FINAL

Appendix H
Data Management Rules

This appendix presents data management rules for the Lower Duwamish Waterway (LDW) database and the middle reach design dataset.

1 Data Management Rules for the LDW Database

The data management rules used to compile the middle reach data for the LDW database are consistent with those used to compile the upper reach data in 2019 (Anchor QEA and Windward 2019) and the Pre-Design Studies data in 2018 (Windward and Integral 2018).

1.1 Organic Carbon Normalization

Many of the sediment remedial action levels (RALs)—such as those for polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), and phthalates—are total organic carbon (TOC)-normalized values. Sediment concentrations that are organic carbon-normalized are calculated on a sample-specific basis using the following equation and total organic carbon (TOC) data:

$$C_{sed,OC} = \frac{C_{sed,dw}}{f_{oc}}$$

Where:

$C_{sed,OC}$	=	organic carbon-normalized sediment chemical concentration (mg/kg OC)
$C_{sed,dw}$	=	dry-weight sediment chemical concentration (mg/kg dw, or µg/kg dw/1,000)
f_{OC}	=	fraction organic carbon, dry-weight basis (%TOC/100)

The Record of Decision (ROD) does not provide direction regarding the TOC range that is appropriate for TOC normalization (EPA 2014). Thus, the range for TOC normalization was from 0.5% to 3.5%, based on the Washington State Department of Ecology's (Ecology's) Sediment Cleanup User's Manual (Ecology 2021). Concentrations in samples with TOC values outside of this range were compared to dry weight equivalent values, which are the lowest apparent effects threshold values listed in Table 8-1 of Ecology's Sediment Cleanup User's Manual.

1.2 Averaging Laboratory Duplicate or Replicate Samples

Contaminant concentrations obtained from the analysis of laboratory duplicates or replicates (i.e., two or more analyses of the same sample) were averaged for a closer representation of the "true" concentration than that provided by the results of a single analysis. Averaging rules were dependent on whether the individual results were detected concentrations or reporting limits (RLs) for non-detected analytes. If all concentrations were detected for a given parameter, the values were simply averaged arithmetically. If all concentrations were non-detected for a given parameter, the minimum RL was reported. If the concentrations were a mixture of detected concentrations and RLs, any two or more detected concentrations were averaged arithmetically, and RLs were ignored. If there was one detected concentration and one or more RLs, the detected concentration was

reported. The latter two rules were applied regardless of whether the RLs were greater or less than the detected concentration.

1.2 Selection of Preferred Results

In some instances, the laboratory generated more than one result for a chemical for a given sample. Multiple results occurred for several reasons, including the following:

- The original result did not meet the laboratory's internal quality control guidelines, and a reanalysis was performed.
- The original result did not meet other project data quality objectives, such as a sufficiently low RL, and a reanalysis was performed.
- Two different analytical methods were used for that chemical.

In each case, a single result was selected for use. The procedures for selecting the preferred result differed depending on whether a single or multiple analytical methods had been used for that chemical.

For the same analytical method, the results were selected using the following guidance:

- If the results were detected and not qualified, then the result from the lowest dilution was selected, unless multiple results from the same dilution were available, in which case the result with the highest concentration was selected.
- If the results were a combination of estimated and unqualified detected results, then the unqualified result was selected. This situation most commonly occurred when the original result was outside the calibration range, thus requiring a dilution. The diluted result within the calibration range was preferentially selected.
- If the results were all estimated, then the result was selected using best professional judgment and considering the rationale for qualification. For example, a result qualified based on laboratory replicate results outside quality control objectives for precision was preferred to a qualified result that was outside the calibration range.
- If the results were a combination of detected and non-detected results, then the detected result was selected. If there was more than one detected result, the applicable rules for multiple results (discussed previously) were followed.
- If the results were all non-detected, then the lowest RL was selected.

For different analytical methods (i.e., when a specific chemical was analyzed in the same sample using different methods), the following rules were applied:

- For results analyzed using the semivolatile organic compound full-scan (US Environmental Protection Agency [EPA] method 8270) and selected ion monitoring (SIM) (EPA method 8270-SIM) methods, the SIM results were selected.
- For results analyzed using EPA method 8081A and any 8270 method (i.e., hexachlorobenzene and hexachlorocyclopentadiene), the method 8081A results were selected.
- For results analyzed using the semivolatile organic compound EPA method 8270 and volatile organic compound (EPA method 8260) methods, the method 8260 results were selected.

