicable ACG (Table 4-13). The MDLs for these two chemicals were below the ACGs, with the exception of all MDLs for n-nitrosodimethylamine. N-nitroso-dimethylamine is known to be difficult to quantify in sediment.

For benthic invertebrates, the ACG was either the SQS or the SL if an SQS was not available. For samples where OC-normalization was not appropriate (i.e., TOC < 0.5% or > 4.0 %), the applicable ACG was the LAET. As shown in Tables 4-14 and 4-15, two chemicals, hexachlorobenzene and benzyl alcohol, had RLs greater than their ACGs. All MDLs for these chemicals were less than the ACG for all results. For sandpiper, all chemicals had RLs and MDLs below the lowest ACG.

Table 4-16 compares RLs and MDLs to Ecology's PQLs. Nine chemicals had at least one RL that exceeded the PQL for that chemical. Three of these nine chemicals also had at least one MDL that exceeded the PQL. With the exception of one chemical (benzoic acid), these elevated MDLs and RLs resulted from analytical interferences and/or analytical dilutions needed for other chemicals present in the samples. The Round 3 target MDL for benzoic acid provided by the laboratory was greater than the Ecology PQL for this chemical.

Table 4-13. RLs and MDLs for surface sediment sample analytes relative to human health ACGs associated with direct exposure

Analyte	Unit	No. of Detected Results	Range of Detected Results	No. of Non-Detected Results	Range of RLs for Non-Detected Results	No. of RLs > ACG	Range of MDLs for Non-Detected Results	No. of MDLs > ACG	Target MDL	Human Health – Direct Exposure ACG
Metals and trace elements										
Antimony	mg/kg dw	2	0.4 – 1.1	45	0.3 – 0.6	0	0.00013 – 0.00029	0	0.62	3.1
Arsenic	mg/kg dw	47	4.0 – 123	0	na	0	na	0	0.83	0.39
Cadmium	mg/kg dw	22	0.4 – 1.1	25	0.3 – 0.5	0	0.00025 – 0.0005	0	0.013	3.7
Chromium	mg/kg dw	47	11.0 – 40	0	na	0	na	0	0.09	210
Cobalt	mg/kg dw	47	3.6 – 12	0	na	0	na	0	0.03	900
Copper	mg/kg dw	47	14.5 – 137	0	na	0	na	0	0.021	310
Lead	mg/kg dw	47	7 – 303	0	na	0	na	0	0.116	40
Mercury	mg/kg dw	40	0.060 – 1.8	7	0.05 – 0.08	0	0.0026 – 0.0042	0	0.0025	2.3
Molybdenum	mg/kg dw	45	0.3 – 8.8	2	0.3 – 0.3	0	0.00013 – 0.00017	0	0.088	39
Nickel	mg/kg dw	47	9.2 – 35	0	na	0	na	0	0.21	160
Selenium	mg/kg dw	0	nd	47	0.6 – 1	0	0.0061 – 0.014	0	0.98	39
Silver	mg/kg dw	24	0.3 – 0.9	23	0.3 – 0.6	0	0.00013 – 0.00029	0	0.032	39
Thallium	mg/kg dw	0	nd	47	0.3 – 0.6	1	0.00005 – 0.00011	0	0.446	0.52
Vanadium	mg/kg dw	47	34.6 – 74	0	na	0	na	0	0.018	55
Zinc	mg/kg dw	47	39 – 346	0	na	0	na	0	1.06	2,300
PAHs										
Tributyltin as ion	µg/kg dw	4	14 – 73	0	na	0	na	0	2.08	1,800
PAHs										
2-Chloronaphthalene	µg/kg dw	0	nd	47	60 – 110	0	28 – 49	0	9.16	4.9×10^5
Acenaphthene	µg/kg dw	6	34 – 210	41	60 – 62	0	31 – 32	0	10.4	3.7×10^5
Anthracene	µg/kg dw	30	33 – 1,200	17	60 – 62	0	24 – 25	0	7.95	2.2×10^6
Benzo(a)anthracene	µg/kg dw	41	46 – 2,200	6	60 – 62	0	26 – 27	0	8.67	620

Table 4-13, cont.

Analyte	Unit	No. of Detected Results	Range of Detected Results	No. of Non-Detected Results	Range of RLs for Non-Detected Results	No. of RLs > ACG	Range of MDLs for Non-Detected Results	No. of MDLs > ACG	Target MDL	Human Health – Direct Exposure ACG
Benzo(a)pyrene	µg/kg dw	41	49 – 3,200	6	60 – 62	0	24 – 25	0	8.05	62
Benzo(b)fluoranthene	µg/kg dw	42	36 – 4,600	5	60 – 62	0	26 – 27	0	8.63	620
Benzo(k)fluoranthene	µg/kg dw	41	52 – 2,200	6	60 – 62	0	24 – 25	0	7.98	6,200
Chrysene	µg/kg dw	43	35 – 3,600	4	60 – 62	0	29 – 30	0	9.65	6.2×10^4
Dibenzo(a,h)anthracene	µg/kg dw	41	6.7 – 340	6	6.1 – 6.2	0	2.6 – 2.6	0	0.5	62
Dibenzofuran	µg/kg dw	5	96 – 170	42	60 – 62	0	52 – 53	0	17.1	2.9×10^4
Fluoranthene	µg/kg dw	46	32 – 7,500	1	61 – 61	0	26 – 26	0	8.57	2.3×10^5
Fluorene	µg/kg dw	14	36 – 320	33	60 – 62	0	35 – 36	0	11.6	2.7×10^5
Indeno(1,2,3-cd)pyrene	µg/kg dw	39	34 – 1,600	8	60 – 62	0	19 – 19	0	6.18	620
Naphthalene	µg/kg dw	7	37 – 180	40	60 – 110	0	35 – 63	0	11.7	5,600
Pyrene	µg/kg dw	45	39 – 4,800	2	61 – 62	0	29 – 29	0	9.38	2.3×10^5
Phthalates										
bis(2-Ethylhexyl) phthalate	µg/kg dw	45	36 – 2,600	2	61 – 62	0	34 – 34	0	11	3.5×10^4
Butyl benzyl phthalate	µg/kg dw	41	6.2 – 200	6	6.1 – 6.2	0	3.6 – 3.7	0	4	1.2×10^6
Diethyl phthalate	µg/kg dw	0	nd	47	60 – 110	0	32 – 57	0	10.6	4.9×10^6
Dimethyl phthalate	µg/kg dw	21	6.1 – 33	26	6.0 – 6.2	0	1.6 – 1.6	0	1.7	1.0×10^8
Di-n-butyl phthalate	µg/kg dw	10	32 – 59	37	60 – 62	0	20 – 21	0	6.64	6.1×10^5
Di-n-octyl phthalate	µg/kg dw	1	92 – 92	46	60 – 62	0	31 – 32	0	10.2	2.4×10^5
Other SVOCs										
1,2,4-Trichlorobenzene	µg/kg dw	0	nd	47	6.0 – 11	0	1.5 – 2.6	0	1.638	6.5×10^4
1,2-Dichlorobenzene	µg/kg dw	0	nd	47	6.0 – 11	0	1.2 – 2.2	0	1.347	3.7×10^5
1,3-Dichlorobenzene	µg/kg dw	0	nd	47	60 – 110	0	25 – 45	0	8.4	1,600
1,4-Dichlorobenzene	µg/kg dw	5	6.2 – 64	42	6.0 – 6.2	0	2.0 – 2.1	0	2.205	3,400
2,4,5-Trichlorophenol	µg/kg dw	0	nd	47	300 – 540	0	18 – 32	0	5.95	6.1×10^5
2,4,6-Trichlorophenol	µg/kg dw	0	nd	47	300 – 540	0	27 – 47	0	8.78	610

Table 4-13, cont.

