Lower Duwamish Waterway Group

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

LOWER DUWAMISH WATERWAY CLAM DATA REPORT

FINAL

Prepared for

Lower Duwamish Waterway Group

For submittal to

US Environmental Protection Agency

February 28, 2019

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Maps

Acronyms

95UCL	95% upper confidence limit (on the mean)
Alpha	Alpha Analytical Lab
ALS	ALS Environmental-Kelso
AOC	Administrative Order on Consent
ARI	Analytical Resources, Inc.
Axys	SGS Axys Analytical Services, Ltd.
BEHP	bis(2-ethylhexyl) phthalate
BHC	benzene hexachloride
Brooks	Brooks Applied Labs
COC	chain of custody
cPAH	carcinogenic polycyclic aromatic hydrocarbon
DCM	dichloromethane
DDT	dichlorodiphenyltrichloroethane
DQO	data quality objective
dw	dry weight
ECD	electron capture detector
EPA	US Environmental Protection Agency
GC	gas chromatography
HCB	hexachlorobenzene
Hg-AFS	hydride generation-atomic fluorescence spectrometry
HRGC/HRMS	high-resolution gas chromatography / high-resolution mass spectrometry
ICP	inductively coupled plasma
ID	identification
LCS	laboratory control sample
LDW	Lower Duwamish Waterway
MS	mass spectrometry
MS/MSD	matrix spike / matrix spike duplicate

NAD83	North American Datum of 1983
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PCP	pentachlorophenol
PeCDD	pentachlorodibenzo-*p*-dioxin
PEF	potency equivalency factor
PSEP	Puget Sound Estuary Program
QAPP	quality assurance project plan
RAO	remedial action objective
RM	river mile
ROD	Record of Decision
SDG	sample delivery group
SIM	select ion monitoring
SVOC	semivolatile organic compound
TBT	tributyltin
TCDD	tetrachlorodibenzo-*p*-dioxin
TEF	toxic equivalency factor
TEQ	toxic equivalent
TOC	total organic carbon
TTL	target tissue level
UCT-KED	universal cell technology-kinetic energy discrimination
Windward	Windward Environmental LLC
ww	wet weight

1 Introduction

This data report presents the results of baseline chemical analyses of clam tissue collected from the Lower Duwamish Waterway (LDW) in May 2018. Baseline clam tissue data were collected as required by the third amendment to the Administrative Order on Consent (AOC) (EPA 2016).

Data quality objectives (DQOs) for the collection of these samples were presented in the *Pre-Design Studies Work Plan* (Windward and Integral 2017), hereafter referred to as the Work Plan, and in the clam quality assurance project plan (QAPP) (Windward 2018). The QAPP also included details regarding project organization, sampling design, analytical methods, and data validation. The QAPP was approved by the US Environmental Protection Agency (EPA) on April 2, 2018. Three DQOs were described in the clam QAPP (Windward 2018). Clam tissue DQOs 1 and 2 are for evaluating contaminant concentrations in clam tissue, while the Porewater DQO 1 is for assessing the relationships among cPAHs in sediment, clam tissue, and porewater.

- **Clam tissue DQO 1** – Establish baseline site-wide 95% upper confidence limit (on the mean) (95UCL) concentrations for human health risk drivers to compare to target tissue levels (TTLs) for Remedial Action Objective 1.[1]
- **Clam tissue DQO 2** – Calculate baseline site-wide mean clam tissue concentrations to assess trends following sediment remediation for contaminants with TTLs.
- **Porewater DQO 1** – Assess the relationship among concentrations of carcinogenic polycyclic aromatic hydrocarbons (cPAHs) in clam tissue, porewater, and sediment to help evaluate whether achieving sediment cleanup levels for cPAHs will reduce concentrations in clam tissue to TTLs.

[1] As stated in the LDW Record of Decision (ROD) (EPA 2014), remedial action objective (RAO) 1 is to "reduce risks associated with the consumption of contaminated resident LDW fish and shellfish by adults and children with the highest potential exposure to protect human health."

For clam tissue DQOs 1 and 2, the 11 clam tissue collection areas were targeted for the collection of clam tissue composite samples. For porewater DQO 1, 20 cPAH porewater investigation areas located within the 11 clam tissue collection areas were targeted for the collection of clam tissue composite samples and co-located surface sediment samples (0–10 cm). After analyzing clam tissue and sediment from the 16 areas where clams and co-located sediment were successfully collected, sediment from 10 of these areas was selected for the cPAH porewater investigation, during which passive samplers were exposed to sediment for 28 days to determine cPAH concentrations in porewater (Appendix A).

This data report describes the clam tissue and the clam tissue/co-located sediment collection and compositing process, discusses any deviations from the QAPP (Windward 2018), and presents results from chemical analyses and data validation. Because of an issue with sample tracking of passive samplers used in the cPAH porewater investigation, re-exposure of new passive samplers to archived sediment samples and analysis of the new passive samplers will occur (Appendix A). Therefore, the methods for passive sampler exposures and the results of the passive sampler analyses are not presented in this data report; they will be presented separately in an addendum to the data evaluation report. This issue impacted only the passive samplers; the corresponding clam tissue and sediment samples were not affected.

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

- Section 2 – Sample Collection, Processing, and Compositing
- Section 3 – Analytical Methods
- Section 4 – Results of Chemical Analyses
- Section 5 – References

The text is supported by the following appendices:

- Appendix A – cPAH Passive Sampler Information
- Appendix B – Field Notes, Field Forms, and COCs
- Appendix C – Data Tables (complete results for all samples)
- Appendix D – Tissue Compositing Plan and Tissue Preparation Notes
- Appendix E – Laboratory Reports and Data Validation Report

2 Sample Collection, Processing, and Compositing

This section summarizes the collection and compositing of clams for DQOs 1 and 2, as well as the collection of clams and co-located sediment for porewater DQO 1. An overview of the sampling design, as was described in the QAPP (Windward 2018), is presented in Table 2-1.