1.3 Significant Figures and Rounding

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

When a calculation involved addition, such as totaling PCBs or PAHs, the calculation was only as precise as the least precise number that went into the calculation. For example (assuming two significant figures):

> 210 + 19 = 229 was reported as 230 because 19 was only reported to 2 significant digits, and the enhanced precision of the trailing 0 in the number 210 was not significant.

When a calculation involved multiplication or division, such as carbon normalization, the original figures for each value were carried through the calculation (i.e., individual values were not adjusted to a standard number of significant figures; instead, the appropriate adjustment was made to the resultant value at the end of the calculation). The result was rounded at the end of the calculation to reflect the value with the fewest significant figures used in the calculation. For example:

> 59.9 x 1.2 = 71.88 was reported as 72 because there were 2 significant figures in the number 1.2.

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

1.4 Calculating Totals

Total PCBs, total dichlorodiphenyltrichloroethanes (DDTs), total PAHs, total chlordane, total xylenes, and total nitrosamines were calculated by summing the detected values for the individual components. For samples in which none of the individual components were detected, the total value was given as the highest RL of any individual component and assigned a U-qualifier (no detected

concentrations). No sum was calculated when 50% or less of the components were analyzed. Concentrations for analyte sums were calculated using the following components:

- Total PCBs were calculated, in accordance with the methods of the Washington State Sediment Management Standards (SMS), using only detected values for all Aroclor mixtures. For individual samples in which none of the Aroclor mixtures were detected, total PCBs were given a value equal to the highest RL of the Aroclors and assigned a U-qualifier. When PCBs were analyzed as 209 individual congeners, the same summing method was applied.
- Total low-molecular-weight polycyclic aromatic hydrocarbons (LPAHs), high-molecular-weight polycyclic aromatic hydrocarbons (HPAHs), PAHs, and benzofluoranthenes were also calculated in accordance with the methods of the SMS. Total LPAHs were the sum of detected concentrations for naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, and anthracene. Total HPAHs were the sum of detected concentrations for fluoranthene, pyrene, benzo(a)anthracene, chrysene, total benzofluoranthenes, benzo(a)pyrene, indeno(1,2,3,-c,d)pyrene, dibenzo(a,h)anthracene, and benzo(g,h,i)perylene. Total benzofluoranthenes were the sum of the b (i.e., benzo(b)fluoranthene), j, and k isomers. Because the j isomer is rarely quantified, the total benzofluoranthenes sum was typically calculated using only the b and k isomers. When the laboratory provided total benzofluoranthenes instead of or in addition to the b and k isomers, the laboratory result was reported, and no sum was calculated. For samples in which all individual compounds within any of the three groups described were non-detected, the highest RL for that sample represented the sum.
- Total DDTs were calculated using only detected values for the DDT isomers: 2,4′-dichlorodiphenyldichloroethane (DDD); 4,4′-DDD; 2,4′-dichlorodiphenyldichloroethylene (DDE); 4,4′-DDE; 2,4′-DDT; and 4,4′-DDT. For individual samples in which none of the isomers were detected, total DDTs were given a value equal to the highest RL among the six isomers and assigned a U-qualifier.
- Total chlordane was calculated using only detected values for the following compounds: alpha-chlordane, gamma-chlordane, oxychlordane, cis-nonachlor, and trans-nonachlor. For individual samples in which none of these compounds were detected, total chlordane was given a value equal to the highest RL among the five compounds listed and assigned a U-qualifier.
- Total xylene was calculated using only detected values for m,p-xylene and o-xylene. For individual samples in which neither of these compounds were detected, total xylene was given a value equal to the higher RL of the two compounds listed and assigned a U-qualifier.

1.5 Calculation of PCB Congener Toxic Equivalents

PCB congener toxic equivalents (TEQs) were calculated using the World Health Organization (WHO) consensus toxic equivalency factor (TEF) values for mammals (Van den Berg et al. 1998; Van den Berg et al. 2006), as presented in Table H1-1. The TEQ was calculated as the sum of each PCB congener concentration multiplied by the corresponding TEF value. When the PCB congener concentration was reported as non-detected, then the TEF was multiplied by one-half the RL.