Analyte	Unit	No. of Detected Results	Range of Detected Results	No. of Non-Detected Results	Range of RLs for Non-Detected Results	No. of RLs > ACG	Range of MDLs for Non-Detected Results	No. of MDLs > ACG	Target MDL	Human Health – Direct Exposure ACG
2,4-Dichlorophenol	µg/kg dw	0	nd	47	300 – 540	0	25 – 45	0	8.3	1.8×10^4
2,4-Dimethylphenol	µg/kg dw	4	6.1 – 20	43	6.0 – 11	0	3.5 – 6.2	0	3.856	1.2×10^5
2,4-Dinitrophenol	µg/kg dw	0	nd	47	600 – 1,100	0	89 – 160	0	29.4	1.2×10^4
2,4-Dinitrotoluene	µg/kg dw	0	nd	47	300 – 540	0	31 – 55	0	10.3	1.2×10^4
2,6-Dinitrotoluene	µg/kg dw	0	nd	47	300 – 540	0	37 – 66	0	12.2	6,100
2-Chlorophenol	µg/kg dw	0	nd	47	60 – 110	0	27 – 48	0	9.02	6,300
2-Methylphenol	µg/kg dw	4	8.6 – 14	43	6.0 – 11	0	3.1 – 5.4	0	3.379	3.1×10^5
3,3′-Dichlorobenzidine	µg/kg dw	0	nd	47	300 – 540	0	140 – 250	0	47.4	1,100
4-Chloroaniline	µg/kg dw	0	nd	47	300 – 540	0	120 – 220	0	39.9	2.4×10^4
4-Methylphenol	µg/kg dw	4	36 – 300	43	60 – 110	0	22 – 39	0	7.3	3.1×10^4
Aniline	µg/kg dw	0	nd	47	60 – 110	0	29 – 52	0	9.64	8.5×10^4
Benzoic acid	µg/kg dw	1	1,600 – 1,600	46	540 – 620	0	270 – 480	0	148	1.0×10^8
Benzyl alcohol	µg/kg dw	1	540 – 540	46	30 – 74	0	14 – 25	0	15.547	1.8×10^6
bis(2-Chloroethyl)ether	µg/kg dw	0	nd	47	60 – 110	0	36 – 64	0	11.9	210
bis(2-Chloroisopropyl)ether	µg/kg dw	0	nd	47	60 – 110	0	36 – 65	0	12	2,900
Hexachlorobenzene	µg/kg dw	0	nd	47	3.0 – 11	0	1.8 – 3.2	0	1.966	300
Hexachlorobutadiene	µg/kg dw	0	nd	47	6.0 – 11	0	2.6 – 4.6	0	2.878	6,200
Hexachloroethane	µg/kg dw	0	nd	47	60 – 110	0	29 – 52	0	9.68	3.5×10^4
Isophorone	µg/kg dw	0	nd	47	60 – 110	0	33 – 59	0	11	5.1×10^5
Nitrobenzene	µg/kg dw	0	nd	47	60 – 110	0	32 – 56	0	10.5	2,000
n-Nitrosodimethylamine	µg/kg dw	0	nd	47	30 – 54	47	22 – 38	47	23.871	9.5
n-Nitroso-di-n-propylamine	µg/kg dw	0	nd	47	30 – 54	0	2.4 – 4.3	0	2.68	69
n-Nitrosodiphenylamine	µg/kg dw	0	nd	47	6.0 – 32	0	2.8 – 4.9	0	3.054	9.9×10^4
Pentachlorophenol	µg/kg dw	0	nd	47	30 – 54	0	12 – 21	0	13.126	3,000
Phenol	µg/kg dw	7	40 – 140	40	60 – 250	0	37 – 66	0	12.2	3.7×10^6

Table 4-13, cont.

Analyte	Unit	No. of Detected Results	Range of Detected Results	No. of Non-Detected Results	Range of RLs for Non-Detected Results	No. of RLs > ACG	Range of MDLs for Non-Detected Results	No. of MDLs > ACG	Target MDL	Human Health – Direct Exposure ACG
PCBs										
Aroclor 1016	µg/kg dw	0	nd	47	3.8 – 120	0	1.3 – 42	0	1.33	390
Aroclor 1221	µg/kg dw	0	nd	47	3.8 – 120	0	1.3 – 42	0	1.33	220
Aroclor 1232	µg/kg dw	0	nd	47	3.8 – 120	0	1.3 – 42	0	1.33	220
Aroclor 1242	µg/kg dw	5	26 – 110	42	3.8 – 120	0	1.3 – 42	0	1.33	220
Aroclor 1248	µg/kg dw	27	6.3 – 240	20	3.9 – 120	0	1.3 – 42	0	1.33	220
Aroclor 1254	µg/kg dw	46	3.4 – 530	1	3.9 – 3.9	0	1.3 – 1.3	0	1.33	220
Aroclor 1260	µg/kg dw	46	4.0 – 240	1	3.9 – 3.9	0	1.3 – 1.3	0	1.33	220
Total PCBs (calc'd)	µg/kg dw	46	8.4 – 1,010	1	12 – 12	0	1.3 – 1.3	0	1.33	220
Dioxins/furans										
2,3,7,8-TCDD	ng/kg dw	5	0.495 – 0.823	0	na	0	na	0	0.036	3.9
1,2,3,7,8-PeCDD	ng/kg dw	5	1.31 – 2.06	0	na	0	na	0	0.069	3.9
1,2,3,4,7,8-HxCDD	ng/kg dw	5	1.98 – 3.75	0	na	0	na	0	0.095	7.8
1,2,3,6,7,8-HxCDD	ng/kg dw	5	11.0 – 17.9	0	na	0	na	0	0.114	39
1,2,3,7,8,9-HxCDD	ng/kg dw	5	6.48 – 11.5	0	na	0	na	0	0.081	39
1,2,3,4,6,7,8-HpCDD	ng/kg dw	5	296 – 668	0	na	0	na	0	0.246	39
OCDD	ng/kg dw	5	2,830 – 4,900	0	na	0	na	0	2.39	39
2,3,7,8-TCDF	ng/kg dw	5	0.992 – 2.04	0	na	0	na	0	0.025	39
1,2,3,7,8-PeCDF	ng/kg dw	5	0.905 – 1.52	0	na	0	na	0	0.085	39
2,3,4,7,8-PeCDF	ng/kg dw	5	2.05 – 4.49	0	na	0	na	0	0.101	39
1,2,3,4,7,8-HxCDF	ng/kg dw	5	6.81 – 14.2	0	na	0	na	0	0.101	39
1,2,3,6,7,8-HxCDF	ng/kg dw	5	2.00 – 3.85	0	na	0	na	0	0.078	78
1,2,3,7,8,9-HxCDF	ng/kg dw	4	0.214 – 0.331	1	0.253 – 0.253	0	0.212 – 0.212	0	0.076	390
2,3,4,6,7,8-HxCDF	ng/kg dw	5	1.59 – 2.63	0	na	0	na	0	0.056	390
1,2,3,4,6,7,8-HpCDF	ng/kg dw	5	56.3 – 92.1	0	na	0	na	0	0.129	390

Table 4-13, cont.