Table 2-1. Summary of sampling design

DQO	Summary of Targeted Sampling Design
Clam Tissue DQOs 1 and 2	· **Inorganic arsenic composites** – Collect 3 clams in each of the 11 clam tissue collection areas (Map 2-1). Create 1 composite for each area. Analyze for inorganic arsenic in separate composite samples of siphon skin and remainder tissue (with whole-body concentrations calculated as described in Appendix C), because inorganic arsenic is known to accumulate preferentially in the siphon skin tissue of the target species (i.e., *Mya arenaria*). · **Composites for other risk drivers** – Collect 10 clams from each of the 11 clam tissue collection areas (Map 2-1). Create 1 composite for each area. Analyze for the human health risk drivers (i.e., cPAHs, PCBs, and dioxins/furans). · **Segment-wide composites for non-risk driver chemicals** – Create whole-body intertidal segment-wide composite samples (i.e., 1 for each of the 3 intertidal segments; Map 2-1) using an equal mass of tissue from each clam tissue collection area in a given segment. Analyze for non-risk driver chemicals as specified in the ROD (i.e., vanadium, TBT, select SVOCs [BEHP, carbazole, HCB, and PCP], and organochlorine pesticides).
Porewater DQO 1	· **Clam tissue** – Collect 3 clams from each of the 20 target cPAH porewater investigation areas (Map 2-1). Combine clams into 1 whole-body composite for each area. · **Co-located sediment** – Collect co-located sediment from the same holes from which clams were collected within each cPAH porewater investigation area. · **Porewater** – Determine freely dissolved concentrations of cPAHs in porewater using passive samplers exposed to the sediment *ex situ*. Analyze passive samplers for a minimum of 10 of the 20 target locations.

BEHP – bis(2-ethylhexyl) phthalate
cPAH – carcinogenic polycyclic aromatic hydrocarbon
DQO – data quality objective
HCB – hexachlorobenzene
PCB – polychlorinated biphenyl
PCP – pentachlorophenol
ROD – Record of Decision
SVOC – semivolatile organic compound
TBT - tributyltin

2.1 FIELD COLLECTION METHODS

Mya arenaria clams (Eastern softshell clams) were collected around the daily low tides on May 15 through 18, 2018, from the 11 clam tissue collection areas described in the QAPP (Windward 2018) (Map 2-1). *M. arenaria* clams were collected by digging at show holes with a stainless steel trowel. As specified in the QAPP, clam collection was conducted to ensure that, to the extent possible, clams collected were spatially distributed throughout the area where they were present (i.e., team members searched for clams throughout the entire clam tissue collection area). The field team searched in a given area until either the target number of clams was collected, or the maximum level of effort specified in the QAPP was met.

For those clams identified for inclusion in the cPAH porewater investigation composite, a co-located sediment sample was also collected. As described in the QAPP, this composite sediment sample consisted of equal volumes of sediment from a depth of 0 to 10 cm at each of the three locations where clams were collected (Windward 2018). Sediment was hand collected from the hole dug for the clam collection using a stainless steel trowel; the sediment was then thoroughly homogenized in stainless steel bowls. Large gravel/rocks and shell debris were excluded from the homogenized sample to the extent practicable.

2.2 COLLECTION RESULTS

To meet the number of clams needed for the various clam tissue analyses (Table 2-1), 13 to 25 *M. arenaria* clams were targeted from each clam tissue collection area. Sufficient clams were collected in all 11 of the clam tissue collection areas for the creation of an inorganic arsenic composite and in 9 of the 11 clam tissue collection areas for the creation of the composite for other risk drivers (i.e., polychlorinated biphenyls [PCBs], dioxins/furans, and cPAHs). In addition, clam tissue and co-located sediment samples were collected from 16 of 20 potential cPAH porewater investigation areas. Areas where fewer than the target number of clams were collected are discussed below:

- **Clam tissue collection area 7** – As anticipated, clam abundance was low in this area (Slip 4), an Early Action Area remediated in 2012. A total of 4 clams were found in this area (fewer than the target of 13 clams) during the allocated maximum level of effort. Only three of the clams were of target size (i.e., ≥ 2 cm width); the fourth clam was 16 mm wide. Thus, only an inorganic arsenic composite was created for this area, because insufficient clam tissue mass was available for any other type of composite.
- **Clam tissue collection area 9** – Clam abundance was also low in this area (located from approximately river mile [RM] 2.9 to RM 3.4 on the west side of the LDW). A total of seven clams were collected from this area. Three of the clams were used to create an inorganic arsenic composite sample, and three were used to create a clam tissue sample for cPAH porewater investigation area 13. Sufficient clams were not available in this clam tissue collection area for the other targeted cPAH porewater investigation areas (i.e., areas 14, 15, and 16).
- **Clam tissue collection area 10** – A total of 19 clams were collected in this area (i.e., sufficient clams for the inorganic arsenic composite, the composite for the other risk drivers, and the composite for cPAH porewater investigation area 19). There were insufficient clams collected in both cPAH porewater investigation area 20 and a possible alternate area (i.e., with similar target cPAH concentrations); thus, cPAH porewater investigation area 20 was abandoned.

Details regarding the clam sampling level of effort in each area and the total numbers of clams collected are provided in Table 2-2. In addition, Maps 2-2 to 2-4 present the locations where individual clams were collected within each of the identified clam tissue collection areas. Co-located sediment location coordinates are provided in Table 2-3.

Table 2-2. Summary of clam collection efforts by clam tissue collection area

Clam Tissue Collection Area	cPAH Porewater Investigation Areas	Sampling Date	Level of Effort (person-hrs[a])		No. of Clams Collected (Target)[c]	Sufficient Clams Collected?			Notes
						Clam Tissue DQOs		Clams for cPAH Porewater Investigation	
			Actual	Max.[b]		Inorganic Arsenic Composite	Other Risk Driver Composite		
Intertidal Segment 1									
1	1, 2	05.16.18	4	9	19 + 5 (19)	ü	ü	ü	none
2	4, 6	05.16.18	5.3	12	19 + 5 (19)	ü	ü	ü	none
3	3, 5	05.16.18	8	9	19 + 5 (19)	ü	ü	ü	none
Intertidal Segment 2									
4	7, 8	05.19.18	7.5[d]	6	19 + 5 (19)	ü	ü	ü	cPAH porewater investigation area 8 moved to an area where clams were present (Map 2-3)
5	9, 10	05.18.19	5.25	6	19 + 5 (19)	ü	ü	ü	none
6	11	05.15.18	3.75	6	16 + 5 (16)	ü	ü	ü	none
Intertidal Segment 3									
7	none	05.15.18	9	9	4 (13)	ü	no (insufficient clams)	na	fewer than the target number of clams collected; maximum level of effort reached
8	12	05.18.18	3.75	6	16 + 5 (16)	ü	ü	ü	none
9	13, 14, 15, 16	05.17.18	12	12	7 (25)	ü	no (insufficient clams)	area 13 only	fewer than the target number of clams collected; maximum level of effort reached
10	19, 20	05.17.18	8.25	12	16 + 3 (19)	ü	ü	area 19 only	clams/sediment not collected from cPAH porewater investigation area 20 due to insufficient clams in both this area and potential alternate area
11	17, 18	05.18.18	9[d]	6	19 + 5 (19)	ü	ü	ü	none

[a] A person-hour is defined as the time spent searching by 1 individual for 1 hour.