Table H1-1
PCB Congener TEF Values

PCB Congener No.	TEF Value for Mammals (unitless)[1]
77	0.0001
81	0.0003
105	0.00003
114	0.00003
118	0.00003
123	0.00003
126	0.1
156	0.00003
157	0.00003
167	0.00003
169	0.03
189	0.00003

Notes:
1. From Van den Berg et al. (2006).
PCB: polychlorinated biphenyl
TEF: toxic equivalency factor

1.6 Calculation of Dioxin/furan Congener TEQs

Dioxin/furan congener TEQs were calculated using the WHO consensus TEF values for mammals (Van den Berg et al. 1998; Van den Berg et al. 2006), as presented in Table H1-2. The TEQ was calculated as the sum of each dioxin/furan congener concentration multiplied by the corresponding TEF value. When the dioxin/furan congener concentration was reported as non-detected, then the TEF was multiplied by one-half the RL.

Table H1-2
Dioxin/furan Congener TEF Values

Dioxin/Furan Congener	TEF Value for Mammals (unitless)[1]
1,2,3,4,6,7,8-HpCDF	0.01
1,2,3,4,6,7,8-HpCDD	0.01
1,2,3,4,7,8,9-HpCDF	0.01
1,2,3,4,7,8-HxCDF	0.1
1,2,3,4,7,8-HxCDD	0.1
1,2,3,6,7,8-HxCDF	0.1
1,2,3,6,7,8-HxCDD	0.1
1,2,3,7,8,9-HxCDF	0.1
1,2,3,7,8,9-HxCDD	0.1
1,2,3,7,8-PeCDF	0.03
1,2,3,7,8-PeCDD	1
2,3,4,6,7,8-HxCDF	0.1
2,3,4,7,8-PeCDF	0.3
2,3,7,8-TCDF	0.1
2,3,7,8-TCDD	1
OCDF	0.0003
OCDD	0.0003

Notes:
1. From Van den Berg et al. (2006).
HpCDD: heptachlorodibenzo-*p*-dioxin
HpCDF: heptachlorodibenzofuran
HxCDD: hexachlorodibenzo-*p*-dioxin
HxCDF: hexachlorodibenzofuran
OCDD: octachlorodibenzo-*p*-dioxin
OCDF: octachlorodibenzofuran
PeCDD: pentachlorodibenzo-*p*-dioxin
PeCDF: pentachlorodibenzofuran
TCDD: tetrachlorodibenzo-*p*-dioxin
TCDF: tetrachlorodibenzofuran
TEF: toxic equivalency factor

1.7 Calculation of Carcinogenic Polycyclic Aromatic Hydrocarbons

cPAH values were calculated using potency equivalency factor (PEF) values (California EPA 2009) based on the individual PAH component's toxicity relative to the toxicity of benzo(a)pyrene. PEF values are presented in Table H1-3. The cPAH TEQ was calculated as the sum of each individual PAH concentration multiplied by the corresponding PEF value. When the individual PAH component concentration was reported as non-detected, then the PEF was multiplied by one-half the RL.

Table H1-3
cPAH PEF Values

cPAH	PEF Value (unitless)[1]
Benzo(a)pyrene	1
Benzo(a)anthracene	0.1
Benzo(b)fluoranthene	0.1
Benzo(k)fluoranthene	0.1
Chrysene	0.01
Dibenz(a,h)anthracene	0.4[2]
Indeno(1,2,3-cd)pyrene	0.1

Notes:
1. PEFs for cPAHs are defined by California EPA (2009) by dividing the inhalation unit risk factor for the compound by the inhalation unit risk factor for benzo[a]pyrene.
2. The PEF value for dibenz(a,h)anthracene is based on the inhalation unit risk factors provided by California EPA (1994). This PEF was used in the LDW Remedial Investigation (Windward 2010).
cPAH: carcinogenic polycyclic aromatic hydrocarbon
EPA: US Environmental Protection Agency
LDW: Lower Duwamish Waterway
PEF: potency equivalency factor