Analyte	Unit	No. of Detected Results	Range of Detected Results	No. of Non-Detected Results	Range of RLs for Non-Detected Results	No. of RLs > ACG	Range of MDLs for Non-Detected Results	No. of MDLs > ACG	Target MDL	Human Health – Direct Exposure ACG
1,2,3,4,7,8,9-HpCDF	ng/kg dw	5	4.20 – 8.31	0	na	0	na	0	0.134	3.90×10^{4}
OCDF	ng/kg dw	5	203 – 353	0	na	0	na	0	0.15	3.90×10^{4}

ACG – analytical concentration goal
dw – dry weight
HpCDD – heptachlorodibenzo-*p*-dioxin
HpCDF – heptachlorodibenzofuran
HxCDD – hexachlorodibenzo-*p*-dioxin
HxCDF – hexachlorodibenzofuran
MDL – method detection limit
na – not applicable
nd – not detected
OCDD – octachlorodibenzo-*p*-dioxin
OCDF – octachlorodibenzofuran
PAH – polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
PeCDD – pentachlorodibenzo-*p*-dioxin
PeCDF – pentachlorodibenzofuran
RL – reporting limit
SVOC – semivolatile organic compound
TCDD – tetrachlorodibenzo-*p*-dioxin
TCDF – tetrachlorodibenzofuran

Table 4-14. RLs and MDLs for surface sediment analytes relative to benthic invertebrate ACGs

Analyte	Unit	No. of Detected Results	Range of Detected Results	No. of Non-Detected Results	Range of RLs for Non-Detected Results	No. of RLs > ACG	Range of Non-Detected MDLs	No. of MDLs > ACG	Target MDL	Benthic Invertebrate ACG[a]
Metals and trace elements										
Antimony	mg/kg dw	2	0.4 – 1.1	45	0.3 – 0.6	0	0.00013 – 0.00029	0	0.62	150
Arsenic	mg/kg dw	47	4.0 – 123	0	na	0	na	0	0.83	57
Cadmium	mg/kg dw	22	0.4 – 1.1	25	0.3 – 0.5	0	0.00025 – 0.00050	0	0.013	5.1
Chromium	mg/kg dw	47	11.0 – 40	0	na	0	na	0	0.09	260
Copper	mg/kg dw	47	14.5 – 137	0	na	0	na	0	0.021	390
Lead	mg/kg dw	47	7 – 303	0	na	0	na	0	0.116	450
Mercury	mg/kg dw	40	0.060 – 1.8	7	0.05 – 0.08	0	0.0026 – 0.0042	0	0.0025	0.41
Nickel	mg/kg dw	47	9.2 – 35	0	na	0	na	0	0.21	140
Silver	mg/kg dw	24	0.3 – 0.9	23	0.3 – 0.6	0	0.00013 – 0.00029	0	0.032	6.1
Zinc	mg/kg dw	47	39 – 346	0	na	0	na	0	1.06	410
PAHs										
2-Methylnaphthalene	mg/kg OC	2	2.8 – 5.2	42	2.2 – 8.1	0	2.0 – 7.4	0	na[b]	38
Acenaphthene	mg/kg OC	5	1.3 – 7.3	39	2.2 – 8.1	0	1.2 – 4.2	0	na[b]	16
Acenaphthylene	mg/kg OC	7	1.6 – 4.2	37	2.2 – 8.1	0	1.0 – 3.8	0	na[b]	66
Anthracene	mg/kg OC	28	1.7 – 42	16	2.2 – 6.8	0	0.90 – 3.3	0	na[b]	220
Benzo(a)anthracene	mg/kg OC	39	2.1 – 110	5	3.0 – 6.8	0	1.3 – 3.0	0	na[b]	110
Benzo(a)pyrene	mg/kg OC	39	2.2 – 130	5	3.0 – 6.8	0	1.2 – 2.8	0	na[b]	99
Benzo(g,h,i)perylene	mg/kg OC	38	1.8 – 51	6	3.0 – 6.8	0	1.3 – 2.9	0	na[b]	31
Total benzofluoranthenes	mg/kg OC	40	4.0 – 350	4	3.0 – 4.3	0	1.3 – 1.9	0	na[b]	230
Chrysene	mg/kg OC	41	2.0 – 180	3	3.0 – 4.3	0	1.5 – 2.1	0	na[b]	110
Dibenzo(a,h)anthracene	mg/kg OC	39	0.29 – 17	5	0.30 – 0.68	0	0.13 – 0.29	0	na[b]	12
Dibenzofuran	mg/kg OC	4	4.6 – 5.7	40	2.2 – 8.1	0	1.9 – 6.9	0	na[b]	15
Fluoranthene	mg/kg OC	44	1.6 – 620	0	na	0	na	0	na[b]	160
Fluorene	mg/kg OC	12	1.6 – 11	32	2.2 – 6.8	0	1.3 – 4.7	0	na[b]	23
Indeno(1,2,3-cd)pyrene	mg/kg OC	37	1.6 – 56	7	3.0 – 6.8	0	0.93 – 2.1	0	na[b]	34

Table 4-14, cont.