[b] The target maximum level of effort specified in the QAPP was based on a 3-person field team (Windward 2018). When a different size field team was utilized during field collection efforts, the total number of person-hours was the same as specified herein.

[c] In addition to the target numbers of clams specified, up to 5 additional clams were retained (where abundant) to provide additional options for compositing.

[d] Additional time was spent in these areas relative to the maximum level of effort, because it was necessary for the field crew to wait for suitable habitat to be exposed at a slightly lower tide.

cPAH – carcinogenic polycyclic aromatic hydrocarbon DQO – data quality objective na – not applicable

Table 2-3. Co-located sediment sampling locations for the cPAH porewater investigation areas

cPAH Porewater Investigation Area	Composite Sample ID	Date	Centroid Sediment Coordinates[a]		Distance of Subsamples from Centroid (ft)	
			X[b]	Y[b]	Average	Range
A01	LDW18-SSCL-A01	05.16.18	1265949	210612	11	5–16
A02	LDW18-SSCL-A02	05.16.18	1265981	210267	8	2–11
A03	LDW18-SSCL-A03	05.16.18	1265949	208036	17	10–23
A04	LDW18-SSCL-A04	05.16.18	1266647	207639	9	3–13
A05	LDW18-SSCL-A05	05.16.18	1265914	207293	5	3–8
A06	LDW18-SSCL-A06	05.16.18	1266840	206983	11	7–15
A07	LDW18-SSCL-A07	05.19.18	1267941	203966	2	1–2
A08	LDW18-SSCL-A08	05.19.18	1268022	204086	14	6–19
A09	LDW18-SSCL-A09	05.18.18	1269245	202570	3	3–5
A10	LDW18-SSCL-A10	05.18.18	1269203	202308	2	1–3
A11	LDW18-SSCL-A11	05.15.18	1269638	200933	11	5–16
	LDW18-SSCL-A11-FD					
A12	LDW18-SSCL-A12	05.18.18	1272443	198266	3	2–3
A13	LDW18-SSCL-A13	05.17.18	1272792	197925	44	29–66
A14	not collected; insufficient clams in this area					
A15	not collected; insufficient clams in this area					
A16	not collected; insufficient clams in this area					
A17	LDW18-SSCL-A17	05.18.18	1276016	195083	6	3–8
A18	LDW18-SSCL-A18	05.18.18	1276073	194806	4	3–6
A19	LDW18-SSCL-A19	05.17.18	1275839	194509	7	5–10
A20	not collected; insufficient clams in this area					

[a] Coordinates are the centroid coordinates from 3 locations where sediment was collected and composited.

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

cPAH – carcinogenic polycyclic aromatic hydrocarbon

FD – field duplicate

ID – identification

NAD83 – North American Datum of 1983

2.2 SAMPLE PROCESSING, IDENTIFICATION, AND COMPOSITING

Once collected, clam and sediment samples were evaluated for acceptability, processed, and identified in accordance with the QAPP (Windward 2018). Copies of field logbooks, surface sediment collection forms, and chain of custody forms (COCs) are presented in Appendix B.

2.2.1 Sample processing

2.2.1.1 Clam tissue

All target specimens at each location were measured valve to valve in accordance with the QAPP (Windward 2018). Each unbroken (i.e., intact) clam ≥ 2 cm retained for compositing and analysis was rinsed with site water to remove excess sediment, wrapped in aluminum foil, and placed in a resealable plastic bag with an individual identification (ID) label. Bagged and labeled clams were held on ice in a cooler for delivery to Analytical Resources, Inc. (ARI) at the end of each day. Tissue samples were stored frozen at ARI and organized into composite groups by Windward Environmental LLC (Windward) staff before further processing.

Whole-body clam tissue preparation—including shucking and homogenization—was conducted by ARI following ARI standard operating procedure 3328S rev 000. Individual clams were held frozen at ARI until approval of the compositing memorandum. Clams were thawed in the refrigerator overnight prior to processing. Dissection of clams for inorganic arsenic siphon and remainder analyses was performed by Windward staff; samples were then homogenized by ARI. Frozen subsamples of homogenized composite tissue samples were shipped via FedEx to Brooks Applied Labs (Brooks Applied) and ALS Environmental-Kelso (ALS) and transported by courier to SGS Axys Analytical Service, Ltd. The analytical methods used by each laboratory are listed in the QAPP and in Section 3.1 of this report (Windward 2018).

2.2.1.2 Sediment

Co-located sediment samples were collected as described in Section 2.1 in accordance with the methods outlined in the QAPP (Windward 2018). Sediment samples were distributed into labeled sample jars and held on ice in a cooler for delivery to ARI at the end of each day. Frozen sediment samples for black carbon analysis were shipped to Alpha Analytical Lab (Alpha) via FedEx.

The analytical methods used for the sediment are listed in the QAPP and in Section 3.1 of this report (Windward 2018).

2.2.2 Sample identification

2.2.2.1 Individual clam specimen ID

Unique alphanumeric IDs were assigned to each individual clam in the field and recorded on the target clam species form. The sample IDs for individual clams include the following:

- Project area ID (i.e., LDW) and two-digit year (18)
- Clam tissue collection area (i.e., C01 through C11)
- Two-letter species code (i.e., CL for clam) and three-digit number indicating the sequential number of the specimen captured during the sampling event

For example, the 11th clam collected in clam tissue collection area 1 was identified as LDW18-C01-CL011.