2 Data Management Rules for Design Datasets

The LDW database includes all data that have been compiled for the LDW. A subset of these data has been selected to be used in the remedial design; this dataset is referred to as the design dataset. There is a design dataset for each LDW reach. The design dataset includes sediment data that are used in geostatistical models to delineate areas with RAL exceedances, as well as data used to establish the depth of contamination. This dataset will be expanded throughout the design process as Pre-Design Investigation (PDI) and other sediment data become available. The data in the LDW database that are not included in the design dataset are referred to as supplemental data. The supplemental data are used to inform the sampling design and the remedial design but not to delineate areas with RAL exceedances.

A design dataset has been constructed for the middle reach following the same data management rules used to develop the design dataset for the upper reach, as described in Appendix D of the Phase II PDI Quality Assurance Project Plan Addendum for the upper reach (Windward and Anchor QEA 2021). The middle reach design dataset includes surface sediment collected from 2011 to the present (post-feasibility study [FS] data) and subsurface data collected from 1990 to the present (remedial investigation (RI)/FS and post-FS data), as discussed in Section 3.1 of the PDI work plan (Windward and Anchor QEA 2023). The steps followed in creating the design dataset were as follows:

- Identify all samples analyzed for chemicals with RALs.

- Exclude any samples identified as:
  - Located within early action areas
  - Located within areas dredged since the sample was collected
  - Located within areas identified as experiencing >1.5 feet of deepening since 2003
  - Collected as part of a monitoring program and superseded by newer data (e.g., data from monitoring year 1 are superseded by those from monitoring year 2)
  - Collected from a depth interval shallower than 5 cm (data that could be helpful for vertical extent were retained, even if they did not represent a RAL interval) (e.g., 0 to 2 cm)
  - Composite samples, as they did not provide location-specific information
  - Surface data from the RI/FS (pre-2011 data unlikely to be representative of surface sediment conditions)

For subtidal locations with multiple sample depths within the 0- to 60-cm RAL interval, the results were averaged to create a single concentration per contaminant representing the 0- to 60-cm interval (i.e., results from a 0- to 30-cm sample and a 30- to 60-cm sample were averaged to represent the 0- to 60-cm interval).

With respect to field duplicates, parent sample results were selected when both parent and field duplicate results were reported, except when a RAL exceedance occurred only in the field duplicate and not in the parent. In such a case, the field duplicate results were selected for all analytes.[1] This rule applied to all field duplicate samples, including those from duplicate cores with reported coordinates slightly different from the parent core.

For PCBs, both PCB Aroclor and congener sums were compared to the PCB RAL. When a sample was analyzed for both, the greater of the two sums was selected for the design dataset.

3 Summary of Data Replacement for the Design Dataset

The Fifth Amendment to the Administrative Order on Consent (AOC) (EPA 2021) specifies that the approach to be used to override existing data with new results shall be identified in the PDI work plan (Windward and Anchor QEA 2023). Specifics to be identified shall include criteria for overriding subsurface data in limited cases, proximity requirements, and a process for evaluating discrepancies between existing and new data that will be identified for discussion and approval by EPA.

The rule used for reoccupied sampling locations in the LDW RI and upper reach design dataset was also used to develop the initial middle reach design dataset. For surface sediment locations that have

[1] If a RAL exceedance were to occur for one or more chemicals in the parent sample, and if a RAL exceedance were to occur for a different chemical (or chemicals) in the field duplicate, the parent sample results would be selected for all chemicals except those that had a RAL exceedance in the field duplicate.

been reoccupied, more recent data (if collected within 10 feet of original sampling locations)[2] have been selected to represent current conditions. If an older sample includes data for contaminants not analyzed for in the newer sample, the older chemistry has been retained in the dataset. The purpose of this rule is to include the most current results available for the 0- to 10-cm interval for comparison to RALs, since surface sediments can change over time as new sediment is deposited.

Compilation of the middle reach design dataset included an evaluation of reoccupied surface sediment sampling locations. A summary of the reoccupied locations is provided in the Excel file that accompanies this appendix (Attachment H-1). The summary also identifies instances wherein there was a RAL exceedance associated with either the older data or the more recent data at reoccupied locations. In rare instances, subsurface sample locations were also reoccupied to address specific questions (Attachment H-1). In these instances, the older data have also been retained in the design dataset for informational purposes.