Analyte	Unit	No. of Detected Results	Range of Detected Results	No. of Non-Detected Results	Range of RLs for Non-Detected Results	No. of RLs > ACG	Range of Non-Detected MDLs	No. of MDLs > ACG	Target MDL	Benthic Invertebrate ACG[a]
Naphthalene	mg/kg OC	5	1.5 – 4.3	39	2.2 – 8.1	0	1.3 – 4.7	0	na[b]	99
Phenanthrene	mg/kg OC	41	2.1 – 97	3	3.0 – 6.8	0	1.6 – 3.5	0	na[b]	100
Pyrene	mg/kg OC	43	2.3 – 260	1	3.0 – 3.0	0	1.4 – 1.4	0	na[b]	1,000
Total HPAH	mg/kg OC	44	1.6 – 1,100	0	na	0	na	0	na[b]	960
Total LPAH	mg/kg OC	41	2.1 – 160	3	3.0 – 6.8	0	1.5 – 3.0	0	na[b]	370
Phthalates										
bis(2-Ethylhexyl) phthalate	mg/kg OC	43	2.0 – 90	1	2.2 – 2.2	0	1.5 – 1.5	0	na[b]	47
Butyl benzyl phthalate	mg/kg OC	39	0.22 – 6.9	5	0.29 – 0.68	0	0.18 – 0.41	0	na[b]	4.9
Diethyl phthalate	mg/kg OC	0	nd	44	2.0 – 8.1	0	1.1 – 4.3	0	na[b]	61
Dimethyl phthalate	mg/kg OC	20	0.29 – 1.7	24	0.20 – 0.68	0	0.053 – 0.18	0	na[b]	53
Di-n-butyl phthalate	mg/kg OC	8	1.3 – 2.6	36	2.0 – 8.1	0	0.66 – 2.7	0	na[b]	220
Di-n-octyl phthalate	mg/kg OC	1	3.2 – 3.2	43	2.0 – 8.1	0	1.0 – 4.2	0	na[b]	58
Other SVOCs										
1,2,4-Trichlorobenzene	mg/kg OC	0	nd	44	0.20 – 0.81	0	0.050 – 0.20	0	na[b]	0.81
1,2-Dichlorobenzene	mg/kg OC	0	nd	44	0.20 – 0.81	0	0.040 – 0.17	0	na[b]	2.3
1,3-Dichlorobenzene	µg/kg dw	0	nd	47	60 – 110	0	25 – 45	0	8.4	170
1,4-Dichlorobenzene	mg/kg OC	5	0.27 – 2.2	39	0.20 – 0.68	0	0.066 – 0.22	0	na[b]	3.1
2,4-Dimethylphenol	µg/kg dw	4	6.1 – 20	43	6.0 – 11	0	3.5 – 6.2	0	3.856	29
2-Methylphenol	µg/kg dw	4	8.6 – 14	43	6.0 – 11	0	3.1 – 5.4	0	3.379	63
4-Methylphenol	µg/kg dw	4	36 – 300	43	60 – 110	0	22 – 39	0	7.3	670
Benzoic acid	µg/kg dw	1	1,600 – 1,600	46	540 – 620	0	270 – 480	0	148	650
Benzyl alcohol	µg/kg dw	1	540 – 540	46	30 – 74	1	14 – 25	0	15.547	57
Hexachlorobenzene	mg/kg OC	0	nd	44	0.20 – 0.81	7	0.060 – 0.23	0	na[b]	0.38
Hexachlorobutadiene	mg/kg OC	0	nd	44	0.20 – 0.81	0	0.090 – 0.35	0	na[b]	3.9
Hexachloroethane	µg/kg dw	0	nd	47	60 – 110	0	29 – 52	0	9.68	1,400
n-Nitrosodiphenylamine	mg/kg OC	0	nd	44	0.20 – 1.1	0	0.093 – 0.37	0	na[b]	11
Pentachlorophenol	µg/kg dw	0	nd	47	30 – 54	0	12 – 21	0	13.126	360

Table 4-14, cont.

Analyte	Unit	No. of Detected Results	Range of Detected Results	No. of Non-Detected Results	Range of RLs for Non-Detected Results	No. of RLs > ACG	Range of Non-Detected MDLs	No. of MDLs > ACG	Target MDL	Benthic Invertebrate ACG[a]
Phenol	µg/kg dw	7	40 – 140	40	60 – 250	0	37 – 66	0	12.2	420
PCBs										
Total PCBs (calc'd)	mg/kg OC	43	0.65 – 46	1	0.43 – 0.43	0	0.046 – 0.046	0	na[b]	12

[a] In Appendix C of the surface sediment QAPP (Windward 2005), the OC-normalized ACGs were converted to dry weight for comparison to dry weight RLs and MDLs using an OC content of 0.5%. In the comparison presented in this table, the RLs and MDLs were converted to OC-normalized values using sample-specific TOC contents for comparison to OC-normalized ACGs.

[b] The target MDLs presented in the surface sediment QAPP addendum (Windward 2006b) are dry weight values.

ACG – analytical concentration goal

dw – dry weight

HPAH – high-molecular-weight polycyclic aromatic hydrocarbon

LPAH – low-molecular-weight polycyclic aromatic hydrocarbon

MDL – method detection limit

na – not applicable

nd – not detected

OC – organic carbon

PAH – polycyclic aromatic hydrocarbon

PCB – polychlorinated biphenyl

RL – reporting limit

SVOC – semivolatile organic compound

Table 4-15. RLs and MDLs for surface sediment analytes relative to benthic invertebrate ACGs for results where OC-normalization was not applicable

Analyte	Unit	No. of Detected Results	Range of Detected Results	No. of Non-Detected Results	Range of Non-Detected RLs	No. of RLs > ACG	Range of Non-Detected MDLs	No. of MDLs > ACG	Target MDL	Benthic Invertebrate ACG
PAHs										
2-Methylnaphthalene	µg/kg dw	1	96 – 96	2	61 – 62	0	56 – 57	0	18.3	670
Acenaphthene	µg/kg dw	1	170 – 170	2	61 – 62	0	32 – 32	0	10.4	500
Acenaphthylene	µg/kg dw	2	130 – 500	1	61 – 61	0	29 – 29	0	9.38	1,300
Anthracene	µg/kg dw	2	200 – 710	1	61 – 61	0	24 – 24	0	7.95	960
Benzo(a)anthracene	µg/kg dw	2	820 – 2,200	1	61 – 61	0	27 – 27	0	8.67	1,300
Benzo(a)pyrene	µg/kg dw	2	1,000 – 3,200	1	61 – 61	0	25 – 25	0	8.05	1,600
Benzo(g,h,i)perylene	µg/kg dw	2	410 – 1,600	1	61 – 61	0	26 – 26	0	8.52	670
Total benzofluoranthenes	µg/kg dw	2	2,800 – 4,700	1	61 – 61	0	26 – 26	0	10.4	3,200
Chrysene	µg/kg dw	2	1,800 – 3,000	1	61 – 61	0	30 – 30	0	9.65	1,400
Dibenzo(a,h)anthracene	µg/kg dw	2	160 – 320	1	6.1 – 6.1	0	2.6 – 2.6	0	0.5	230
Dibenzofuran	µg/kg dw	1	130 – 130	2	61 – 62	0	52 – 53	0	17.1	540
Fluoranthene	µg/kg dw	2	3,900 – 4,900	1	61 – 61	0	26 – 26	0	8.57	1,700
Fluorene	µg/kg dw	2	61 – 260	1	61 – 61	0	36 – 36	0	11.6	540
Indeno(1,2,3-cd)pyrene	µg/kg dw	2	420 – 1,600	1	61 – 61	0	19 – 19	0	6.18	600
Naphthalene	µg/kg dw	2	45 – 180	1	61 – 61	0	36 – 36	0	11.7	2,100
Phenanthrene	µg/kg dw	2	900 – 3,400	1	61 – 61	0	32 – 32	0	10.3	1,500
Pyrene	µg/kg dw	2	2,800 – 4,800	1	61 – 61	0	29 – 29	0	9.38	2,600
Total HPAH	µg/kg dw	2	14,100 – 26,300	1	61 – 61	0	30 – 30	0	10.4	12,000
Total LPAH	µg/kg dw	2	1,340 – 5,200	1	61 – 61	0	57 – 57	0	9.36	5,200
Phthalates										
bis(2-Ethylhexyl) phthalate	µg/kg dw	2	140 – 190	1	61 – 61	0	34 – 34	0	11	1,300
Butyl benzyl phthalate	µg/kg dw	2	9.3 – 34	1	6.1 – 6.1	0	3.7 – 3.7	0	4	63
Diethyl phthalate	µg/kg dw	0	nd	3	61 – 62	0	32 – 33	0	10.6	200
Dimethyl phthalate	µg/kg dw	1	6.2 – 6.2	2	6.1 – 6.2	0	1.6 – 1.6	0	1.7	71
Di-n-butyl phthalate	µg/kg dw	2	43 – 59	1	61 – 61	0	20 – 20	0	6.64	1,400

Table 4-15, cont.