2.2.2.2 Clam composite sample ID

Composite clam samples were identified using a similar convention; their IDs include the following:

- Project area ID (i.e., LDW) and two-digit year (18)
- Clam tissue collection area (i.e., C01 through C11)
- Species code (i.e., CL for clam) and a two-letter tissue type code (i.e., WB, SP, or RM for whole body, siphon skin, or remainder [after removal of the siphon skin], respectively)
- Composite ID (i.e., "comp" and a one-digit sequential composite number)

For example, the whole-body clam composite sample with calculated arsenic concentrations based on the siphon skin and remainder arsenic concentrations for clam tissue collection area 1 was identified as LDW18-C01-CLWB-comp1. The whole-body clam composite sample collected from clam tissue collection area 1 that was analyzed for PCBs, dioxins/furans, and cPAHs was identified as LDW18-C01-CLWB-comp2.

For the segment-wide intertidal composite samples analyzed for the non-risk driver chemicals, the composite IDs are similar to those for the clam composites, except that the clam tissue collection area portion of the ID was replaced by an intertidal segment ID (i.e., S1, S2, and S3 for segment 1 [RM 0 to RM 1.3], segment 2 [RM 1.3 to RM 2.6], and segment 3 [above RM 2.6], respectively). For example, the whole-body clam composite sample collected from intertidal segment 2 was identified as LDW18-S2-CLWB-comp1.

For the clam composite samples collected for the cPAH porewater investigation, IDs include the following:

- Project area ID (i.e., LDW) and two-digit year (18)
- cPAH porewater investigation area (i.e., A01 through A20)
- Species code (i.e., CL for clam) and a two-letter tissue type code (i.e., WB for whole body)
- Composite ID (i.e., "comp" and a one-digit sequential composite number)

For example, the first whole-body clam composite sample collected from cPAH porewater investigation area 5 was identified as LDW18-A05-CLWB-comp1.

2.2.2.3 Sediment samples for cPAH porewater investigation

For the co-located sediment samples for the cPAH porewater investigation, the sample IDs include the following:

- Project area ID (i.e., LDW) and two-digit year (18)

- Sample type (i.e., SSCL for surface sediment co-located with clam samples)
- cPAH porewater investigation area ID (i.e., A01 through A20)

For example, the sediment sample collected from cPAH porewater investigation area 9 was identified as LDW18-SSCL-A09.

2.2.3 Clam tissue compositing

Composite clam tissue samples were created by homogenizing individual specimens together. The numbers and types of composite samples created for each type of chemical analysis are presented in Table 2-4. Additional compositing details—including the ID and length of each clam included in the composite samples—are provided in the compositing plan (Appendix D), which was developed with and approved by EPA. During sample collection, five extra clams were retained from each tissue collection area to provide additional options for compositing; none of these extra clams were included in the composite samples.

Table 2-4. Numbers of clam composite tissue samples

Clam Tissue Composite Type	Sample Type	No. of Individuals per Composite Sample	No. of Composite Tissue Samples
Inorganic arsenic composites	siphon skin	3	11
	remainder	3	11
Other risk driver composites[a]	whole body	10	9
Segment-wide composites[b]	whole body	30	3
cPAH porewater investigation composites	whole body	3	16

[a] Other risk driver composites were analyzed for PCB Aroclors, PCB congeners (6 of 10 composites), dioxins/furans, and cPAHs.

[b] Segment-wide composites were analyzed for vanadium, TBT, SVOCs, and organochlorine pesticides.

cPAH – carcinogenic polycyclic aromatic hydrocarbon

PCB – polychlorinated biphenyl

SVOC – semivolatile organic compound

TBT – tributyltin

2.3 FIELD DEVIATIONS FROM THE QAPP

The QAPP states that the first-whole body clam composite sample collected from clam tissue collection area 1 will be identified as LDW18-C01-CLWB-comp1 (Windward 2018). Instead, the calculated whole-body arsenic concentration result was identified as LDW18-C01-CLWB-comp1, and the whole-body clam composite sample analyzed for PCBs, dioxins/furans, and cPAHs was identified as LDW18-C01-CLWB-comp2. This naming convention was used for all of the clam tissue collection areas.

3 Analytical Methods

The analytical methods used to analyze the clam tissue composites and co-located sediment are summarized in this section and presented in detail in the QAPP (Windward 2018). This section also discusses laboratory deviations from the QAPP.

3.1 ANALYTICAL METHODS

Tissue and sediment samples were analyzed according to the methods presented in Tables 3-1 and 3-2.

Table 3-1. Analytical methods for clam tissue analyses

Analyte	Method	Reference	Extraction Solvent	Laboratory
PCB Aroclors	GC/ECD	EPA 3350-C Mod EPA 8082A	DCM/acetone	ARI
cPAHs	GC/MS	EPA 3350-C Mod EPA 8270D-SIM	DCM/acetone	ARI
SVOCs	GC/MS	EPA 3350-C Mod EPA 8270D	DCM/acetone	ARI
TBT	GC/MS	EPA 3350-C Mod EPA 8270-SIM	0.10% tropolone/DCM	ARI
Dioxins/furans	HRGC/HRMS	EPA 1613B	80:20 toluene: acetone extraction	Axys
PCB congeners	HRGC/HRMS	soxhlet extraction EPA 1668C	DCM	Axys
Organochlorine pesticides	GC/MS	EPA 3541 EPA 8270D/1699 Mod	DCM	ALS
Vanadium	ICP-MS	EPA 6020A UCT-KED	na	ARI
Inorganic arsenic	HG-AFS	EPA 1632	na	Brooks Applied
Percent solids	drying oven	PSEP (1997)	na	ARI
Lipids	gravimetric extraction	Bligh and Dyer (1959) (mod)	na	ARI

ALS – ALS Environmental-Kelso
ARI – Analytical Resources, Inc.
Axys – SGS-Axys Analytical Services Ltd.
Brooks – Brooks Applied Labs
cPAH – carcinogenic polycyclic aromatic hydrocarbon
DCM - dichloromethane
ECD – electron capture detector
EPA – US Environmental Protection Agency
GC – gas chromatography
HG-AFS – hydride generation-atomic fluorescence spectrometry
HRGC/HRMS – high-resolution gas chromatography/ high-resolution mass spectrometry
ICP – inductively coupled plasma
MS – mass spectrometry
na – not applicable
PCB – polychlorinated biphenyl
PSEP – Puget Sound Estuary Program
SIM – select ion monitoring
SVOC – semivolatile organic compound
TBT – tributyltin
UCT-KED – universal cell technology-kinetic energy discrimination