4 References

Anchor QEA, Windward. 2019. Remedial design work plan for the Lower Duwamish Waterway upper reach. Final. Submitted to EPA December 16, 2019. Anchor QEA, Inc. and Windward Environmental LLC, Seattle, WA.

California EPA. 1994. Health effects of benzo(a)pyrene. Office of Environmental Health Hazard Assessment, California Environmental Protection Agency, Berkeley, CA.

California EPA. 2009. Technical support document for cancer potency factors: methodologies for derivation, listing of available values, and adjustments to allow for early life stage exposures. Air Toxicology and Epidemiology Branch, Office of Environmental Health Hazard Assessment, California Environmental Protection Agency, Sacramento, CA.

Ecology. 2021. Sediment cleanup user's manual. Guidance for implementing the cleanup provisions of the sediment management standards, Chapter 173-204 WAC. Third revision December 2021. Pub. No. 12-09-057. Toxics Cleanup Program, Washington State Department of Ecology, Olympia, WA.

EPA. 2014. Record of Decision. Lower Duwamish Waterway Superfund Site. US Environmental Protection Agency.

EPA. 2021. Fifth Amendment to the Administrative Order on Consent for remedial investigation/feasibility study (AOC) for the Lower Duwamish Waterway (LDW), CERCLA-10-2001-0055. US Environmental Protection Agency, Region 10, Olympia, WA.

Van den Berg M, Birnbaum L, Bosveld ATC, Brunström B, Cook P, Feeley M, Giesy JP, Hanberg A, Hasegawa R, Kennedy S, Kubiak T, Larsen JC, van Leeuwen FXR, Djien Liem AK, Nolt C, Peterson RE, Poellinger L, Safe S, Schrenk D, Tillitt D, Tysklind M, Younes M, Waern F, Zacharewski T. 1998. Toxic equivalency factors (TEFs) for PCBs, PCDDs, PCDFs for humans and wildlife. Environ Health Perspect 106(12):775-792.

[2] The 10-foot rule is consistent with inherent measurement error in the differential global positioning systems (GPSs) used in sampling surveys for the PDI and past sampling efforts. The differential GPS used for PDI surface sediment sampling has a measurement error of approximately 3 to 6 feet. Given the inherent measurement error, it is not possible to definitively distinguish different sampling locations within 10 feet of one another for samples collected after 2001. Prior to 2001, GPS technology was less accurate, so measurement errors may have been greater. If a reoccupied sampling location was more than 10 feet away from the old location, it was considered a separate sampling location and the older data were retained.

Van den Berg M, Birnbaum LS, Denison M, De Vito M, Farland W, Feeley M, Fiedler H, Hakansson H, Hanberg A, Haws L, Rose M, Safe S, Schrenk D, Tohyama C, Tritscher A, Tuomisto J, Tysklind M, Walker N, Peterson RE. 2006. The 2005 World Health Organization reevaluation of human and mammalian toxic equivalency factors for dioxins and dioxin-like compounds. Toxicol Sci 93(2):223-241.

Windward. 2010. Lower Duwamish Waterway remedial investigation. Remedial investigation report. Final. Prepared for Lower Duwamish Waterway Group. Windward Environmental LLC, Seattle, WA.

Windward, Integral. 2018. Technical memorandum: Compilation of existing data. Final. Submitted to EPA on November 19, 2018. Windward Environmental LLC and Integral Consulting Inc., Seattle, WA.

Windward, Anchor QEA. 2021. Attachment D. Data management rules. Quality assurance project plan addendum for the Lower Duwamish Waterway Upper Reach: Pre-Design Investigation Phase II. Final. Windward Environmental LLC and Anchor QEA, Seattle, WA.

Windward, Anchor QEA. 2023. Pre-design investigation work plan for the Lower Duwamish Waterway - Middle Reach. Final. Submitted to EPA February 14, 2023. Windward Environmental LLC and Anchor QEA, Seattle, WA.

Attachment H-1
Data Replacement Details

See separate Excel file.