Analyte	Unit	No. of Detected Results	Range of Detected Results	No. of Non-Detected Results	Range of Non-Detected RLs	No. of RLs > ACG	Range of Non-Detected MDLs	No. of MDLs > ACG	Target MDL	Benthic Invertebrate ACG
Di-n-octyl phthalate	µg/kg dw	0	nd	3	61 – 62	0	31 – 32	0	10.2	6,200
Other SVOCs										
1,2,4-Trichlorobenzene	µg/kg dw	0	nd	3	6.1 – 6.2	0	1.5 – 1.5	0	1.638	31
1,2-Dichlorobenzene	µg/kg dw	0	nd	3	6.1 – 6.2	0	1.2 – 1.3	0	1.347	35
1,4-Dichlorobenzene	µg/kg dw	0	nd	3	6.1 – 6.2	0	2.0 – 2.0	0	2.205	110
Hexachlorobenzene	µg/kg dw	0	nd	3	6.1 – 6.2	0	1.8 – 1.8	0	1.966	22
Hexachlorobutadiene	µg/kg dw	0	nd	3	6.1 – 6.2	0	2.6 – 2.7	0	2.878	11
n-Nitrosodiphenylamine	µg/kg dw	0	nd	3	6.1 – 12	0	2.8 – 2.8	0	3.054	28
PCBs										
Total PCBs (calc'd)	µg/kg dw	3	8.4 – 1,010	0	na	0	na	0	3.054	130

ACG – analytical concentration goal

dw – dry weight

HPAH – high-molecular-weight polycyclic aromatic hydrocarbon

LPAH – low-molecular-weight polycyclic aromatic hydrocarbon

MDL – method detection limit

na – not applicable

nd – not detected

PAH –polycyclic aromatic hydrocarbon

PCB – polychlorinated biphenyl

RL – reporting limit

SVOC – semivolatile organic compound

Table 4-16. RLs and MDLs for surface sediment analytes relative to Ecology PQLs

Analyte	Unit	No. of Detected Results	Range of Detected Results	No. of Non-Detected Results	Range of Non-Detected RLs	No. of RLs > PQL	Range of Non-Detected MDLs	No. of MDLs > PQL	Target MDL	Ecology PQL
Metals and trace elements										
Antimony	mg/kg dw	2	0.4 – 1.1	45	0.3 – 0.6	0	0.00013 – 0.00029	0	0.62	50
Arsenic	mg/kg dw	47	4.0 – 123	0	na	0	na	0	0.83	19
Cadmium	mg/kg dw	22	0.4 – 1.1	25	0.3 – 0.5	0	0.00025 – 0.0005	0	0.013	1.7
Chromium	mg/kg dw	47	11.0 – 40	0	na	0	na	0	0.09	87
Copper	mg/kg dw	47	14.5 – 137	0	na	0	na	0	0.021	130
Lead	mg/kg dw	47	7 – 303	0	na	0	na	0	0.116	150
Mercury	mg/kg dw	40	0.060 – 1.8	7	0.05 – 0.08	0	0.0026 – 0.0042	0	0.0025	0.14
Nickel	mg/kg dw	47	9.2 – 35	0	na	0	na	0	0.21	47
Silver	mg/kg dw	24	0.3 – 0.9	23	0.3 – 0.6	0	0.00013 – 0.00029	0	0.032	2
Zinc	mg/kg dw	47	39 – 346	0	na	0	na	0	1.06	137
Butyltins										
Monobutyltin as ion	µg/kg dw	2	5.2 – 5.4	2	3.9 – 4.0	0	2.1 – 2.2	0	5.36	5
Dibutyltin as ion	µg/kg dw	3	6.9 – 18	1	5.7 – 5.7	1	1.2 – 1.2	0	2.18	5
Tributyltin as ion	µg/kg dw	4	14 – 73	0	na	0	na	0	2.08	5
PAHs										
2-Methylnaphthalene	µg/kg dw	3	85 – 110	44	60 – 110	0	55 – 98	0	18.3	223
Acenaphthene	µg/kg dw	6	34 – 210	41	60 – 62	0	31 – 32	0	10.4	167
Acenaphthylene	µg/kg dw	9	32 – 500	38	60 – 62	0	28 – 29	0	9.38	433
Anthracene	µg/kg dw	30	33 – 1,200	17	60 – 62	0	24 – 25	0	7.95	320
Benzo(a)anthracene	µg/kg dw	41	46 – 2,200	6	60 – 62	0	26 – 27	0	8.67	433
Benzo(a)pyrene	µg/kg dw	41	49 – 3,200	6	60 – 62	0	24 – 25	0	8.05	533
Benzo(g,h,i)perylene	µg/kg dw	40	31 – 1,600	7	60 – 62	0	26 – 26	0	8.52	223
Chrysene	µg/kg dw	43	35 – 3,600	4	60 – 62	0	29 – 30	0	9.65	467
Dibenzo(a,h)anthracene	µg/kg dw	41	6.7 – 340	6	6.1 – 6.2	0	2.6 – 2.6	0	0.5	77
Dibenzofuran	µg/kg dw	5	96 – 170	42	60 – 62	0	52 – 53	0	17.1	180
Fluoranthene	µg/kg dw	46	32 – 7,500	1	61 – 61	0	26 – 26	0	8.57	567

Table 4-16, cont.