Table 3-2. Analytical methods for sediment analyses

Analyte	Method	Reference	Extraction Solvent	Laboratory
cPAHs	GC/MS	EPA 3550C/ EPA 8270D-SIM	DCM/ acetone	ARI
Black carbon	infrared	EPA 9060 with Gustafsson Acadi-Dey black carbon modification	na	Alpha
TOC	high-temperature combustion	EPA 9060	na	ARI
Percent solids	drying oven	PSEP (1997)	na	ARI

Alpha – Alpha Analytical Lab
ARI – Analytical Resources, Inc.
cPAH – carcinogenic polycyclic aromatic hydrocarbon
DCM - dichloromethane
EPA – US Environmental Protection Agency
GC – gas chromatography
MS –mass spectrometry
na – not applicable
PSEP – Puget Sound Estuary Program
SIM – select ion monitoring
TOC – total organic carbon

3.2 LABORATORY DEVIATIONS FROM THE QAPP

Laboratory deviations from the QAPP (Windward 2018) are as follows:

- Due to a laboratory oversight, a laboratory control sample (LCS) was analyzed instead of a certified reference material for polycyclic aromatic hydrocarbons (PAHs) for clam tissue analysis. The LCS was used to assess accuracy.
- The homogenization of the siphon skin samples was performed with a razor blade instead of a blender due to low sample mass (i.e., to avoid the loss of tissue in the blender).
- The standard reference material and matrix spike / matrix spike duplicate (MS / MSD) for organochlorine pesticide analysis were not analyzed due to an oversight by the laboratory. An LCS / LCS duplicate was used to assess precision and accuracy.
- Black carbon results were provided by Alpha rather than by ALS. The initial black carbon results reported by ALS were all non-detects. The Alpha method provided a lower reporting limit.

None of these deviations impact data quality or the ability to assess precision and accuracy.

4 Results of Chemical Analyses

This section summarizes the results of the chemical analyses and data validation of clam tissue for clam tissue DQOs 1 and 2 (Section 4.1) and the results of the clam tissue and co-located sediment analyses for the cPAH porewater investigation (i.e., porewater DQO 1) (Section 4.2). The full results of the cPAH porewater investigation—including an evaluation of the clam tissue, sediment, and porewater data—will be presented in an addendum to the data evaluation report (Task 6 of the Work Plan (Windward and Integral 2017)).

Data management practices—including methods used for calculations (e.g., concentrations of total PCBs and TEQs)—are presented in the Work Plan (Windward and Integral 2017; see Appendix C of the Work Plan). Data tables are presented in Appendix C,[2] and laboratory reports and the data validation report are presented in Appendix D.

4.1 Chemistry Results for Composite Clam Tissue Samples (Clam Tissue DQOs 1 and 2)

This section summarizes chemistry and conventional parameter results for composite clam tissue samples collected for clam tissue DQOs 1 and 2. Inorganic arsenic and conventional parameter results for the siphon skin and remainder composite samples are summarized in Table 4-1. The other risk drivers (i.e., PCBs, dioxins/furans, and cPAHs) and conventional parameter results for the whole-body composite samples are summarized in Table 4-2. The detection frequencies of the TEQ components for each sample are summarized in Table 4-3 to provide additional detection information about congeners and compounds included in these sums. Non-risk driver chemistry results for the segment-wide whole-body composite samples are summarized in Table 4-4.

As specified in the QAPP (Windward 2018), six of the whole-body risk driver composite samples (two from each of the three segments) were analyzed for PCB congeners. In addition, the QAPP specified that any clam tissue samples for which PCB Aroclors were not detected would also be analyzed for PCB congeners. Because PCB Aroclors were detected in all clam tissue samples, no additional PCB congener analyses were necessary.

[2] As stated in Appendix C of the Work Plan, concentrations obtained from the analysis of laboratory duplicates or replicates are presented as an average concentration.

Table 4-1. Inorganic arsenic and conventional parameter results for clam siphon and remainder composite samples

Location ID	Siphon Skin				Remainder				Calculated Whole Body[a]			
	Composite ID (LDW18-)	Inorganic Arsenic (mg/kg ww)	Percent Solids (%)	Lipids (%)	Composite ID (LDW18-)	Inorganic Arsenic (mg/kg ww)	Percent Solids (%)	Lipids (%)	Composite ID (LDW18-)	Inorganic Arsenic (mg/kg ww)	Percent Solids (%)	Lipids (%)
C01	C01-CLSP-Comp1	38.3	18.8	0.075 J	C01-CLRM-Comp1	0.067	7.50	0.50	C01-CLWB-Comp1	2.6	8.25	0.47 J
C02	C02-CLSP-Comp1	23.3	15.3	0.069 J	C02-CLRM-Comp1	0.048	8.40	0.45	C02-CLWB-Comp1	1.5	8.84	0.43 J
C03	C03-CLSP-Comp1	19.5	17.1	0.075 J	C03-CLRM-Comp1	0.072	7.27	0.36	C03-CLWB-Comp1	1.8	8.17	0.33 J
C04	C04-CLSP-Comp1	34.3	15.7	0.12	C04-CLRM-Comp1	0.167	9.73	0.45	C04-CLWB-Comp1	3.82	10.4	0.41
C05	C05-CLSP-Comp1	9.06	13.9	0.099 J	C05-CLRM-Comp1	0.056	9.40	0.55	C05-CLWB-Comp1	0.69	9.72	0.52 J
C06	C06-CLSP-Comp1	13.7	14.7	0.098 J	C06-CLRM-Comp1	0.052	5.66	0.28	C06-CLWB-Comp1	0.87	6.20	0.27 J
C07	C07-CLSP-Comp1	24.5	20.3	0.18	C07-CLRM-Comp1	0.10	8.74	0.51	C07-CLWB-Comp1	4.1	10.6	0.46
C08	C08-CLSP-Comp1	13.8	20.2	0.083 J	C08-CLRM-Comp1	0.064	6.36	0.37	C08-CLWB-Comp1	1.2	7.54	0.35 J
C09	C09-CLSP-Comp1	24.5	19.8	0.066 J	C09-CLRM-Comp1	0.060	8.82	0.54	C09-CLWB-Comp1	2.3	9.81	0.50 J
C10	C10-CLSP-Comp1	36.3	16.4	0.033 J	C10-CLRM-Comp1	0.095	6.19	0.33	C10-CLWB-Comp1	3.1	7.04	0.31 J
C11	C11-CLSP-Comp1	311	21.8	0.11	C11-CLRM-Comp1	0.191	7.41	0.37	C11-CLWB-Comp1	37.4	9.13	0.34

Note: See Appendix C for complete data tables.