Analyte	Unit	No. of Detected Results	Range of Detected Results	No. of Non-Detected Results	Range of Non-Detected RLs	No. of RLs > PQL	Range of Non-Detected MDLs	No. of MDLs > PQL	Target MDL	Ecology PQL
Fluorene	µg/kg dw	14	36 – 320	33	60 – 62	0	35 – 36	0	11.6	180
Indeno(1,2,3-cd)pyrene	µg/kg dw	39	34 – 1,600	8	60 – 62	0	19 – 19	0	6.18	200
Naphthalene	µg/kg dw	7	37 – 180	40	60 – 110	0	35 – 63	0	11.7	700
Phenanthrene	µg/kg dw	43	39 – 3,400	4	61 – 62	0	32 – 32	0	10.3	500
Pyrene	µg/kg dw	45	39 – 4,800	2	61 – 62	0	29 – 29	0	9.38	867
Phthalates										
bis(2-Ethylhexyl) phthalate	µg/kg dw	45	36 – 2,600	2	61 – 62	0	34 – 34	0	11	433
Butyl benzyl phthalate	µg/kg dw	41	6.2 – 200	6	6.1 – 6.2	0	3.6 – 3.7	0	4	21
Diethyl phthalate	µg/kg dw	0	nd	47	60 – 110	1	32 – 57	0	10.6	67
Dimethyl phthalate	µg/kg dw	21	6.1 – 33	26	6.0 – 6.2	0	1.6 – 1.6	0	1.7	24
Di-n-butyl phthalate	µg/kg dw	10	32 – 59	37	60 – 62	0	20 – 21	0	6.64	467
Di-n-octyl phthalate	µg/kg dw	1	92 – 92	46	60 – 62	0	31 – 32	0	10.2	2,067
Other SVOCs										
1,2,4-Trichlorobenzene	µg/kg dw	0	nd	47	6.0 – 11	0	1.5 – 2.6	0	1.638	31
1,2-Dichlorobenzene	µg/kg dw	0	nd	47	6.0 – 11	0	1.2 – 2.2	0	1.347	35
1,3-Dichlorobenzene	µg/kg dw	0	nd	47	60 – 110	47	25 – 45	0	8.4	57
1,4-Dichlorobenzene	µg/kg dw	5	6.2 – 64	42	6.0 – 6.2	0	2 – 2.1	0	2.205	37
2,4-Dimethylphenol	µg/kg dw	4	6.1 – 20	43	6.0 – 11	0	3.5 – 6.2	0	3.856	29
2-Methylphenol	µg/kg dw	4	8.6 – 14	43	6.0 – 11	0	3.1 – 5.4	0	3.379	63
4-Methylphenol	µg/kg dw	4	36 – 300	43	60 – 110	0	22 – 390	0	7.3	223
Benzoic acid	µg/kg dw	1	1,600 – 1,600	46	540 – 620	46	270 – 480	46	148	217
Benzyl alcohol	µg/kg dw	1	540 – 540	46	30 – 74	1	14 – 25	0	15.547	57
Hexachlorobenzene	µg/kg dw	0	nd	47	3.0 – 11	0	1.8 – 3.2	0	1.966	22
Hexachlorobutadiene	µg/kg dw	0	nd	47	6.0 – 11	0	2.6 – 4.6	0	2.878	11
Hexachloroethane	µg/kg dw	0	nd	47	60 – 110	47	29 – 52	1	9.68	47
n-Nitrosodiphenylamine	µg/kg dw	0	nd	47	6.0 – 32	1	2.8 – 4.9	0	3.054	28
Pentachlorophenol	µg/kg dw	0	nd	47	30 – 54	0	12 – 21	0	13.126	120

Table 4-16, cont.

Analyte	Unit	No. of Detected Results	Range of Detected Results	No. of Non-Detected Results	Range of Non-Detected RLs	No. of RLs > PQL	Range of Non-Detected MDLs	No. of MDLs > PQL	Target MDL	Ecology PQL
Phenol	µg/kg dw	7	40 – 140	40	60 – 630	2	37 – 380	1	12.2	140
PCBs										
Total PCBs (calc'd)	µg/kg dw	46	8.4 – 1,010	1	12 – 12	1	1.3 – 1.3	0	1.33	6
Dioxins/furans										
2,3,7,8-TCDD	ng/kg dw	5	0.495 – 0.823	0	na	0	na	0	0.036	10
1,2,3,7,8-PeCDD	ng/kg dw	5	1.31 – 2.06	0	na	0	na	0	0.069	10
1,2,3,4,7,8-HxCDD	ng/kg dw	5	1.98 – 3.75	0	na	0	na	0	0.095	10
1,2,3,6,7,8-HxCDD	ng/kg dw	5	11.0 – 17.9	0	na	0	na	0	0.114	10
1,2,3,7,8,9-HxCDD	ng/kg dw	5	6.48 – 11.5	0	na	0	na	0	0.081	10
1,2,3,4,6,7,8-HpCDD	ng/kg dw	5	296 – 668	0	na	0	na	0	0.246	10
OCDD	ng/kg dw	5	2,830 – 4,900	0	na	0	na	0	2.39	10
2,3,7,8-TCDF	ng/kg dw	5	0.992 – 2.04	0	na	0	na	0	0.025	10
1,2,3,7,8-PeCDF	ng/kg dw	5	0.905 – 1.52	0	na	0	na	0	0.085	10
2,3,4,7,8-PeCDF	ng/kg dw	5	2.05 – 4.49	0	na	0	na	0	0.101	10
1,2,3,4,7,8-HxCDF	ng/kg dw	5	6.81 – 14.2	0	na	0	na	0	0.101	10
1,2,3,6,7,8-HxCDF	ng/kg dw	5	2.00 – 3.85	0	na	0	na	0	0.078	10
1,2,3,7,8,9-HxCDF	ng/kg dw	4	0.214 – 0.331	1	0.253 – 0.253	0	0.212 – 0.212	0	0.076	10
2,3,4,6,7,8-HxCDF	ng/kg dw	5	1.59 – 2.63	0	na	0	na	0	0.056	10
1,2,3,4,6,7,8-HpCDF	ng/kg dw	5	56.3 – 92.1	0	na	0	na	0	0.129	10
1,2,3,4,7,8,9-HpCDF	ng/kg dw	5	4.20 – 8.31	0	na	0	na	0	0.134	10
OCDF	ng/kg dw	5	203 – 353	0	na	0	na	0	0.15	10

dw – dry weight
HpCDD – heptachlorodibenzo-*p*-dioxin
HpCDF – heptachlorodibenzofuran
HxCDD – hexachlorodibenzo-*p*-dioxin
HxCDF – hexachlorodibenzofuran
MDL – method detection limit
na – not applicable
nd – not detected
OCDD – octachlorodibenzo-*p*-dioxin
OCDF – octachlorodibenzofuran
PAH – polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
PeCDD – pentachlorodibenzo-*p*-dioxin
PeCDF – pentachlorodibenzofuran
PQL – practical quantitation limit
RL – reporting limit
SVOC – semivolatile organic compound
TCDD – tetrachlorodibenzo-*p*-dioxin
TCDF – tetrachlorodibenzofuran

4.2 CHEMICAL DATA VALIDATION RESULTS

Independent validation of all chemical analysis results was conducted by LDC. The complete data validation report is provided in Appendix E. The following subsections summarize the results of the validation but do not list every sample affected by data qualification as a result of the data validation. Detailed information regarding every qualified sample is available in Appendix E.

4.2.1 Overall data quality

The 47 surface sediment samples (44 samples plus 3 field duplicate samples) submitted to ARI were analyzed in three sample delivery groups (SDGs). LDC conducted a full data validation (i.e., EPA Level 4) on one ARI SDG (JZ53); summary validation was performed on the sample results from the remaining ARI SDGs. The summary validation included a review of all quality control (QC) summary forms submitted by ARI, including calibration, internal standard, and ICP-MS interference check sample (ICS) summary forms. The five surface sediment samples submitted to Axys for dioxin and furan analyses were analyzed in one SDG. LDC conducted a full validation on all of the dioxin and furan results. Table 4-17 identifies the numbers of samples analyzed in each SDG by ARI and Axys, the analyses performed, and the level of data validation (i.e., full or summary). The requirements for data validation were met, as specified in the QAPP (Windward 2005).