[a] Whole-body concentrations were calculated from the siphon skin and remainder samples, as described in Appendix C.

ID – identification

J – estimated concentration

ww – wet weight

Table 4-2. Other risk driver chemistry and conventional parameter results for clam tissue composite samples

Location ID	Composite ID	Total PCB Aroclors (µg/kg ww)	Total PCB Congeners (µg/kg ww)	PCB TEQ[a] (ng/kg ww)	Dioxin/Furan TEQ[a] (ng/kg ww)	cPAH TEQ[a] (µg/kg ww)	Percent Solids (%)	Lipids (%)
C01	LDW18-C01-CLWB-Comp2	13.3 J	16.126 J	0.449	0.192 J	8.14 J	9.44	0.64
C02	LDW18-C02-CLWB-Comp2	11.3 J	20.020 J	0.226 J	0.379 J	9.20 J	10.0	0.53
C03	LDW18-C03-CLWB-Comp2	11.6 J	na	na	0.456 J	5.38 J	8.49	0.36
C04	LDW18-C04-CLWB-Comp2	19.6 J	22.660 J	0.239 J	5.55 J	5.41 J	9.46	0.52
C05	LDW18-C05-CLWB-Comp2	15.0	na	na	0.242 J	11.0 J	9.03	0.50
C06	LDW18-C06-CLWB-Comp2	12.3 J	27.810 J	0.348 J	0.354 J	5.35 J	8.12	0.38
C08	LDW18-C08-CLWB-Comp2	13.8 J	25.520 J	0.297 J	0.201 J	5.22 J	6.44	0.34
C10	LDW18-C10-CLWB-Comp2	8.0	na	na	0.247 J	5.32	7.61	0.30
C11	LDW18-C11-CLWB-Comp2	13.2 J	21.760 J	0.236	0.201 J	6.23 J	8.12	0.35

Note: See Appendix C for complete data tables.

[a] Detection frequencies for TEQ components are presented in Table 4-3.

cPAH – carcinogenic polycyclic aromatic hydrocarbon
ID – identification
J – estimated concentration
na – not analyzed
PCB – polychlorinated biphenyl
TEQ – toxic equivalent
ww – wet weight

Table 4-3. Detection frequency of TEQ components for clam tissue composite samples

Location ID	Composite ID	Detection Frequency of TEQ Component Chemicals		
		PCB Congeners[a]	Dioxins/Furans[b]	cPAHs[c]
C01	LDW18-C01-CLWB-Comp2	12 / 12	8 / 17	5 / 7
C02	LDW18-C02-CLWB-Comp2	11 / 12	7 / 17	6 / 7
C03	LDW18-C03-CLWB-Comp2	na	11 / 17	4 / 7
C04	LDW18-C04-CLWB-Comp2	11 / 12	13 / 17	5 / 7
C05	LDW18-C05-CLWB-Comp2	na	8 / 17	7 / 7
C06	LDW18-C06-CLWB-Comp2	12 / 12	7 / 17	4 / 7
C08	LDW18-C08-CLWB-Comp2	12 / 12	8 / 17	4 / 7
C10	LDW18-C10-CLWB-Comp2	na	6 / 17	1 / 7
C11	LDW18-C11-CLWB-Comp2	11 / 12	7 / 17	6 / 7

Note: See Appendix C for complete data tables.

[a] The 12 PCB congeners included in the TEQ are PCB-77, PCB-81, PCB-105, PCB-114, PCB-118, PCB-123, PCB-126, PCB-156, PCB-157, PCB-167, PCB-169, and PCB-189.

[b] The 17 dioxins/furans included in the TEQ are 2,3,7,8-TCDD; 1,2,3,7,8-PeCDD; 1,2,3,6,7,8-HxCDD; 1,2,3,4,7,8-HxCDD; 1,2,3,7,8,9-HxCDD; 1,2,3,4,6,7,8-HpCDD; OCDD; 2,3,7,8-TCDF; 1,2,3,7,8-PeCDF; 2,3,4,7,8-PeCDF; 1,2,3,6,7,8-HxCDF; 1,2,3,7,8,9-HxCDF; 1,2,3,4,7,8-HxCDF; 2,3,4,6,7,8-HxCDF; 1,2,3,4,6,7,8-HpCDF; 1,2,3,4,7,8,9-HpCDF; and OCDF. Two component dioxins/furans have TEFs of 1, making them more influential in the TEQ. The first component (2,3,7,8-TCDD) was not detected in any of the clam tissue composite samples, and the second component (1,2,3,7,8-PeCDD) was detected in only the composite sample from clam tissue collection area C04. TEFs are an estimate of the relative toxicity of each dioxin/furan congener, which are used to calculate the TEQ. This process was described further in the Work Plan (Windward and Integral 2017).

[c] The 7 PAHs included in the TEQ are benzo(a)pyrene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene. Benzo(a)pyrene, the only cPAH with a PEF of 1, was only detected in the clam tissue composite samples from clam tissue collection areas C05 and C11. PEFs are an estimate of the relative toxicity of each individual cPAH (i.e., relative to the toxicity of benzo(a)pyrene), which are used to calculate the TEQ. This process was described further in the Work Plan (Windward and Integral 2017).

cPAH – carcinogenic polycyclic aromatic hydrocarbon
HpCDD – heptachlorodibenzo-*p*-dioxin
HpCDF – heptachlorodibenzofuran
HxCDD – hexachlorodibenzo-*p*-dioxin
HxCDF – hexachlorodibenzofuran
ID – identification
OCDD – octachlorodibenzo-*p*-dioxin
OCDF – octachlorodibenzofuran
PCB – polychlorinated biphenyl
PeCDD – pentachlorodibenzo-p-dioxin
PeCDF – pentachlorodibenzofuran
PEF – potency equivalency factor
TCDD – tetrachlorodibenzo-*p*-dioxin
TCDF – tetrachlorodibenzofuran
TEF – toxic equivalency factor
TEQ – toxic equivalent