The majority of the data did not require qualification, or were qualified with a J, indicating an estimated value. Based on the information reviewed, the overall data quality was considered acceptable for use in the Phase 2 RI/FS, as qualified. The results of the validation are summarized in Section 4.2.4 by analyte group.

Table 4-17. Level of data validation performed for each SDG and numbers of surface sediment samples in each SDG

SDG	Lab	Validation Level	Numbers of Surface Sediment Samples Analyzed					
			SVOCs	PCB Aroclors	Metals and Mercury	Butyltins	Conventionals[a]	Dioxins/ Furans
JZ15	ARI	summary	11	11	11	0	11	0
JZ53	ARI	full	19	19	19	4	19	0
KA18	ARI	summary	17	17	17	0	17	0
WG20336	Axys	full	0	0	0	0	0	5
Percentage of samples that received full validation			40%	40%	40%	100%	40%	100%

[a] Includes total solids, TOC, and grain size.

ARI – Analytical Resources, Inc.
Axys – Axys Analytical Services, Ltd.
PCB – polychlorinated biphenyl
SDG – sample delivery group
SVOC – semivolatile organic compound

4.2.2 Sample transport and holding times

All analyses of surface sediment samples were conducted within maximum holding times. The chain-of-custody documents were reviewed for documentation of cooler temperatures. All cooler temperatures met validation criteria.

4.2.3 Field rinsate blank results

RBs were submitted for the analysis of SVOCs, selected SVOCs by SIM, PCBs, metals (including mercury), and butyltins. Two metals and two SVOCs were detected in the RB samples. Copper was detected in all three RBs at concentrations ranging from 0.6 to 2.2 µg/L, and zinc was detected in LDW-SS325-RB at 5 µg/L. LDW-SS325-RB also had detected concentrations of bis(2-ethylhexyl) phthalate (1.1 µg/L) and benzyl alcohol (3.0 µg/L). No data were qualified as a result of these concentrations.

4.2.4 Analytical results

This section presents the data validation results for each of the following analytes or groups of analytes: metals (including mercury), butyltins, SVOCs, SVOCs by SIM, PCBs (as Aroclors), dioxins and furans, and conventional parameters.

4.2.4.1 Metals (including mercury)

Calibration

An initial calibration was performed daily for all analyses, and all QC requirements were met. The frequency of analysis and all QC criteria for the initial calibration verification (ICV) and continuing calibration verification (CCV) were also met for each analysis.

Blanks

No metals were detected in the method blank or calibration blank samples.

Interference Check Sample Analysis

The frequency of analysis and QC criteria were met for the ICP-MS ICSs. These samples are not analyzed for mercury.

Matrix Spike

All matrix spike (MS) results were within QC limits of 70 to 130%, with the following exceptions. The MS recovery for silver of 18% was below QC limits in SDG KA18; thus, the associated results were J- or UJ-qualified. Low percent recoveries were reported for antimony in all three MS samples (ranging from 1.6 to 3.4%), resulting in the J- or UJ-qualification of all detected and non-detected antimony results. The results were not rejected because the post-digestion spike recoveries for antimony were greater than 70%, although the systematic low recoveries may be indicative of an overall low bias in both the detected and non-detected results for this chemical.

Laboratory Duplicate Samples

Laboratory duplicate samples were analyzed at the required frequency. All laboratory duplicate results met QC limits of ≤ 30% relative percent difference (RPD).

Laboratory Control Samples and Standard Reference Material

All percent recoveries for laboratory control samples (LCSs) were within QC limits. Standard reference material (SRM) samples were analyzed at the required frequencies and all results were within QC limits.

Internal Standards

All internal standard results were within QC limits.

Sample Result Verification

Some sample results were recalculated by LDC during data validation. All recalculated results confirmed the values reported by the laboratory.

4.2.4.2 Butyltins

Calibration

Initial calibration was performed as required by the method. Calibration verifications were also performed at the required frequency, 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

All MS/matrix spike duplicate (MSD) results were within QC limits.

Laboratory Control Samples and Standard Reference Material

All LCS and SRM results were within QC limits.

Internal Standards

All internal standard recoveries and retention times were within QC limits.

4.2.4.3 SVOCs (including PAHs)

Calibration

Initial calibration was conducted correctly and verified at the required frequencies. All response factors, system performance check compounds, and percent relative standard deviations (%RSDs) were adequate in each initial calibration, with the following exception. The %RSD for 2,4-dinitrophenol associated with SDGs JZ15 and KA18 was 31%, which is outside of the QC limit of 30%. All associated results were non-detected and UJ-qualified.

All percent differences (%Ds) of the continuing calibration relative to the initial calibration were ≤ 25%, with the exception of hexachlorocyclopentadiene in a CCV in SDG KA18 (27%). All results associated with this CCV for this chemical were non-detect and UJ-qualified. The %Ds of the ICV (second source standard) were within the QC limit of ≤ 25% for all chemicals.

Blanks

Phenol was detected in the method blank in SDG JZ53 at 64 µg/kg dw. Sample concentrations were compared to the concentration detected in this method blank. Four detected concentrations that were less than 5 times the blank concentration for this chemical were qualified as non-detected with elevated RLs ranging from 75 to 250 µg/kg dw.

Surrogate Recovery

Surrogates were added to all samples and blanks as required by the method. All surrogate recoveries were within QC limits.

Matrix Spike

All MS/MSD results were within QC limits of 40 to 130%, with one exception. Percent recoveries of 36 and 33% were found in the MS and MSD, respectively, for benzo(g,h,i)perylene in sample LDW-SS316-010. The associated detected result for this chemical in this sample was J-qualified.

Laboratory Control Samples and Standard Reference Material

LCS results were reviewed, and percent recoveries were within QC limits of 40 to 130%, with the following exceptions. LCS recoveries for aniline in SDGs JZ53 and KA18 were 25 and 34%, respectively; in SDG JZ15, low recoveries were found for 4-chloroaniline (29%) and 3,3'-dichlorobenzidine (36%). All sample results associated with these LCS recoveries were non-detected and UJ-qualified. SRM samples were analyzed at required frequencies, and all results were within QC limits.

Internal Standards

All internal standard areas and retention times were within QC limits.

Compound Quantification

All compound identification and quantification parameters were within validation criteria. When detected concentrations exceeded the calibration range of the instrument, extracts were diluted and reanalyzed to obtain results within the calibration range.

4.2.4.4 SVOCs by selected ion monitoring

Calibration

Initial calibration was conducted correctly and verified at the required frequencies. All response factors, system performance check compounds, and %RSDs were adequate in the initial calibration.

All %Ds of the continuing calibration relative to the initial calibration were ≤ 25%, with the following exceptions. A CCV associated with 13 samples in SDGs JZ15 and KA18 had a %D of 36% for dibenzo(a,h)anthracene; the associated results were all detected concentrations and were J-qualified. In SDG JZ15, a CCV had a %D of 38% for 2,4-dimethylphenol, which resulted in the UJ-qualification of the 11 associated results, which were all non-detected.