Table 4-4. Non-risk driver chemistry results for segment-wide clam tissue composite samples

Analyte	Unit	Segment 1 (Clamming Areas C01-C03)[a] LDW18-S1-CLWB-Comp1	Segment 2 (Clamming Areas C04-C06)[b] LDW18-S2-CLWB-Comp1	Segment 3 (Clamming Areas C08, C10, and C11)[c] LDW18-S3-CLWB-Comp1
Metals and organometals				
Vanadium	mg/kg ww	1.23	1.38	1.34
TBT	µg/kg ww	6.19	7.44	5.34
SVOCs				
BEHP	µg/kg ww	50.0 U	50.0 U	70.7
Carbazole	µg/kg ww	20.0 U	20.0 U	19.9 U
HCB	µg/kg ww	20.0 U	20.0 U	19.9 U
PCP	µg/kg ww	100 UJ	100 UJ	99.6 UJ
Organochlorine pesticides				
Total DDTs	µg/kg ww	0.70 U	0.70 U	0.70 U
Aldrin	µg/kg ww	0.23 U	0.22 U	0.22 U
Dieldrin	µg/kg ww	0.23 U	0.22 U	0.22 U
alpha-BHC	µg/kg ww	0.26 U	0.26 U	0.26 U
gamma-BHC	µg/kg ww	0.23 U	0.22 U	0.22 U
Total chlordane	µg/kg ww	0.77 U	0.77 U	0.77 U
Heptachlor	µg/kg ww	0.23 U	0.22 U	0.22 U
Heptachlor epoxide	µg/kg ww	0.23 U	0.22 U	0.22 U

Note: See Appendix C for complete data tables.

[a] Segment 1 includes clam tissue collection areas from RM 0 to 1.3 (i.e., areas C01, C02, and C03).

[b] Segment 2 includes clam tissue collection areas from RM 1.3 to 2.6 (i.e., areas C04, C05, and C06).

[c] Segment 3 includes clam tissue collection areas above RM 2.6 (i.e., areas C08, C10, and C11). Insufficient tissue was collected from areas C07 and C09 for inclusion in this composite.

BEHP – bis(2-ethylhexyl) phthalate
BHC – benzene hexachloride
DDT – dichlorodiphenyltrichloroethane
HCB – hexachlorobenzene
ID – identification
J – estimated concentration
PCP – pentachlorophenol
SVOC – semivolatile organic compound
TBT – tributyltin
U – not detected at given concentration
UJ – not detected at estimated concentration
ww – wet weight

4.2 CHEMISTRY RESULTS FOR CPAH POREWATER INVESTIGATION SAMPLES

This section summarizes chemistry and conventional parameters for 16 clam tissue samples and 16 co-located sediment samples (plus 1 field duplicate) analyzed for the cPAH porewater investigation as part of porewater DQO 1. As a result of a sample tracking issue that required the re-exposure of new passive samplers to archived sediment samples (described in Section 1 and Appendix A), the cPAH porewater results based on passive sampler data have been delayed. Therefore, validated passive sampler

data will be provided as an addendum to the data evaluation report, along with the evaluation of the relationships among co-located surface sediment ,clam tissue, and porewater based on the new data.

In consultation with EPA, 10 cPAH porewater investigation samples (i.e., those from areas A01, A02, A04, A06, A07, A08, A10, A11, A17, and A18) were selected for porewater assessment based on a review of the sediment cPAH results (both the TEQ and the individual cPAHs), sediment TOC results, and co-located clam tissue cPAH results (both the TEQ and the individual cPAHs) (Appendix A). Chemistry and conventionals results are presented in Table 4-5 for clam tissue and in Table 4-6 for sediment.

Table 4-5. cPAH porewater investigation clam tissue sample results for cPAHs and conventionals

Location ID[a]	Sample ID	PAHs (µg/kg ww)								Conventionals (%)	
		Benzo(a) anthracene	Benzo(a) pyrene	Benzo(b) fluoranthene	Benzo(k) fluoranthene	Chrysene	Dibenzo(a,h) anthracene	Indeno (1,2,3-cd) pyrene	cPAH TEQ	Percent Solids	Lipids
A01	LDW18-A01-CLWB-Comp1	4.81 J	3.77 J	4.50 J	2.58 J	7.20	5.00 U	5.00 U	6.28 J	11.2	0.52
A02	LDW18-A02-CLWB-Comp1	4.35 J	4.99 U	3.06 J	1.76 J	4.64 J	4.99 U	4.99 U	4.71 J	9.44	0.45
A03	LDW18-A03-CLWB-Comp1	36.6	39.9	26.4	16.8	38.4	6.12	21.3	52.8	10.0	0.45
A04	LDW18-A04-CLWB-Comp1	4.97 U	4.97 U	1.52 J	4.97 U	4.97 U	4.97 U	4.97 U	4.40 J	9.46	0.63
A05	LDW18-A05-CLWB-Comp1	2.64 J	4.93 U	2.87 J	1.82 J	4.32 J	4.93 U	4.93 U	4.47 J	7.59	0.39
A06	LDW18-A06-CLWB-Comp1	2.93 J	4.99 U	2.09 J	1.51 J	4.55 J	4.99 U	4.99 U	4.44 J	9.71	0.56
A07	LDW18-A07-CLWB-Comp1	3.05 J	4.94 U	2.42 J	4.94 U	5.08	4.94 U	4.94 U	4.55 J	9.13	0.42
A08	LDW18-A08-CLWB-Comp1	3.16 J	4.93 U	2.39 J	4.93 U	4.28 J	4.93 U	4.93 U	4.54 J	10.7	0.47
A09	LDW18-A09-CLWB-Comp1	3.05 J	4.96 U	2.39 J	1.59 J	4.36 J	4.96 U	4.96 U	4.47 J	8.30	0.35
A10	LDW18-A10-CLWB-Comp1	5.11	4.94 U	2.85 J	1.73 J	5.72	4.94 U	4.94 U	4.73 J	9.39	0.45
A11	LDW18-A11-CLWB-Comp1	3.68 J	4.97 U	2.47 J	1.53 J	6.38	4.97 U	4.97 U	4.56 J	11.4	0.68
A12	LDW18-A12-CLWB-Comp1	4.98 U	4.98 U	4.98 U	4.98 U	4.98 U	4.98 U	4.98 U	4.51 U	7.69	0.26
A13	LDW18-A13-CLWB-Comp1	4.93 U	4.93 U	1.71 J	4.93 U	4.07 J	4.93 U	4.93 U	4.40 J	10.4	0.34
A17	LDW18-A17-CLWB-Comp1	2.76 J	4.98 U	2.69 J	1.52 J	4.42 J	4.98 U	4.98 U	4.48 J	9.24	0.40
A18	LDW18-A18-CLWB-Comp1	4.39 J	3.91 J	4.31 J	2.72 J	6.01	4.96 U	2.65 J	6.37 J	9.64	0.42
A19	LDW18-A19-CLWB-Comp1	5.00 U	5.00 U	1.64 J	5.00 U	5.00 U	5.00 U	5.00 U	4.44 J	8.91	0.26

Note: Shaded rows indicate that the passive sampler for this area was selected for analysis. See Appendix C for complete data tables.

[a] Insufficient clam tissue was available from cPAH porewater investigation areas A14, A15, A16, and A20 for the creation of a cPAH composite.

cPAH – carcinogenic polycyclic aromatic hydrocarbon
ID – identification
J – estimated concentration
PAH – polycyclic aromatic hydrocarbon
TEQ – toxic equivalent
U – not detected at given concentration
ww – wet weight

Table 4-6. cPAH porewater investigation sediment sample results for cPAHs and conventionals

Location ID[a]	Sample ID	PAHs (µg/kg dw)								Conventionals (%)		
		Benzo(a) anthracene	Benzo(a) pyrene	Benzo(b) fluoranthene	Benzo(k) fluoranthene	Chrysene	Dibenzo(a,h) anthracene	Indeno (1,2,3-cd) pyrene	cPAH TEQ	TOC	Percent Solids	Black Carbon
A01	LDW18-SSCL-A01	610	613	365	236	598	101	306	811	0.640 J	78.17	0.172 J
A02	LDW18-SSCL-A02	7.69	6.78	6.54	3.13 J	8.00	4.78 U	5.94	10.2 J	0.740 J	72.20	0.168 J
A03	LDW18-SSCL-A03	8,960	8,790	5,030	3,290	8,830	1,480	4,360	11,600	1.78 J	62.47	0.281 J
A04	LDW18-SSCL-A04	13.0	12.8	14.2	8.06	23.3	2.69 J	8.01	18.4 J	0.500 J	73.13	0.073 J
A05	LDW18-SSCL-A05	56.4	76.2	92.5	45.9	116	12.8	51.2	107	1.26 J	63.98	0.166 J
A06	LDW18-SSCL-A06	31.4	33.1	34.2	17.7	44.3	6.24	22.0	46.6	0.530 J	73.08	0.060
A07	LDW18-SSCL-A07	67.0	94.2	71.0	37.5	108	17.0	55.5	125	1.90 J	65.52	0.069 J
A08	LDW18-SSCL-A08	124	145	100	57.3	195	26.4	86.0	194	0.570 J	72.41	0.231
A09	LDW18-SSCL-A09	29.8	34.2	39.5	20.1	44.5	5.69	20.8	47.9	0.770 J	76.27	0.056 J
A10	LDW18-SSCL-A10	37.3	40.0	39.4	21.5	50.6	8.01	24.7	56.0	0.400 J	87.94	0.024 J
A11	LDW18-SSCL-A11	54.8	63.4	72.9	36.4	83.1	12.2	46.0	90.1	1.39 J	59.52	0.153
A11 (FD)	LDW18-SSCL-A11-FD	38.3	45.0	55.5	25.8	60.6	8.88	32.3	64.3	1.15 J	60.82	0.158
A12	LDW18-SSCL-A12	17.5	17.7	21.3	9.79	27.9	4.52 J	12.8	25.9 J	0.610 J	79.03	0.079
A13	LDW18-SSCL-A13	46.0	53.6	50.8	30.3	68.9	13.2	42.8	76.6	0.680 J	71.87	0.140
A17	LDW18-SSCL-A17	144	148	143	76.4	181	29.2	98.0	208	1.05 J	59.28	0.269
A18	LDW18-SSCL-A18	896	1,020	789	489	916	209	624	1,390	0.770 J	72.17	0.230 J
A19	LDW18-SSCL-A19	49.6	58.0	54.3	32.7	74.6	11.0	40.4	80.8	0.840 J	58.42	0.160 J

Note: Shaded rows indicate that passive sampler for this area was selected for analysis. See Appendix C for complete data tables.

[a] Insufficient clam tissue was available from cPAH porewater investigation areas A14, A15, A16, and A20 for the creation of a cPAH composite, so co-located sediment was also not collected.

cPAH – carcinogenic polycyclic aromatic hydrocarbon
dw – dry weight
FD – field duplicate
ID – identification
J – estimated concentration
PAH – polycyclic aromatic hydrocarbon
TEQ – toxic equivalent
TOC – total organic carbon
U – not detected at given concentration

4.3 DATA VALIDATION RESULTS

Independent data validation was performed on all results by EcoChem, Inc. Full validation was performed on a minimum of 10% of the data or a single sample delivery group (SDG), as specified in the QAPP (Windward 2018). A summary-level validation review was conducted on the remaining data. All data presented in this report were determined to be acceptable for use as qualified.

The data validation report, which is presented in Appendix D, includes detailed information regarding all data qualifiers. Clam tissue PAH, PCB congener, and dioxin/furan results were qualified as estimated (i.e., J-qualified) when either 1) the reported results were below the reporting limits (i.e., the compound was positively identified but the concentration was an estimate below the reporting limit) or 2) results were reported as estimated maximum possible concentrations.

Additional data qualifications of note are summarized below.

- TOC results for SDG 18E0231 (17 sediment samples) were qualified as estimated (J-qualified) with a potential low bias due to MS/MSD recoveries below the laboratory lower control limit.
- Black carbon results from Alpha were qualified as estimated (J-qualified) due to laboratory duplicate and MS/MSD relative percent differences above the control limit in SDG L1828580 (10 sediment samples).
- The method blank for lipids in SDG 18F0331 had a detected value that was approximately two times the reporting limit (within normal range based on laboratory performance records). Eight tissue sample results had concentrations less than five times the laboratory blank concentration and were thus qualified as estimated (J-qualified).

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