The %Ds of the ICV were within the QC limit of ≤ 25% for all chemicals, with the following exceptions. The ICV in SDG JZ15 had recoveries outside of QC limits for 2,4-dimethylphenol (37%), dimethyl phthalate (55%), and n-nitrosodiphenylamine (71%). All associated results for these chemicals were non-detected and UJ-qualified, with the exception of two detected concentrations of dimethyl phthalate, which were J-qualified. In addition, for benzyl alcohol, 17 undetected results were UJ-qualified and 1 detected concentration was J-qualified in SDGs JZ53 and KA18 because of an ICV %D above the QC limit (29%).

Blanks

No SVOCs were detected in the method blanks.

Surrogate Recovery

All surrogate recoveries were above the QC limits of 40%, except for low percent recoveries, ranging from 31 to 38%, for two surrogates each in samples LDW-SS302-010, LDW-SS307-010, and LDW-SS317-010. As a result, all of the detected or non-detected results for chemicals associated with these surrogates were J- or UJ-qualified.

Matrix Spike

All MS/MSD results were within QC limits.

Laboratory Control Samples and Standard Reference Materials

LCS results were reviewed and recoveries were within the QC limits of 40 to 130%, with the exception of a 24% recovery for 2,4-dimethylphenol in an LCS in SDG JZ15. All associated sample results for this chemical were non-detected and UJ-qualified. SRM samples were analyzed at required frequencies, and results were within QC limits.

Internal Standards

All internal standard areas and retention times were within QC limits.

Compound Quantification

All compound identification and quantification parameters were within validation criteria**.** Eighteen tentatively identified results for three chemicals were Y-qualified by the laboratory as non-detected because of chromatographic interference, as presented in Table 4-18. The Y-qualifier indicates that matrix interference in the sample prevented adequate resolution of the analyte. These Y-qualified results were mapped

to a U-qualifier to indicate a non-detected result at the concentration of the chromatographic interference.

Table 4-18. SVOC SIM sample results reported at elevated RLs because of chromatographic interference

Analyte	No. of Samples with Y-Qualified Results	RL or Range of RLs for Y-Qualified Results (µg/kg dw)	Range of RLs for Unqualified Results (µg/kg dw)[a]
Benzyl alcohol	9	30 – 74	30 – 54
n-Nitrosodiphenylamine	8	6.7 – 32	6.0 – 6.2
n-Nitroso-di-n-propylamine	1	49	30 – 54

[a] Sample RLs varied based on the amount of sample volume used for each analysis, the analytical dilution, and the amount of total solids in the sample.

dw – dry weight

MDL – method detection limit

RL – reporting limit

SIM – selected ion monitoring

SVOC – semivolatile organic compound

Y – analyte is not detected at or above the RL, which is elevated because of chromatographic interference

4.2.4.5 PCBs (as Aroclors)

Calibration

Initial calibration and calibration verifications 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 %D calculated for the CCVs were within the QC limits of 15%.

Blanks

PCBs were not detected in any of the method blanks.

Surrogate Recovery

Surrogates were added to all samples and blanks as required by the method. Surrogate recoveries were within the QC limits of 50 to 150% in all undiluted samples, with the following exceptions. Two samples had high surrogate recoveries because of Aroclor interference, LDW-SS305-010 at 159% and LDW-SS321-010 at 192%. The detected Aroclor results for these samples were J-qualified.

Internal Standards

The laboratory used internal standards for quantification. All internal standard areas and retention times were within QC limits.

Matrix Spike

All MS/MSD results were within QC limits for all undiluted samples.

Laboratory Control Samples and Standard Reference Material

All LCS results were within the QC limits of 50 to 150%. SRM samples were analyzed at the required frequencies, and all results were within QC limits.

Compound Quantification

All PCB compound identification and quantification parameters were within validation criteria. When detected concentrations exceeded the calibration range of the instrument, extracts were diluted and reanalyzed to obtain results within the calibration range.

In general, when more than one Aroclor is present in a sample, the potential exists for a high bias from the contribution of one Aroclor to another caused either by common peaks or by peaks that cannot be completely resolved. Analytical peaks are selected, and Aroclor identification is made, based on the best resolution possible for that particular sample. In this dataset, RLs for specific PCB Aroclors were elevated in 10 samples because of chromatographic interferences and overlapping Aroclor patterns. Elevated RLs ranged from 5.8 to 82 µg/kg dw, above the target RL of 4.0 µg/kg dw. Aroclor concentrations were reported based on the individual Aroclors that provided the best match to the sample pattern.

Thirteen detected Aroclor concentrations in ten samples had results from the two analytical columns that exceeded the RPD QC limit of 40%. As a result, the Aroclors identified in Table 4-19 were J-qualified. The reported result was selected from the analytical column with the higher of the two values.

Table 4-19. Detected PCB Aroclor results with dual-column RPDs greater than the QC limit

SAMPLE ID	ANALYTE	RPD
LDW-SS304-010	Aroclor 1254	42
LDW-SS313-010	Aroclor 1248	51
LDW-SS315-010	Aroclor 1248	57
	Aroclor 1254	53
LDW-SS317-010	Aroclor 1248	62
	Aroclor 1254	62
LDW-SS318-010	Aroclor 1260	51
LDW-SS320-010	Aroclor 1260	43
LDW-SS321-010	Aroclor 1260	68
LDW-SS325-010	Aroclor 1248	68
	Aroclor 1254	61
LDW-SS331-010	Aroclor 1260	53
LDW-SS340-010	Aroclor 1260	45

ID – identification

QC – quality control

RPD – relative percent difference

4.2.4.6 Dioxins and furans

Calibration

All criteria for the initial and continuing calibration were met.

Blanks

Specific dioxins and furans were detected in the method blank. Sample results were compared to the concentrations detected in the method blank, and all sample results were detected concentrations greater than five times the blank concentrations.

Laboratory Duplicates

The results for the laboratory duplicate sample were reviewed, and the RPDs between the sample and the duplicate sample were within QC limits.

Compound Identification and Quantification

All compound identification and quantification parameters were within validation criteria, with the following exception. In sample LDW-SS321-010, the 1,2,3,7,8,9-HxCDF result did not meet the method ion abundance criteria and was K-qualified by Axys to indicate that it was an estimated maximum possible concentration. This K-qualified result was mapped to a U-qualifier and is regarded as a non-detected result.

Laboratory Control Samples and Standard Reference Material

LCS and SRM results were reviewed, and the recoveries were all within QC limits.

Internal Standards

All internal standard recoveries were within QC limits.

4.2.4.7 Total solids, grain size, and total organic carbon

Calibration

All calibration and calibration verification criteria for each method were met, as applicable.

Blanks

Method blanks were reviewed for each of the applicable analyses. All method blanks met validation criteria.

Matrix Spike

MS results were reviewed for the TOC analyses. Percent recoveries were within QC limits.

Laboratory Replicate Samples

Laboratory replicate samples were analyzed for each method at the required frequencies. All results were within QC limits.

Laboratory Control Samples and Standard Reference Material

LCS and SRM results were reviewed for the TOC analyses, and all results were within QC limits.

Compound Quantification

All sample result verifications and compound quantitation limits were acceptable.

5.0 References

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